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Review Article

A Review On Lemongrass Oil Act As A Antifungal And Anti-Bacterial Agent

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ABSTRACT

Lemongrass oil, derived from the Cymbopogon species, has been traditionally utilized for its diverse therapeutic properties. This review aims to consolidate and evaluate the scientific evidence regarding its antifungal and antibacterial activities. Lemongrass oil is rich in bioactive compounds, particularly citral, which is primarily responsible for its potent antimicrobial effects. Various in vitro and in vivo studies have demonstrated the efficacy of lemongrass oil against a broad spectrum of bacterial and fungal pathogens. The mechanisms of action include disruption of microbial cell membranes, inhibition of biofilm formation, and interference with microbial enzyme systems. The review also explores the potential applications of lemongrass oil in clinical and agricultural settings, emphasizing its role as a natural alternative to synthetic antimicrobials. Safety profiles and potential resistance issues are also discussed. The findings support the integration of lemongrass oil in antimicrobial strategies, highlighting its promise in combating infections and enhancing food safety.

INTRODUCTION

Lemongrass oil has a strong lemon-like odour due to high citral content (75-90%). The minimum commercial requirement is 70% citral content. The major quality checking measures are its citral content and its solubility in alcohol. This is an essential ingredient in toiletry products such as toilet soaps, bath salts, etc.It is also employed in artificial lemon flavouring and in the manufacture of ionenes. Ionenes are very important for the production of artificial flavour, perfumes, and soaps and as raw material for vitamin A manufacturing. Here in this article, we intend to explore how to start a small-scale lemongrass oil manufacturing business. The oil is of a reddish-yellow to reddish-brown colour, with a strong, lemon odour. It is also used in pharmaceutical preparations, such as pain balm, disinfectants, and

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mosquito repellent cream. Lemon grass, popularly known as citronella grass is a member of the Poaceae family and belongs to the genus Cymbopogon. The genus Cymbopogon constitutes of approximately 140 species that show widespread growth across the semi-temperate and tropical regions of Asian, American and African continents. Australia and Europe are home to only a few species of lemon grass. Also known as 'Squinant' in English, lemon grass is known by various other colloquial names throughout the world. The members of the Cymbopogon genus produce volatile oils and thus are also known as aromatic grasses.1,2A strong lemon fragrance, a predominant feature of this grass, is due to the high citral content of its oil. The redolence of the oil enables its use in soaps, detergents, etc. As a good source of citral, it finds an application in the perfumery as well as food industries. It is also the starting material for the manufacture of ionone's, which produce Vitamin A.3Lemon grass contains several bioactive compounds that impart medicinal value to it. Considerable evidence is available for its ethnopharmacological applications.4 According to the WHO, herbal medicine is considered an important part of the healthcare industry by more than two-thirds of the population in developing countries. A part from an overall description of lemon grass, this review article also highlights its medicinal properties that make it a potent herb for Pharmacognstic applications. Cymbopogon spp. are fast-growing C4 perennial sedges from the grass family Poaceae and are primarily cultivated for their essential oils. The genus lemongrass comprises about 180 species, such as Cymbopogon citratus, Cymbopogon flexuosus, Cymbopogon winterianus, Cymbopogon martinii, Cymbopogon nardus, and Cymbopogon refractus. These aromatic grasses are of great commercial interest due to their wide applications in different areas such as the food, pharmaceutical, and cosmetic industries. The plant propagates through seed and slips and has thin and lanceolate leaves that appear to emerge directly from the soil without any stem Although lemongrass cultivation is cosmopolitan, India has a monopoly over its production and export. Bioactive Compounds Present in Lemon Grass and its OilA vast array of ethnopharmacological applications of lemon grass exist today. Its health restorative capacity may be ascribed to the diverse secondary metabolites it produces. Analysis of the grass showed the presence offats, proteins, carbohydrates, fiber, minerals and several other bioactive compounds (Table 1-3). These can be grouped under different classes like alkaloids, terpenoids, flavanoids, phenols, saponins and tannins. Reports have also confirmed the presence of anthraquinones, steroids, phlobotannins, and cardiac glycosides in lemon grass.

Cymbopogon citratus

Scientific classification-:

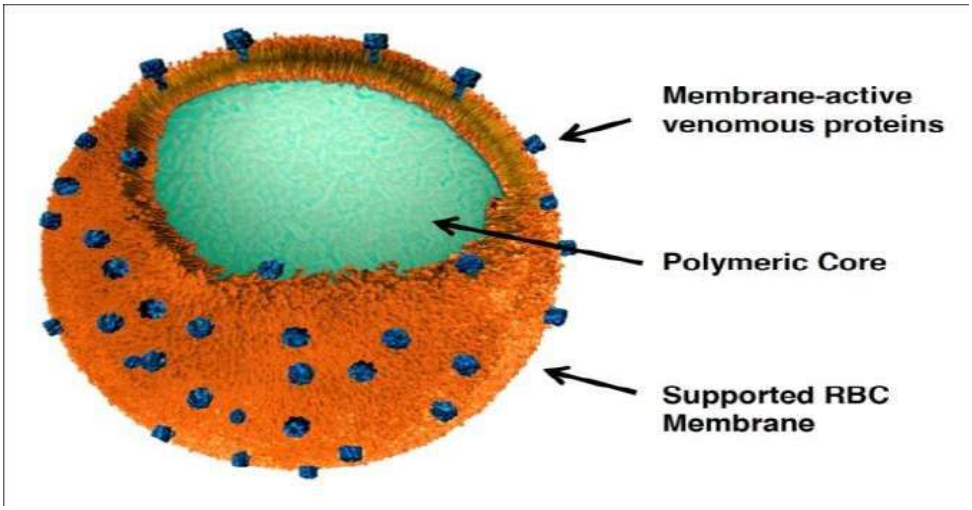
Kingdom: plantae
Clade: Tracheophytes
Clade: Monocots
Clade: Commelinids
Order: Poalrs
Family: Poaceae
Subfamily; panicoideae
Subertribe: Andropogonodae
Tribe: Andropogonodae
Subtribe: Andropogoninae
Genus: Cymbopogon

Types Species:

Cymbopogon Schoenanthus

Nanosponges:

While designing a drug delivery system, researchers mainly focus on delivering the accurate amount of drug at the target site. In this way, many approaches are utilized by using modern nanotechnology, which proved best in its manner.1 Nanotechnology is a branch of science that employs nanomaterials at the nanoscale for creating nanoengineered products with advanced features and improved characteristics in the size range of 1 to 100 nm. One billionth of a meter is a nanometer. Nanomaterials are physical compounds with at least one fraction in the range of 1 to 100 nm. 2. These NPs are observed in a number of diverse shapes, including polymeric nanoparticles, hard-phospholipid nanoparticles, nanoemulsions, dendrimers, nanosponges, liposomes, carbon nanotubes, micellar systems, etc.3 In this regard, the use of nanotechnology in the medical field is transitioning from passive structures' to 'active structures' through more precise pharmacological drug therapies or "smart drugs" that are made by coupling certain ligands to nanocarriers or aptamers. A wide variety of drug substances like antifungal, antiviral, anti-cancer, volatile oils, gases, proteins and peptides can be ensnared in colloidal nanoparticulate structures known as nanosponges.



NS are 3D spongy structures, around the size of a virus containing nanometric cavities or voids. Simply they are encapsulating drug delivery systems.4,5 These sponges move all around the body until they identify the exact target, attach to the surface, and release the drug gradually. They are five times more efficient than conventional techniques at delivering drugs for breast cancer and are non-irritating, non-mutagenic, non-allergic, and non-toxic.6 NS are solid by nature, capable of ensnaring both hydrophilic and lipophilic substances. Due to this property, they are suitable for enhancing the solubility, permeability as well as bioavailability of compromised drugs like camptothecin, paclitaxel, dexamethasone, etc. It also helps less or poor water-soluble molecules become more soluble by encapsulating them in polar cavities. They are porous, insoluble in water and other organic solvents, innocuous and stable up to 300°C.

The development of nanosponges involves the use of many polymers and cross-linkers which result in the delivery of entrapped drugs in a controlled predictable way at the target site.7 In this way, NS is the leading frontier in drug delivery which reduces the dose and dose-related toxicities. It can be administered through oral, parenteral, and topical routes. Oral administration of NS can be done in the form of capsules, tablets, or solid dispersions by using suitable excipients and diluents that deliver the drug efficiently at the target site.8 For the parenteral route different

aqueous solutions like sterile water, and saline is used for NS dispersion while in topical delivery hydrogel is best suited. This ultimately results in improved safety, effectiveness, patient compliance, an extended drug shelf life, and ultimately lower healthcare expenditures. Nanotechnology has the potential to be the most significant engineering breakthrough since the industrial revolution. Nanotechnology has so far produced nanoparticles, nanocapsules, nanospheres, nano suspensions, nanocrystals, and nano-erythosomes, among other formulations. Nanotechnology is described as the synthesis and manipulation of materials at the nanoscale level in order to produce products with unique features. Nanomaterials have received a lot of interest in recent years. Richard P. Feynman, a physicist at Cal Tech, predicted nanomaterials in 1959. "There is lots of room at the bottom," he remarked, suggesting that scaling down to the nanoscale and beginning from the bottom was the key are materials with a minimum of one dimension within the vary of 1-100 nanometers.1 There are many different types of nanoparticles, including polymeric nanoparticles, solid-lipid nanoparticles, nanoemulsions, nanosponges, carbon nanotubes, micellar systems, and dendrimers, among others. The compound can simply be transported for parenteral distribution in sterile water, saline, or other aqueous solutions. They can successfully be incorporated into topical hydrogel for topical administration. Nanosponges are a novel class of materials made up of small particles having a few nanometer-wide holes that may encapsulate a wide range of compounds. These particles are capable of transporting both lipophilic and hydrophilic molecules, as well as enhancing the solubility of molecules that are weakly water soluble. These microscopic sponges can move through the body until they reach the intended target region, where they adhere to the surface and start to release the medicine in a steady and controlled manner. For a given dosage, the drug will be more effective since it can be released at the precise target place rather than circulating throughout the body. These nanosponges also have an important property called aqueous solubility, which makes it possible to use these systems successfully for medications with limited solubility.

Advantages of Nanosponges:

- Nanosponges allows components to be entrapped and thus reduces adverse effects.
- Remains stable at pH levels ranging from 1 to 11.
- They can withstand temperatures of up to 1300°C.
- They act like self-sterilizer, because of their tiny pore size (0.25m) which does not allow bacteria to penetrate.
- They are of low-cost and free-flowing.
- They improve the solubility of drugs that aren't easily soluble.
- They increase the bioavailability of drug.
- They have improved formulation flexibility, improved stability, and increased elegance.
- Increase aqueous solubility of the poorly water-soluble drug.
- Nanosponges can release the drug molecules in a predictable fashion. Because of their tiny pore size (0.25 μm), bacteria cannot penetrate the nanosponges and they act like a self-sterilizer.
- Nanosponges drug delivery system are non-irritating, non- mutagenic and non-toxic.
- Nanosponges help to remove the toxic and venom substance from the body.
- Nanosponges drug delivery system minimize side effect.
- Increase formulation stability and enhance the flexibility of the formulation.
- Reduce dosing frequency.
- Better patient compliance.

- Nanosponges complexes are stable over wide range of pH (i.e. 1- 11) and a temperature of 130 °C [4-6].

Characteristics of Nanosponges-

There are several characteristics of nanosponges which make it different from other nanoparticles. Such characteristics are being discussed below:

- Nanosponges are insoluble in organic solvents & water porous, nontoxic, and thermostable up to 3000C, unlike other nanoparticles.
- Their size distribution is limited, with a mean diameter of less than 1 m.
- Carbonate nanosponges have a zeta potential of about 25 mV, which results with stable water suspensions that do not aggregate over time due to a higher zeta
- potential.
- Nanosponges protect the medication from physiological breakdown and are non-irritating, non- mutagenic, non-allergic, and non-toxic.
- By generating inclusion and non-inclusion complexes nanosponges can encapsulate a variety of pharmacological compounds.
- Nanosponges are porous particles that are primarily utilized to encapsulate medications that are poorly soluble.

Composition Of Nanosponges -

1. Polymer and copolymers -

The choice of polymer can have an impact on the development and performance of nanosponges. The cavity size must be appropriate for incorporating the specific medication molecule. The polymer chosen is determined by the needed release and the medicine to be encapsulated. The chosen polymer should have the ability to bind to specified ligands. Eg. Cyclodextrins and their derivatives such as Methyl- cyclodextrin (-CD), alkyloxy carbonyl cyclodextrins, 2- hydroxy propyl-CDs, and copolymers such as poly (Valero lactoneallylvalero lactone) and poly (Valero lactone-allyl Valero lactone oxepanedione), Hyper cross-linked polystyrenes, ethyl cellulose and PVA are among the polymers used to make nanosponges.

2. Cross linking agents -

The cross-linking agent can be selected based on the structure of the polymer and the medicine that will be synthesized. Depending on the type of cross linkers used, water soluble or insoluble nanosponge structures are created. Examples: Diphenyl Carbonate, Diarylcarbonates, Di-Isocyanates, Pyromellitic anhydride, Carbonyl-di-Imidazoles, Epichloridrine, Glutaraldehyde, Carboxylic acid dianhydrides, 2,2-bis(acrylamido) Acetic acid and Dichloromethane.

Factors Formulation Of Nanosponges -Affecting

1. Type of Drug
2. Type of Polymer used
3. Temperature
4. Method of preparation nanosponge
5. Degree of substitution

1.Type of Drug

The therapeutic molecules that will be used in incision and non-incision nanosponge complexes should have the following characteristics:

1. The drug molecule's structure should not include more than five condensed rings.
2. The drug's melting point should be less than 250°C.
3. In water, drug solubility should be less than 10 mg/ml.
4. The molecular weight of drug should be between 100 and 400 gm/mole.

2. Type of Polymers Used

The type of polymer employed in nanosponge formulation can have an impact on the nanosponge formation and performance. The polymer utilised in the formulation determines the size of the nanosponge cavity and drug complexation.

3. Temperature

The drug/nanosponge complexation can be affected b temperature changes. Reduces the perceived stability's magnitude by a factor of two.

The constant increase in temperature of the Drug/Nanosponge complex could be related to the likely lowering of drug/Nanosponge contact forces as temperature rises.

4. Method of Preparation Nanosponges

The loading of a drug into a nanosponge has the potential to change the nanosponge/drug complexation. In any instance, the success of a method is determined by the nature of the drug and polymer. Freeze drying has proven to be the most effective way for drug complexation in many cases.

5. Degree of Substitution

The type, amount, and placement of the substituent on the parent molecule can all affect the ability of nanosponge to complex.

Method Prepration Of Nanosponges -

There are several methods of preparation of Nanosponges:

1. Solvent method
2. Ultrasound-assisted synthesis
3. Emulsion solvent diffusion method
4. From Hyper crosslinked β-Cyclodextrin.

1.Solvent method

The polymer is combined with a suitable solvent, preferably a polar aprotic solvent such as dimethylformamide or dimethyl sulfoxide. This mixture is applied to an excess of crosslinker, preferably in a 4 to 16 molar ratio of crosslinker to polymer. The reaction is carried out at temperatures ranging from 10 °C to the solvent's reflux temperature for 1 to 48 hours. Carbonyl compounds are preferred cross linkers (dimethyl carbonate and carbonyl diimidazole). Following the completion of the reaction, the solution is allowed to cool to room temperature before being added to a substantial amount of distilled water, filtered under vacuum, and purified using a long Soxhlet extraction with ethanol. The product is vacuum dried and pulverised in a mechanical mill to produce a homogenous powder.

2.Ultrasound-assisted synthesis

Nanosponges can be made using this process, which involves reacting polymers with cross-linkers in the absence of a solvent and sonication. The nanosponges produced will be spherical, homogenous in size, and less than 5 microns in diameter. The cross-linker in this approach is di-phenyl carbonate (or) pyromelitic anhydride. Place the flask in a water-filled ultrasonic bath and heat it to 90°C. For 5 hours, sonicate the mixture.

3.Emulsion solvent diffusion method

Different concentrations of ethyl cellulose and polyvinyl alcohol can be used to make nanosponges. To optimize drug loading and achieve a customised release, several drug-to-polymer ratios are used. The dispersed phase with drug and polymer dissolved in 20 mL dichloromethane, is slowly added to a specific amount of polyvinyl alcohol in 100 mL of aqueous external phase using a magnetic or mechanical stirrer at 1000-1500 rpm for 3-5 hours. The generated nanosponges are filtered and dried in an oven at 40°C for 24 hours before being placed in a container.

4.Hypercrosslinked β-Cyclodextrin

Cross connecting different types of cyclodextrins (CD's) with a carbonyl or dicarboxylate chemical as a cross linker can produce nanosponges. To optimise drug loading and obtain a customised release profile, the ratio of CD's can be changed during preparation. β –cyclodextrin nanosponges are generated by placing 100 ml of Dimethy Formamide (DMF) in a round bottomed flask and adding 17.42g of anhydrous β -CD to accomplish complete dissolution. The solution is then added to 9.96 g of carbonyl di-imidazole (61.42 mmol) and allowed to react for 4 hours at 100oC. The transparent block of hyper cross linked cyclodextrin is roughly crushed once condensation polymerization is done, and an excess of deionized water is added to remove DMF. Finally, by using Soxhletextraction with ethanol, any left over by products or unreacted chemicals are totally

eliminated. The resulting white powder is dried in a 60°C oven overnight before being ground in a mortar. Water is used to disperse the fine powder that had been obtained. The colloidal part of the solution that remained suspended in water is extracted and lyophilized. The resulting nanosponges are sub-micron in size and spherical in shape. Melt method-In this method, NS are developed by melting polymer and crosslinker together at a specific point of temperature then allowed to cool and the product is recovered by subsequent washing with appropriate solvent. The obtained product is blank NS which is further subjected to encaplutation of the drug.

Bubble electrospinning -

setup are a high-voltage source, a grounded collector, a syringe pump, and a syringe. However, the main issue limiting its usage is the volume of nanofibers produced.17 Polyvinyl alcohol is the polymer that is used in the bubble electrospinning method. A 10% aqueous solution of polymer is formed and heated up to 80 to 90oC for two hours to create a one-phase β-mixture. In the next step, the polymer mixture is permitted to cool at room temperature before being utilized to convert into nano-porous fibers.

Micro-wave radiation assisted synthesis of nanosponges-

As compared to the traditional method, the development of NS by utilizing microwave radiation is the most convenient and time-saving method.31 In this method, NS are formulated in the presence of microwave irradiation which produces a highly crystalline nanoporous structure with improved complexation and maximum encapsulation efficiency in less time.32 It is also advantageous to use the method since it allows for the provision of energy in a precise manner.

Emulsion solvent diffusion method-

Emulsion solvent diffusion is a two-step method that uses polyvinyl alcohol and ethyl cellulose. Ethyl cellulose is dissolved in dichloromethane and then the aqueous solution of polyvinyl alcohol is added to it by keeping the mixture at a magnetic stirrer at a speed of 1000 rpm for two hours.37 After thorough stirring the reaction is completed and NS are collected by filtration and drying at 40oC.38

Quasi-emulsion solvent method-

In this method, different quantities of NS can be developed by using the polymer. Eudragit RS 100 is used to prepare the internal phase and added to a reasonable dissolvable.40 The drug to be incorporated is prepared as a solution and ultrasonicated at 35°C to dissolve it. This inner phase is then added to an external phase that contains polyvinyl alcohol, which acts as an emulsifying agent.41 The mixture is then blended at 1000–2000 rpm for three hours at room temperature before being dried for twelve hours in a hot air oven at 40°C.

Drug Loading in Nanosponges-

NSs are pretreated to obtain a smaller particle size i.e., less than 500 nm, in this manner, NSs are first subjected to sonication to prevent aggregation followed by centrifugation and then freeze drying.In the subsequent step, aqueous suspension of NSs is allowed to be stirred with an excess amount of drug for a specific period of time.44 Once the complexation is completed the free drug is separated by centrifugation and drug-loaded NSs are retained either by solvent evaporation or freeze-drying method.

Application Of Nanosponges -

Nanosponges for drug delivery -

Nanosponges can transport water-insoluble medicines due to their nanoporous properties. Nanosponge can speed up the dissolution of medications, improve their solubility and stability, hide undesirable flavours, and convert liquids to solids. Nanosponges made of cyclodextrin are said to transport drugs to the target place more effectively than direct injection. Nanosponge can be formed into oral, parenteral, topical, or

inhalation dosage forms due to its solid structure. They could be mixed with excipients, diluents, lubricants, and anticaking agents to make capsules or tablets for oral delivery. They can be transported in sterile water, saline, or other aqueous solutions for parenteral delivery. They can be mixed into a topical hydrogel for topical delivery.

Nanosponges for cancer therapy-

Because of their low solubility, anticancer medication distribution is one of the most difficult jobs in the pharmaceutical industry today. According to one study, the nanosponge combination is three times more effective than direct injection in suppressing tumour growth. A specific peptide is firmly linked to a top layer of radiation- induced cells on the tumour receptor after a complex loading of the nanosponge with a medication. When thnanosponges come into contact with a cancer cell, they adhere to its surface and begin to release medication molecules. Targeting medicine administration has the advantage of achieving a more effective therapeutic impact at the same dose with fewer side effects.34

The role of nanosponges in fungal infection treatment-

One of the most serious diseases in the world is fungal skin infections. Topical therapy is a promising therapeutic option for skin infections because it has a number of advantages, including the ability to target medications directly to the infection site and lowering systemic side effects. Itraconazole is an antifungal medicine classified as a class II biopharmaceutical, with a slow dissolution rate and low bioavailability. Itraconazole nanosponges is found to boost its solubility and alleviated the bioavailability problem. The solubility of itraconazole can be increased in these nanosponges if -cyclodextrin is utilised as a carbon cross linked and loaded with itraconazole.

In the treatment of blood poisoining as an absorbent-

By absorbing the toxin, nanosponges can remove the hazardous poisonous chemical from our blood. Instead of utilising antidotes, we can use nanosponges to absorb toxins by injecting them into the bloodstream. The nanosponge imitates a red blood cell in the bloodstream, leading toxins to assault and absorb it.

To improve the poor solubility of drugs-

One of the most important issues to address throughout the design and development of materials is poor solubility. The efficacy of a formulation can be harmed by medication solubility issues. Nanosponge serves as a carrier for molecules, encapsulating them in its core and attempting to improve the formulation's solubility. The current way for increasing solubility is using a –cyclodextrin nanosponge.

Introduction Of Cream -

The word ‘Cosmetic’ derived from a Greek word – ‘kosmesticos’ that means to adorn. From that time any materials used to beautification or promoting appearance is known as cosmetic. The word “cosmetics” actually stems from its use in Ancient Rome. They were typically produced by female slaves known as “cosmetae” which is where the word “cosmetics” stemmed from. Cosmetics are used to enhance appearance. Makeup has been around for many centuries. The first known people who used cosmetics to enhance their beauty were the Egyptians. Makeup those days was just simple eye coloring or some material for the body. Now-a-days makeup plays an important role for both men and women. The importance of cosmetics has increased as many people want to stay young and attractive. Cosmetics are readily available today in the form of creams, lipstick, perfumes, eye shadows, nail polishes, hair sprays etc. Other cosmetics like face powder give glow to the skin after applying the base cream. Then we have lipsticks, which are

applied by many women of all ages. They are made from wax and cocoa butter in the desired amount. Cosmetics like Creams, gels, and colognes are used on a daily basis by both women and men. Creams act as a cleanser for the face in many circumstances. More recently anti-ageing creams have been manufactured which can retain younger looking skin for many years. The best cleansing agents are cleansing cream, soap and water. Cosmetic creams serve as a skin food for hard, dry and chapped skin. It mainly lubricates, softens and removes unwanted dirt from the skin. Some popular fat creams that are used include Vaseline and Lanolin. Dry creams are used in the manufacture of soap and gelatin which is used as a base for the skin. Hair care has become one of the fastest developing markets in the beauty industry. Many young men turn to oils and gels to maintain and style their hair. Products like hair gels, oils, and lotions have been introduced in the market to help protect hair fall and dandruff. Some professions, like the show business industry, focus on the importance of the outer appearance. Many personalities and artists have utilized makeup to beat the harsh lights and the glare of camera flashes. They very well know the importance of their looks and maintain them by using a variety of cosmetics. Recent research has show that makeup helps in protection from harmful rays of the sun. Many beauty products manufacturers have utilized the needs of people to protect themselves and their skin from the rays of the sun. Many beauty products manufacturers have utilized the needs of people to protect themselves and their skin from the rays of the sun. The Importance of Cosmetics Today Cosmetics help to enhance our appearance and make us feel more confident. With more cosmetics on the market today than ever before, it becomes obvious to us that they play a great role in our everyday life. Over the last decades the treatment of illness have been accomplished by administrating drugs to human body via various roots namely oral, sublingual, rectal, parental, topical, inhalation etc. Topical delivery can be defined as the application of a drug containing formulation to the skin to directly treat cutaneous disorder or the cutaneous manifestations of a general disease (eg:-psoriasis) with the intent of containing the pharmacological or the effect of drug to the surface of the skin or within the skin semi-solid formulations in all their diversity dominate the system for topical delivery , but foams, spray , medicated powders, solutions and even medicated adhesive systems are in use. Creams are semisolid dosage forms containing one or more drug substances dissolved or dispersed in a suitable base. This term has conventionally been applied to semisolids that possess a relatively fluid consistency formulated as either water-in-oil (e.g., Cold Cream) or oil-in-water (e.g., Fluocinolone Acetonide Cream) emulsions. However, more recently the term has been limited to products consisting of oil-in-water emulsions or aqueous microcrystalline dispersions of long-chain fatty acids or alcohols that are water washable and more cosmetically and aesthetically acceptable.

Advantages-

- Avoidance of first pass metabolism
- Convenient and easy to apply
- Avoid of possibility
- Inconveniences of intravenous therapy and of the varied conditions of absorption
  like pH changes presence of enzymes gastric emptying time etc.
- Reaching of efficacy with lower total daily dosage of drug by continuous drug
  input
- Avoid fluctuation of drug levels inter-and intra patent variations.

Disadvantages-

- Skin irritation of contact dermatitis may occur due to the drug and / excipients

- Poor permeability of some drugs through the skin
- Risk of allergic reactions
- Can be used only for drugs which require very small plasma concentration for
- action
- Enzyme in epidermis may denature the drugs
- Drugs of larger particle size not easy to absorb through the skin.

Creams-

These are the solid or semisolid preparation which is either an o/w or w/o type emulsion. Creams are preferred to ointment because they are easier to spread and in case of o/w emulsion they are easier to remove. Today, the use of cream cosmetics products has increased tremendously. Human contact to cosmetics formulations and their ingredients occurs primarily via the topical route such as cream and lotion. Several considerations are necessary regarding the appropriateness and safety of cosmetics, because cosmetics preparations are used nearly continually and in direct contact with the skin[33,34,38].

W/O Creams-

These types of creams contain water dispersed in oil phase with help of emulsifier. This type of cream is chosen to ointment because as the water evaporates from the skin the process soothes the inflamed tissue[33,35,38].

O/W Creams:-

O/W creams generally rub into the skin and disappear with little or no trace of their former presence. Hence they are called vanishing creams. On application to skin much of the continuous phase evaporates and increases the concentration of water soluble drug in adhering film. The concentration gradient for drug across the stratum corneum should therefore increase and promote percutaneous absorption. To minimize drug precipitation and to promote drug bio-availability water miscible co-solvent such as propylene glycols, glycerine, ethanol, polyethylene glycols may be incorporated. O/W creams are non occlusive because they do not deposit a continuous film of water imperious lipid. A correctly formulated cream can deposit lipids and other moisturizer on and in stratum corneum and reinstate the tissue ability to hydrates. Creams are semisolid emulsion system that has a creamy appearance as the result of reflection of light from their emulsified phase.

Types Of Creams-

A. Cleansing cream
B. Massage creams
C. Night creams
D. Moisturizing creams
E. Foundation creams
F. Vanishing creams
G. Al lpurpose creams

A. Cleansing cream:-

Cleansing cream is required for removal of facial make up, surface grime, oil, water and oil soluble soil efficiently mainly from the face & throat.

Characteristic of a good cleansing cream:-

1. Be able to effectively remove oil soluble & water soluble soil, surface oil from skin.
2. Should be stable & have good appearance.
3. Should melt or soften on application to the skin
4. Should spread easily without too much of drag.
5. Its physical action on skin & pore openings should be that of flushing rather than

Absorption.

Type of cleansing cream:-

I.) Anhydrous type:-

It contains mixture of hydrocarbon, oils and waxes. It also contains cetyl alcohol, spermaceti, cocoa butter, fatty acid esters etc. Not popular[35,37,39].

Mineral oil.....80 gm,
Petroleum jelly.....15gm
Ozokerite wax .....5 gm
Preservative and perfumes .....q.s

Emulsified type:-

They can be either o/w or w/o type.

Common Ingredients:-

Oil phase.....Spread easily

Waxes.....Give appropriate thixotropy

Emollient material.....likes cetyl alcohol, spermaceti, and lanolin

Water phase with preservative

Different types:-

Cold Cream:-

Cooling effect is produced due to slow evaporation of the water contained in the formulation. These are w/o type.

Beeswax Borax type:-

These contain high percentage of mineral oil. These are o/w type. This cream contains high amount of mineral oil for cleansing action. Basically these are o/w type emulsion. After the cream is being rubbed into the skin satisfactory quantity of water evaporates to impart a phase inversion to the w/o type. The solvent action of the oil as external phase imparts cleansing property. In this type of cream borax reacts with free fatty acids present in the bees wax and produces soft soap which acts as the emulsifying agent and emulsifies the oil phase[27,29,38].

A typical formulation:-

Bees wax .....2 gm

Borax.....2 gm

Almond oil.....50 gm

Rose water .....35.5 gm

Lanolin..... 0.5gm

Preservative and perfume .....q.s

B) Night & massage cream:-

These are generally applied on the skin and left for several hours say overnight and assist in the revamp of skin which has been injured by exposure to various elements or exposure to detergent solution or soap. The mostly have a moisturizing & a nourishing effect of affected skin. These also contain vitamins and hormones basing on the application. This cream gives better look to the skin and prevents dryness.

A typical formulation

Mineral oil.....38gm

Borax 1gm

Petroleum jelly.....8gm

Water 35gm

White bees wax.....15gm

Perfume & preservative..... q.s

Paraffin wax 1.0gm

Lanolin..... 2gm

C) Vanishing cream:-

These are named so as they seem to vanish when applied to the skin. High quantity of stearic acid as oil phase use. This provides an oil phase which melts above body temperature and crystslises in a suitable form, so as to imperceptible in use and gives a non greasy film.

- Main component is emollient esters ,stearic acids
- Part of stearic acid is saponified with an alkali & rest of stearic acid is emulsified
- this soap in big quantity of water.
- The quality of cream depends on the amount of acid saponified & nature of alkali
- used.
- NaOH makes harder cream than KOH.
- Borax makes cream very white but product has tendency to grain.
- Pearliness can be attained using liq.paraffin, cocoa butter, starch, castor oil,
- almond oil.
- Ammonia solution has a tendency to discolor creams made with it after some
- time.
- Cetyl alcohol improves touch and stability at low temperature without affecting sheen

A typical formulation

Stearic acid.....15gm

Glycerin..... 5gm

KOH..... 0.5 gm

Water..... 75.82 gm
NaOH.....0.18 gm
Cetyl alcohol..... 0.50 gm
Propylene glycol.....3.0gm
Preservative &perfume.....q.s
Stearic acid has whiteness like snow so some times the preparation is called as SNOW

D) Foundation cream:-

They are applied to skin to provide a smooth emollient base or foundation for the application of face powder & other make up preparations. They help the powder to adhere to skin. They are almost o/w type[33,26,38].

Types:

1. Pigmented
2. Unpigmented

A typical formulation

Lanolin..... 2 gm
Propylene glycol 8gm
Cetyl alcohol..... 0.50 gm
Water ..... 79.10 gm
Stearic acid 10gm
Perfume &preservative.....q.s
KoH..... 0.40 gm

E) Hand & body cream:-

¸ The repeated or constant contact with soap and detergent damages & removes film of sebum thus this cream is used to impart following functions to the skin.

¸ The function of these creams are

- Reduce Water Loss.
- Provide Oily Film To Protect The Skin.
- Keep The Skin Soft, Smooth But Not Greasy.

Type: -

a. Liquid cream:-consistency is of liquid nature
b. Solid creams: - Consistency is higher
c. Nonaqueous type:-Not containing any aqueous medium[22,27,29].

A typical formulation

a.) Isopropyl myristate ..... 4 gm
Mineral oil .....2 gm
Stearic acid 3.gm
Emulsifying wax .....0.275 gm
Lanolin .....2.5 gm
b.) Glycerin.....3.0gm
Triethanolamine .....1 g
Water .....84.225 gm
Perfume and Preservative ...q.s

(F) All purpose creams:-

All purpose means it is suitable for hands, face and body. They are w/o types[9,11,17].

Formula:-

For oil phase

Mineral oil 18% Petroleum jelly 2% Paraffin wax 3% Ozokerite 7 %
For water phase
Water 61.3%
Glycerol 5%
Magnesium sulphate 0.2%
Perfume, preservative q.s

Nano Cream-

Recent years have drawn increasingattention to the use of topical vehicle systems to help in drug permeation through the skin. Drugs of choice are usually those that are problematic when taken orally, such as piroxicam, a highly effective anti-inflammatory, antipyretic, and analgesic. Nano-cream/semi-solid emulsion falls under the category of topical preparations thatare applied on the outer surface.Nanocream can be prepared by high-energy techniques like ultrasound generators, high-pressure homogenizers or high shear stirring. As a result, they are very useful in composing cosmetics and personal care products due to the small droplets having a particle size in the range of nanoparticle (100–600 nm) thereby permitting uniform and smooth deposition ofthe cream onto the skin surface. This increases the effective release of active drug ingredients on the skin surface contained in the cream in a semisolid basefor the purpose of healing several diseases. Moreover, the semisolid base can be of either nature namely hydrophilic or hydrophobic. Nanotechnology is nothing but the fundamental

study about how materials or particles react or works at the nanoscale (be it at the atomic, molecular or subatomic level) in the development and use of structures, devices, and systems having unique characteristics and purposes. [5] Nanotechnology entered in the field of cosmetics and health products nearly 40 years ago with liposome moisturizing creams. Rising usage of the technology substantiates the enormous future it has for both the industry as well as the consumers. In fact, there are currently a variety of nanomaterials in practice such as nanoemulsions and nanoparticles of naturally occurring minerals namely copper, silver, titanium dioxide, silicon dioxide, alumina, zinc oxide, and calcium fluoride. It is well known that when the drug molecules are transported through the skin, they undergo two processes, starting with the drug penetration through the stratum corneum followed by the drug diffusion method into the deeper tissues. However, various factors such as size, log P, ionic strength, the ability of hydrogen bonding, and physicochemical characteristics of the vehicle govern the rate as well as the degree of the transport of drug through the stratum corneum. Nanomaterials have secured extensive use in the composition hair repairing shampoos, serums and conditioners, creams to heal wrinkles, moisturizing and skin whitening creams.

Advantages-

1. The use of nano cream is aimed to make fragrances last longer, sunscreens more effective
2. and anti-ageing creams.
3. To optimize manufacturing conditions for skincare formulation, a multi-component system.
4. It keeps skin thriving with the help of different constituents that are rich in anti-oxidants.
5. The cream lightens the skin and helps get rid of marks that are a result of unequal
6. arrangement and spread of melanin such as sunspots, age spots, and freckles.
7. It averts the occurrence of grey hair and also plays an important role in medical care
8. given in the case of loss of hair. Additionally, it acts as a preservative to keep lightness
9. and transparency of ingredients namely anti-oxidants as well as vitamins.
10. Another major advantage is that it protects from the harmful effects of the UV radiation
11. in conjunction with other substances called organic sunscreens such as 2- hydroxy-4-
12. methoxy benzophenone. The purpose of organic sunscreens is to facilitate a decrease in
13. the absorption of UV radiation.
14. The most skin brighteners also have anti-ageing effects. Such substances help to beautifythe skin. This keeps the skin looking young and beautiful.
15. Nanomaterials used as UV filters in sunscreen products.

Disadvantages-

People‟s undesirable experiences are based on the skin type and the ingredients found in a specific nano cream. Such undesirable effects could be anything ranging from mild to very serious.

1. Smaller particles have a higher reactivity, are more chemically reactive and produce more
2. significant numbers of reactive oxygen species.
3. Nanoparticles of TiO2that were photo-activated were found harmful to skin fibroblasts and nucleic acids and human colon carcinoma cells.
4. 3. It may cause oxidative stress, inflammation, and subsequent harm to proteins, membranes, and DNA.
5. However, certain ingredients such as hydroquinone, ammoniated mercury and alcohol can be the cause of danger

and result in severe and far-reaching health effects on the body.

6. Besides, ultrafine particles such as dust, coal, silicate, asbestos, etc.if inhaled can pulmonary inflammation. Such happenings can result inpulmonary fibrosis, cytotoxicity and even malignancy.

Methods of Preparation of Nanocreams-

Nanocream/Nanoemulsions can be prepared by using high and low energy methods. In high energy methods, mechanical devices deliver the requisite high disruptive forces. On the contrary, in low energy methods, there is no requirementfor external power. Production of nano cream is achieved by using the intrinsic physiological properties of the system. In this nano cream preparation method, there is stored energy of the system is utilized by alteration of parameters such as temperature, the composition of the system. At the initial studies of nano cream, the high energy methods were the only choice for researches. Thus, high energy stirring and ultrasonic emulsification were the most widely used method for the preparation of nanocream. Nowadays, the low-energy methods have drawn considerable attention since they are „soft", nondestructive and cause no damage to encapsulated molecules.

1. High – Energy Emulsification Method:

Nanocream or nanoemulsions are those non-equilibrium systems that cannot be formed rapidly. For this cause, mechanical or chemical energy input is essential to make them. Nanocream are generally prepared by using high energy methods in which mechanical energy input is applied by high-pressure homogenizers, highshear stirring, and ultrasound generators. The mechanical devices provide strong forces that disrupt oil and water phases to form cream. In high energy methods, input energy density is about 108 -1010 W kg-1. The Required energy is supplied in the shortest time to the system to obtain homogeneous small- sized particles. High-pressure homogenizers have the potential to do this and therefore they are hence extensively for preparation of nanocream.

2. High-Pressure Homogenization-

This is the most popular method used for the production of nano cream. This method offers benefits from the high-pressure homogenizer or the piston homogenizer to manufacture that particle sizes are up to 1 nm. During this method, the macroemulsion is forced to pass through in a small orifice at an operating pressure between 500 to 5000 psi. This process can be again carried out until the final product reaches the required size of the droplet and polydispersity index (PDI). Also, the uniformity of the size of the droplet in such formulations is specified by PDI. Higher PDI indicates a lower uniformity of droplet size as observed in the case of such cream formulations. Monodisperse tests have PDI lower than 0.08, PDI somewhere in the range of 0.08 and 0.3 states a limited size circulation, though PDI more noteworthy than 0.3 shows wide size appropriation. This quantity of energy and rise in temperatures duringthe high-pressure homogenization process might cause deterioration of the components Thermolabile compounds such as proteins, enzymes, and nucleic acids may be damaged.

3. Ultrasonic Emulsification

There are two mechanisms that occur in the process of ultrasonic emulsification. Firstly,theacoustic field makes interfacial waves that make the oil stage to scatter in the nonstop stage as beads. Furthermore, ultrasound incites acoustic cavitation which gives development and breakdown of microbubbles individually because of weight changes of a solitary sound wave. In this way, levels of highly localized turbulence are generated, and this causes micro implosions which disrupt large droplets into sub-micron size. In this method, the premixed blend is disturbed by vibrating strong surface at 29 kHz or bigger

frequencies. High-power ultrasonic gadgets, for example, centering horns and pointed tips cause outrageous shear and cavitation that bring about separating of beads. The advancement of these parameters is important to get ready definitions having fine beads. Be that as it may, there are a few worries about sonication techniques since they can incite protein denaturation, polysaccharide depolymerization and lipid oxidation.

4 Microfluidization-

It is the most widely used method in the pharmaceutical industry to acquire fine particles. In this technique, a device named microfluidizer is utilised thereby offering high pressures. During this process, a high-pressure force applied to the particle interaction chamber and thus small sizes with submicron ranged particles can be produced. Uniform nano cream or nanoemulsion production can be achieved by repeating the process many times and varying the operating pressure to get the desired particle size. There is an impact between rough emulsion planes from two inverse diverts in the spout of microfluidizer which is additionally called the collaboration chamber. The portability of unrefined emulsion is given by a pneumatically fueled siphon that has the ability to pack air up to pressures between 150 to 650 MPa. This high weight powers the unrefined emulsion stream to experience microchannel and after the impact of two inverse channels, colossal degree of shearing power is gotten.

5. Phase Inversion Temperature-

In this method, the temperature is changed at constant composition. Non-ionic surfactants which have temperature-dependent solubility like polyethoxylated surfactants play an essential role. Emulsification is achieved by modifying the affinities of surfactants for water and oil as a function of temperature. During the heating of polyethoxylated surfactants, they become lipophilic because of the dehydration of polyoxyethylene groups. within the PIT method, the droplet sizes and also the interfacial tensions reach their minimum value. it's been reported that stable and fine particles droplets will be produced by the rapid cooling of the emulsion near the temperature of PIT.

6 Phase Inversion Composition-

In this method, the composition is changed at a constant temperature. It is more appropriate for massive production on a bigger scale than the PIT method as the incorporation of an additional substance to an emulsion is simpler than adjusting change in temperature. By adding water to the system, the volume of water increases thereby resulting to reach a transition composition.

Pharmaceuticals applications of Nanocream

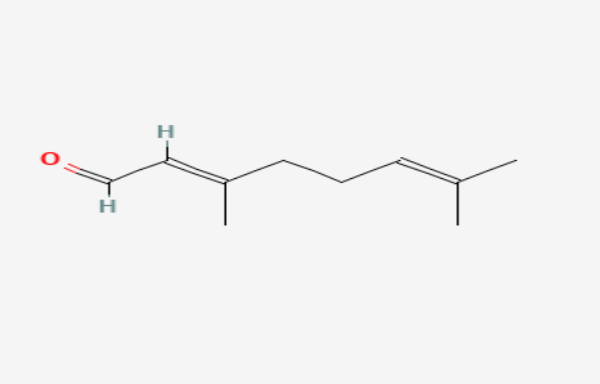
1. Topical applications of drugs are applied with a variety of desired effects, including the targeting of local tissues for a dermatological impact.
2. The commonly used drug in the management of a wide variety of conditions ranging from dermatitis and psoriasis to skin infections to acne.
3. Nanocream also provides a means of sustained delivery and thus minimises the frequency of drug administration.

Composition of lemongrass essential-

Lemongrass essential oil is composed of a variety of chemical compounds that contribute to its aroma, flavor, and therapeutic properties. The primary components typically include:

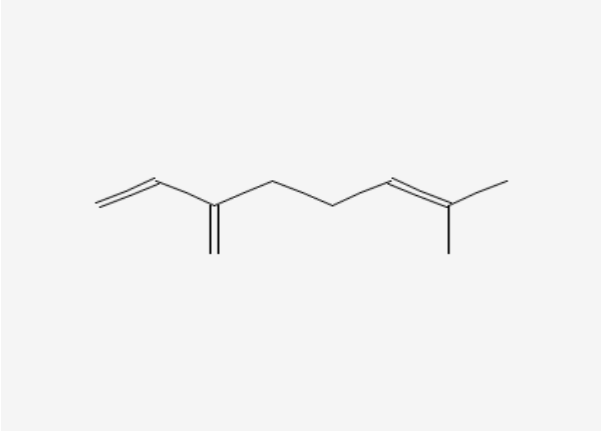
1.Citral- (Geranial and Neral): 70-80%

Citral is the main component and is responsible for the lemon-like fragrance of the oil. It exists as two isomers: geranial (also known as citral A) and neral (also known as citral B)



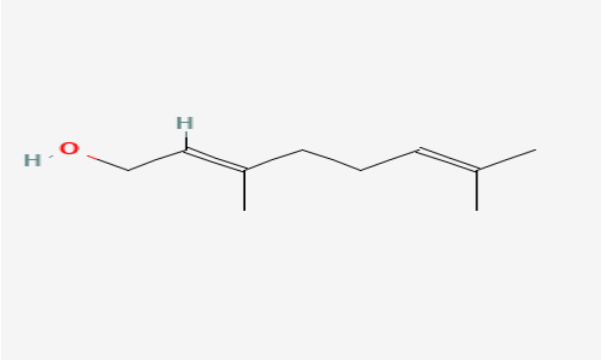
2.Myrcene- 10-20%

Myrcene is a monoterpene that adds a slightly spicy and balsamic note to the oil.



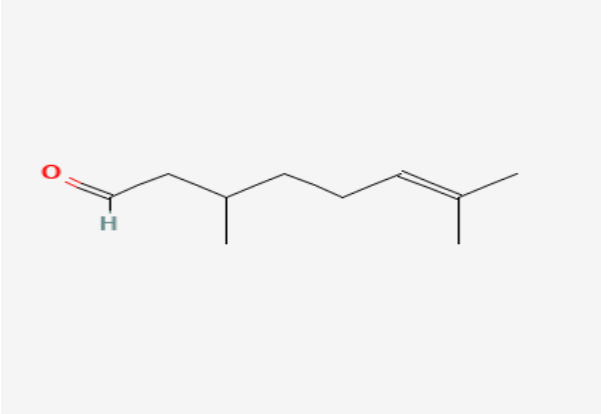
3.Geraniol- 1-5%

Geraniol has a sweet, rose-like scent and contributes to the overall fragrance profile of the oil.



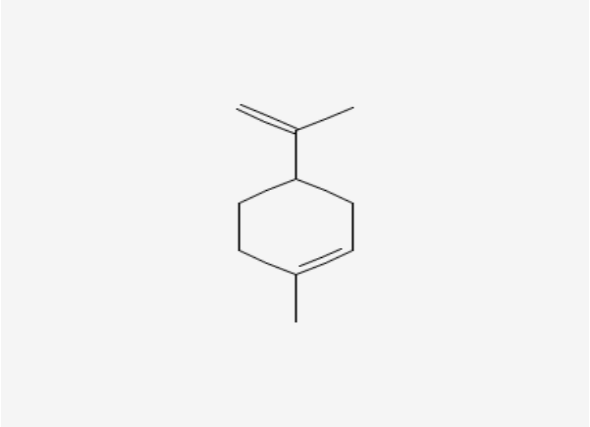
4.Citronellal- 1-4%

Citronellal has a fresh, citrus aroma and adds to the insect-repellent properties of the oil.



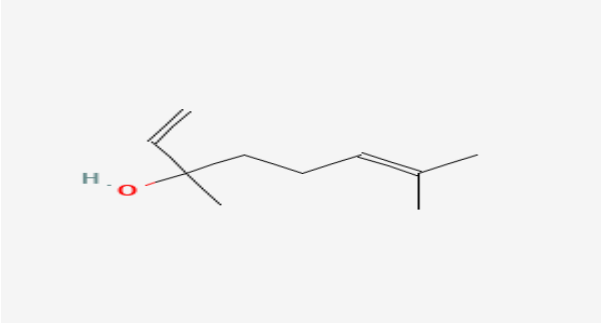
5.Limonene-1-2%

Limonene has a light, citrusy scent and adds to the oil's overall aroma.



6.Linalool- 0.5-1.5%

Linalool contributes a floral, lavender-like fragrance.



Other minor constituents can include:

- Farnesol
- Nerol
- Terpinolene
- Beta-caryophyllene

The exact composition can vary depending on factors such as the geographical origin of the

lemongrass, the method of cultivation, and the conditions under which the oil is extracted

Extraction Methods-

1 .Solvent Extraction Method:

Weigh 150 grams of dried lemongrass sample remove from the sliced lemongrass sample and put in 1 Ignite a clean flat-bottomed flask. 500ml n-hexane solvent was poured into a flask. The flask and contents are allowed to stand for 36 hours; this is done to extract all the oil components in the lemongrass. Then the extract is Pour into another 1-liter beaker. 200 ml ethanol are added to extract essential oils because they are essential the oil is soluble in ethanol. Then mix the mixture Transfer to a 500ml separatory funnel Separation through a process called liquid/liquid

Separation process-

Separated content the funnel is allowed to reach equilibrium, Divided into two layers (depending on their Density is different. Collect the lower ethanol extract and upper hexane into two separate 250ml beakers and place them in a 78 °C water bath. This is done to remove the ethanol from leaving only natural essential oils. Oil production is determined by weighing the extract on an electronic scale Weigh the balance. The difference between the final weight and the initial weight of the beaker containing the extract the weight of the empty beaker gives the essential oil.

2. Steam Distillation Methods:

Put 150 grams of fresh lemongrass sample into 1 lighted round bottom flask with 250 ml of distilled water water. The flask is equipped with a rubber stopper Connect to the condenser and heat. 0 0C water Condensation through the condenser in the countercurrent to ensure steam. When water When it reaches 100 oC, it starts to boil Essential oil from lemongrass. When the lemongrass is heated and the essential oil is extracted from leaves mixed with water vapor. Through the condenser and steam Condensed into liquid. With the use of ice cubes, Make cooling possible and volatilize Avoid using essential oils. Condensate is Use a 500ml beaker to collect directly, and then pour into the separatory funnel. This forms two Oil layer and water layer. Separated faucet Open the funnel to release water, and the oil Collect immediately 100ml stoppered bottle. The bottle is tightly closed to prevent the evaporation of essential oils. Oil is collected Weigh the volume of oil obtained [9].3. Solvent Extraction Methods: Pour 140 g of dried lemongrass sample from sliced lemongrass sample and 200 ml of ether solvent into the flask. Let the flask and contents stand for 18 hours. The extract was decanted into another beaker. 200 ml of ethanol was added to the extract. Separate the mixture in a separatory funnel. Collect the ethanol extract and ether layer into two separate beakers. To remove ethanol, keep the sample in a water bath at 75-80 degrees Celsius. Determine the oil yield by weighing the extract

Fig 4 Steam Distillation Method

3.Hydrodistillation Methods:

Put 500ml distilled water and 140g fresh lemongrass sample into Round-bottomed flask, the flask is equipped with a rubber stopper and connected to the condenser, and heating. Allow water to flow counter currently through the condenser, and heated. Allow water to flow

counter currently through the condenser. After reaching the appropriate temperature, the essential oil, mixed with the water vapor was extracted from the leaves. The oil-water overhead product was skilled the condenser. The vapors were condensed and hence separated. Avoid volatilization by cooling with ice cubes. The condensate was collected using a beaker. Then use a separatory funnel to separate. Immediately collect the oil in the bottle with stopper and close tightly

Microwave assisted extraction -

In the "MAE" whole ("M/s Falcon Microwave Technology, Mumbai, India"), essential lubricant wasderived from lemongrass leaves. The water-saturated plant material ('100 g on a dry support') was stockedin a chalice with a volume of 2 L, in addition to miscellaneous quantities of water.When microwaves are used, water fragments in the containers of leaves endeavor to reorganize themselves,accompanying the magnetic field of currents intensely fast.The upset fragments create plenty of heat anddissolve. The growing vapor aggregation inside the containers causes a rise in pressure against the cell wall ,developing in a container obstruction rupture.Because essential lubricate is volatile, it is evaporated and itmoves with water vapor toward the condenser, that is upheld or maintained above the cavity of microwave .The essential lubricant and water are before being divided and decanted. Oil was dried out and observed at 2strengths Celsius. The MAE unit was fight attack 850 W. Each experiment was recurring three periods., and therefore retained at 290 °C for 2.5 record; and the ionization fad, photoelectric impact at '70 eV'.

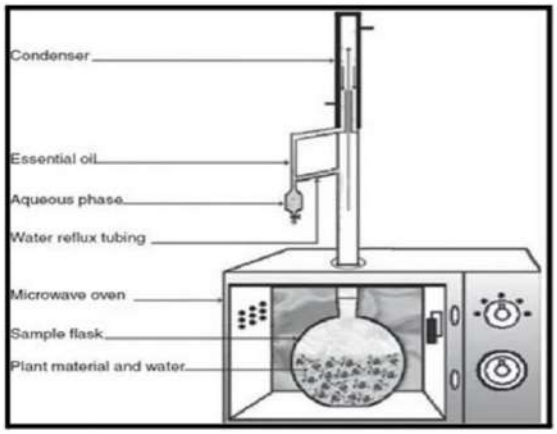


Fig. 5 : Microwave assisted hydrodistillation[41]

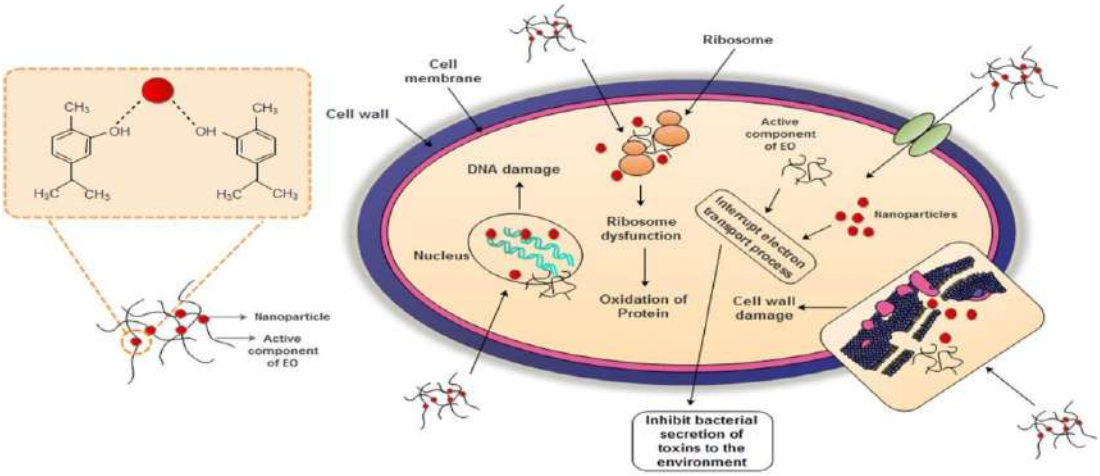
4.Ultrasound Extraction-

(Sonication)According to Sukhdev et al. (2008), ultrasound extraction procedure involves the use of ultrasound with frequency range of 20 kHz - 2000 kHz. This method is function of frequency. Ultrasound-assisted extraction is recommended to accomplished vital valuable compounds. This technique was developed in 1950 (Vinatoru, 2001). In ultrasound extraction as shown in Figure 6, the plants raw materials are immersed in solvent like water, methanol or ethanol and then subjected to ultrasound. This technique has also been featured as worthful technique in food and plants processing (Bhaskaracharya et al., 2009).4.9. Simultaneous-distillation-extraction technique (SDE)In this method, the combination of either hydro-distillation and or steam distillation with solvent extraction is utilized. This technique is mostly used for isolation of volatile constituents from oils bearing plants. Solvent of choice must be indissoluble in water as well possess high purity. Simultaneous distillation process has been modified into several variants with the consideration of efficiency, scale and quality of end-products. The technique uses less solvent; eliminate excessive thermal degradation and dilution of extract with water. The only disadvantage is that, it introduces artifact into the extract as well loss of compounds that have strong affinity for wate

Antibacterial Activity-

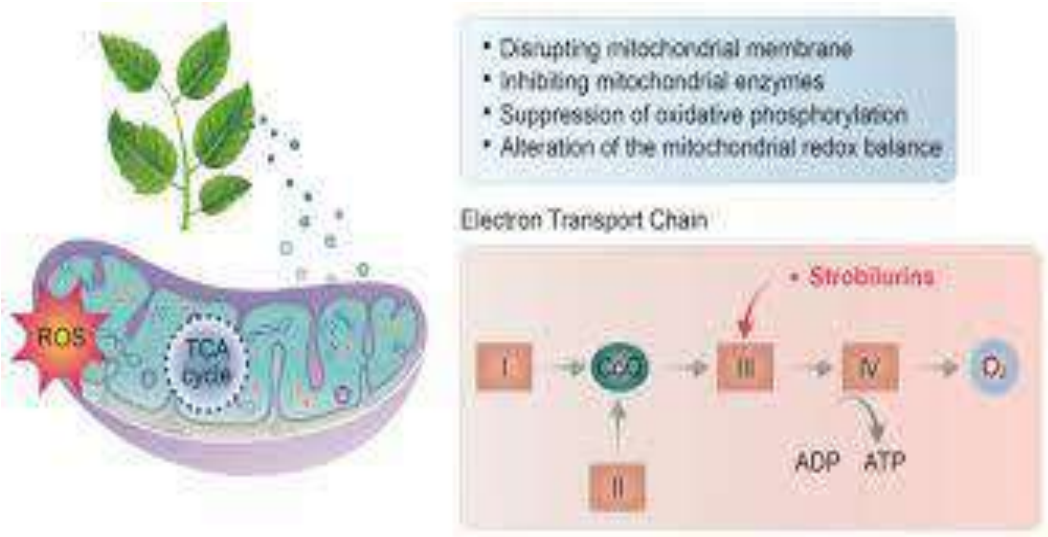
The antibacterial characteristic of LEO is well established [18,40,49,50,51,52,53]. It has been suggested that LEO induces the destruction of bacterial biofilms and hinders further bacterial growth and development [54]. Furthermore, LEO components can destabilize the bonds between the lipid bilayer and neutralize the bacteria through membrane disintegration [55]. LEO can confer structural changes, as well, in different bacteria. It was reported to cause complete disfiguration and distortion in the Pseudomonas spp. [56]. The MIC values for LEO and citral against P. aeruginosa were calculated as >40% and 10%, respectively. Furthermore, LEO blocks biofilm formation in bacterial colonies [54], for example, 0.125% (v/v) of LEO can restrict biofilm formation in methicillin-resistant Staphylococcus aureus strains [57]. It can disrupt the cell membrane and inhibit cytoplasmic metabolism, making LEO effective against both Gram-negative and Gram-positive bacteria [34,49,55]. Cymbopogon khasianus essential oil inhibited the growth of Escherichia coli with the MIC and MBC (Minimum Bactericidal Concentration) values of 20 µg/mL each. It can also retard the growth of Bacillus subtilis, Salmonella enterica typhimurium, Staphylococcus aureus, Klebsiella pneumoniae with a MIC range of 25–50 µg/mL [47]. Multiple recent studies against MDR (multidrug-resistant) bacteria [58,59] show that, while a low concentration of LEO retards growth and biofilm formation, a higher concentration can confer complete elimination of Salmonella Heidelberg.

The bacteriostatic and bactericidal characteristics of LEO primarily depend on the bacteria and oil concentration [60,61]. However, several other factors, such as oil composition, extraction method, plant developmental stage, and environmental variables including temperature can influence the oil's effectiveness. Therefore, lemongrass oils from different species might exhibit effects of different nature and intensity. Nevertheless, the host organism can also decide oil effectiveness to a certain extent depending on its morpho-physiological attributes [62]. Therefore, EOs react differently with Gram-positive and Gram-negative bacteria, owing to their dissimilar cell-wall structures [60,63]. Costa et al. [64] examined Cymbopogon flexuosus EO (µL mL−1) against Listeria monocytogenes, Staphylococcus aureus, and Salmonella typhimurium and determined their MICs and MBCs as of 3.9 µL mL−1 each. The MICs of citral against Cronobacter sakazakii strains ranged from 0.27 to 0.54 mg/mL. Scanning electron microscopy analysis further confirmed that C. sakazakii cell membranes were damaged by citral [65]. Table 2 traces the efficacies of lemongrass essential oils against various gram positive and gram negative bacteria.



Antifungal Activity-

The antifungal activity of LEO has been reported against multiple fungi. Volatiles from lemongrass oil, such as phenols, flavonoids, and flavones, are effective against numerous fungal strains.Helal et al. reported that LEO caused plasma membrane disruption and disorganization of mitochondria and resulted in Ca2+, K+, and Mg2+ leakage. The loss of ions can further affect signal transduction and fungal germination. Moreover, Alviano et al. [74] observed that LEO components induce cell size reduction and inhibit the spore germination in Candida albicans. LEO can directly act upon the fungal lipid bilayer owing to its readily volatile and lipophilic nature. It can form a charge–transfer complex with the lipid bilayer, destabilizing the membrane and inhibiting further membrane synthesis, and retards fungal spore formation and cellular respiration. Boukhatem et al. found that the vapor form of LEO inhibits mycotic growth and development more effectively than the liquid phase, probably because of the direct accumulation of LEO vapors on fungal mycelium. In this regard, Table 3 depicts the MIC values of EOs obtained from different Cymbopogon species against various fungal strains.The efficacy of essential oils obtained from different lemongrass species against some common pathogenic fungi. MIC, minimum inhibitory concentration.



LEO components including citral, geraniol, myrcene, limonene, and linalool, have significant antifungal activity. Geraniol increases the outward leakage rate of potassium ions, while citral damages the microtubules and exhibits cytotoxicity in fungi . Linalool, a monoterpene alcohol, comprises numerous fungicidal properties. It retards the overall development and propagation of different fungi through the respiratory restriction of their aerial mycelia Additionally, other aldehydes of LEO can confer antimycotic activity through cross-linkage reaction within the fungal membrane. EOs can remain effective for a longer duration against fungal spore production, ensuring improved shelf life for food products.It was also suggested that lemongrass oil induces reactive oxygen species (ROS) production in fungi and afflicts severe oxidative damage that leads to subsequent cellular death. This can also enable EOs as a sustainable alternative in the food preservation and packaging industries. Edible coating of EOs, including LEO on stored fruits, meat, and dairy products, discourages fungal attack and food spoilage through restricting fungal growth and reproduction. The edible coatings of EOs have increased antimicrobial potential over the free EOs due to their altered surface charge and amplified action on multiple target sites in the mycotic membrane.This extends edibility and maintains physicochemical qualities, including the tastes and odours of such products.However, different EOs have different antimicrobial mechanisms, and thus acquisition of resistance by microbes against the wide array of compounds in EOs is rare.

REFERENCES

1. Alka Sing, et al, (Oct 2023). International Journal Of Pharmaceutical Quality Assurance & Pharmaceutical Analysis. Nanosponges-A Versatile Apporoach of Drug Delivery System.14,1246-1255.
2. Verma S, et al. (Sep 2023). Biomedical and Pharmacology Journal . Nanoparticles-A Booming Drug Delivery System in Chemotherapy.l;16(3):1785-90.
3. Tiwari K, et al. (Mar2022). Journal of Materials Science: Materials in Medicine .The ascension of nanosponges as a drug delivery carrier: Preparation, characterization, and applications;33(3):28.
4. Jain A,et al .(Jun 2020). Journal of drug delivery science and technology. Engineered was versatile biodegradable carriers: An insight. 101643
5. Tannous M ,et al. (Mar 2020). Nanosponges for combination drug therapy: State-of-the-art and future directions. Nanomedicine. 15(07):643-6.

6. Pawar S, et al, (Jun 2019). International Journal of Pharmaceutics.Diversity of β-cyclodextrin-based nanosponges for transformation of actives.30:333-50.
7. Anwar W, et al. (2019). Universal Journal of Pharmaceutical Research. Screening study for formulation variables in preparation and characterization of candesartan cilexetil loaded nanostructured lipid carriers; 4(6): 8-19.
8. Patra JK, et al .(Dec 2018). . Journal of Nanobiotechnology. Nano based drug delivery systems: recent developments and future prospects.16(1):1-33.
9. Mishra R,et al .(Nov2018). Nature, nanoscience, and textile structures. Nanotechnology in Textiles: Theory and Application.
10. Alka S. (2017). World Jornal of Pharmacy and Pharmaceutical Sciences. Development and evaluation of cyclodextrin based nanosponges for bioavailability enhancement of poorly bioavailable drug; 6:805-36.
11. Wadekar Pradnya Pradeep, et al. (2017). Universal Journal of Pharmaceutical Research . A review on gold nanoparticles synthesis and characterization; 2(4): 65-69.
12. Desai MA, et al, (2015), Extraction of essential oil from leaves of lemongrass using microwave radiation: optimization, comparative, kinetic, and biological studies, ACS Sustainable Chemistry & Engineering, 3, 421-431.
13. Avoseh O, et al, (2015), Cymbopogon species; ethnopharmacology, phytochemistry and the pharmacological importance, Molecules, 20, 7438-7453.
14. Chime, S.A.et al, (2014). Nanoemulsions-Advances in Formulation, Characterization and Applications in Drug Delivery, Ali DS, Application of Nanotechnology in Drug Delivery, Crotia: In Tech; 77-111.
15. 15.Ekpenyong CE, et al, (2014). Journal of Pharmacognosy and Phytochemistry. Phytochemical constituents, therapeutic applications and toxicological profile of Cymbopogoncitratus Stapf (DC) leaf extract, 3,133-141.
16. Halabi MF, et al, (2014). BioMed Research International. Anti-proliferative effect and phytochemical analysis of Cymbopogoncitratus extract, 1-8.
17. Boukhate , et al ,(2014)." Libyan Journal of Medicine. "Lemongrass (Cymbopogon citratus) essential oil as a potent anti-inflammatory and antifungal drugs, 9(1), 25431.
18. AH NA, Zaibunnisa AH, etal, (2013). International Food Research Journal. An experimental design approach for the extraction of lemongrass (Cymbopogoncitratus) oleoresin using pressurized liquid extraction (PLE), 451-455.
19. Garg D, et al, (2012). Research Journal of Pharmaceutical, Biological and Chemical Sciences. Comparative analysis of phytochemical profile and antioxidant activity of some Indian culinary herbs, 3, 845-854.
20. Joshua AA, et al, (2012), Journal of Medical Sciences, Comparative studies on the chemical composition and antimicrobial activities of the ethanolic extracts of lemon grass leaves and stems, Asian 4, 145-148.
21. Mirghani MES, et al, (2012). International Food Research Journal. Bioactivity analysis of lemongrass (Cymbopogancitratus) essential oil, 19, 569-575.
22. Garg D, et al, (2012). Research Journal of Pharmaceutical, Biological and Chemical Sciences. Comparative analysis of phytochemical profile and antioxidant activity of some Indian culinary herbs, 3, 845-854.
23. Lovelyn, C.et al. (2011), Journal of Biomaterials and Nanobiotechnology.

Current State of Nanoemulsions in Drug Delivery ; 2: 626-639.

24. 24.Tyagi, A. K., et al, (2010)."Antimicrobial potential and chemical composition of lemongrass (Cymbopogon citratus) oil against food-borne pathogens and spoilage microorganisms." International Journal of Food Microbiology, 144(1), 75-80.
25. Fagbohun ED, et al, (2010), International Journal of Pharmaceutical Sciences Review and Research. Chemical composition and antibacterial activities of some selected traditional medicinal plants used in the treatment of gastrointestinal infections in Nigeria, 5, 192-197.
26. Asaolu MF, et al, (2009). Pakistan Journal of Nutrition.Chemical compositions, phytochemical constituents and in vitro biological activity of various extracts of Cymbopogon citratus, 8, 1920-1922.
27. Oloyede OI, (2009). Journal of Natural Products, Chemical profile and antimicrobial activity of Cymbopogoncitratus leaves,2, 98-103.
28. Asaolu MF, et al, (2009). Pakistan Journal of Nutrition.Chemical compositions, phytochemical constituents and in vitro biological activity of various extracts of Cymbopogon citratus, 8, 1920-1922.
29. Oloyede OI, (2009). Journal of Natural Products, Chemical profile and antimicrobial activity of Cymbopogoncitratus leaves,2, 98-103.
30. Marongiu B, et al, (2006), Natural Product Research, Comparative analysis of the oil and supercritical CO2 extract of Cymbopogon citratus Stapf, 20, 455-459.
31. Jafari, S.M. et al. (2006), International Journal of Food Properties. Nanoemulsion production by sonication and microfluidization: A comparison; 9: 475–485.
32. Koul VK, et a, (2004), Indian Journal of Chemical Technology, Steam distillation of lemon grass (Cymbopogon spp.), 1, 135-139.
33. Akhila, A , et al, (1984) . Indian Journal of Pharmaceutical Sciences . "Antimicrobial activity of essential oil of Indian lemongrass.", 46(5), 192-194.
34. Onawunmi, G. O.et al. (1984). Journal of Ethnopharmacology. "Antibacterial constituents in the essential oil of Cymbopogon citratus.", 12(3), 279-286
35. Mishra, A. K.et al, (1994). Applied and Environmental Microbiology. "Evaluation of some essential oils for their toxicity against fungi causing deterioration of stored food commodities.", 60(4), 1101-1105.
36. Hammer, K. A.et al. (1999). Journal of Applied Microbiology. "Antimicrobial activity of essential oils and other plant extracts .86(6), 985-990.

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