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REVIEW ARTICLE

TITLE:

ANTIBACTERIAL AND ANTIFUNGAL COSMETICS: A NANO TECHNOLOGICAL APPROACH

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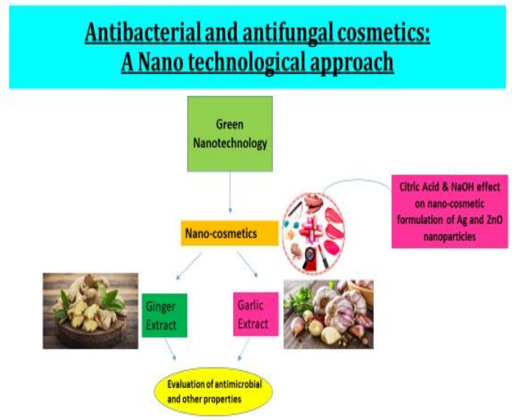
ANTIBACTERIAL AND ANTIFUNGAL COSMETICS: A NANO TECHNOLOGICAL APPROACH

Abstract:

Green nanotechnology has emphasized green chemistry concepts, and the principles of green Chemistry approach has been instrumental in the creation of modern nanotechnologies for economic, social, and health advantages. Nanotechnology has potential applications in nanocosmetics. This review contains a description of the green synthesis, characterization of silver and zinc oxide nanoparticles synthesized using ginger and garlic extract and their applications in cosmetic formulations. Ginger and garlic extract possess strong antioxidative and antimicrobial properties. Citric acid serves as reducing and stabilizing agent in synthesis of nanoparticles. Concentration of NaOH also influence the size and structure of nanoparticles. The present review present various studies for synthesis of antibacterial and antifungal properties of Ag and ZnONPs. In cosmetic formulations, silver nanoparticles can be safely used in preparations of anti-acne, anti-dandruff, and antimicrobial products which are discussed in the present review. ZnO-NPs are commonly used to treat a number of different skin disorders and have anticancer characteristics. These are nontoxic, skin compatible, antimicrobial and have broad application in cosmetic industry.

KEYWORDS: cosmetics, nanoparticles, iron nanoparticles, zinc oxide nanoparticles, ginger extract, garlic extract.



1.0 Introduction:

Nanotechnology is a vital area of modern science that deals with the synthesis, techniques, and modification of particle structures ranging in size from 1 to 100 nanometers. Due to their entirely new and advanced properties based on size, shape, dispersion, and structure, applications of nanoparticles and nanomaterials are rapidly growing on numerous levels. It is rapidly gaining prominence in a wide range of industries, including health care, cosmetics, food and feed, drug-gene distribution, climate, health, biomedical, mechanics, optics, and chemical industries **(Ahmed, Ahmad, Swami, & Ikram, 2016).**

Green nanotechnology has expanded on the field of green chemistry, and the principles of Green chemistry paradigm has played an important role in the creation of new nanomaterials for combined economic, social, health and environmental interest **(Hutchison, 2008)**. Green nanotechnology focuses on the creation of innovative and sustainable technologies for obtaining nanoparticles, assembling them locally, and integrating them into productive devices and services in a cost-effective, simplistic, and environmentally sustainable. Green synthesis methods can efficiently handle a number of Nano toxicology and hazard problems and challenges. Green synthesis nanomaterials have the same qualities as their chemical counterparts, and one of their properties can be influenced by altering reaction parameters such as temperature and pH (**Abdelaziz et al., 2013**).

In the formulation of cosmetics, nanosized materials are widely used in pharmaceutical industry(**S. Raj, Jose, Sumod, & Sabitha, 2012**).

Currently, there are about 600 nanotechnology based consumer goods in the market from manufacturing companies. Nanotechnology yielded $30 billion of manufactured goods last year (a figure projected to rise to $2.6 trillion by 2014), and the National Science Foundation predicts that the nanotechnology industry will continue to hire more than 2 million people by 2015 (**Guix et al., 2008**). Nanomaterials have properties that boost existing cosmetics formulas, or at the very least the quality of the product **(Oberdörster, Oberdörster, & Oberdörster, 2005)**.

Phytochemical tests show that lupeol, oleanolic acid, ursolic acid, sitosterol, leucocyanidin, rutin, anthocyanins, proanthocyanidins, glucosides, kaempferol and quercetin are present in the plant and its metabolites. According to pharmacological research, the plant has anti-oxidant, gastro protective, antibacterial, hepatoprotective, and chemopreventive properties **(Baliga & Kurian, 2012).** Since numerous attempts in the field of nanoparticle synthesis have been done using various methods, biological synthesis is the latest and advanced approach due to its low cost, reduced chemical use, and increased yield **(Raliya & Tarafdar, 2013).**

NPs may seem to be a novel concept in the cosmetics industry. As a result, it is questioned whether sunblock and toothpaste are healthy these days. While the ancient Greeks and Romans were unaware of nanotechnology, they used it in their cosmetics **(Walter et al., 2006).** Nano emulsions, also recognized as submicron emulsions (SME), are the most versatile nanostructured systems for cosmetics. They are systems of standardized and incredibly small particles size. They are incrementally used in cosmetics. Nowadays, different approaches such as nanocarrier expansion, nanomedicine revolution, antioxidant usage, and other revolutionary techniques are most often used in the cosmetics industry to reduce environmental hazards **(Qushawy & Nasr, 2020).**

Plant extracts can be used to synthesize nanoparticles rather than using a harmful capping, reducing, or stabilizing agent. It enables nanoparticles to be synthesized in a cost effective, environmentally sustainable, and non-toxic manner. This environmentally friendly approach prevents the formation of toxic waste product which could be harmful to the ecosystem **(Philip, Unni, Aromal, & Vidhu, 2011).** Present review article discusses the properties of ginger and garlic extracts for synthesis of different nanoparticles that are used in cream.

1.1 Properties of ginger:

Ginger root, also known as ginger, is the rhizome of the plant *Zingiber officinale*, which has been used since over 2,000 years **(S. Khan et al., 2016)**. Ginger's most pungent properties are comprised of 6-gingerol and its derivatives, which are commonly used for medicinal purposes **(Rai, Yadav, & Gade, 2009)**. Antimicrobial, antifungal properties, and many pharmaceutical properties, has been described for gingerol related components. Alkaloids, flavonoids, zingiberene, shogoals and gingerols are among the bioactive constituents in ginger, and also possess antioxidant properties **(Butt & Sultan, 2011)**.

Ginger extract biomolecules play important role in the reduction of silver ions (Ag^{+}) to metallic AgNPs (Ag^{0}). In ginger extract, presence of phenolic compounds, proteins and terpenoids, reduce NP aggregation and improve stability by covering them. The stability of the nanoparticles can be improved using ginger extract (Velmurugan et al., 2014). According to recent studies, ginger contains over 400 different compounds, including carbohydrates, lipids, phenolic compounds and terpenes. Many of these phytochemicals are thought to contribute to ginger's antioxidative, anti-inflammatory and antimicrobial properties **(Prasad & Tyagi, 2015)**.

Ginger contain minerals (Na, Ca, Fe, P, K, Zn, Cu, Mn and Mg) by concentrations of 50, 257.6, 34.6, 125.6, 2150, 0.4, 0.01, 0.02 and 50 ppm **(Meriga, Mopuri, & MuraliKrishna, 2012)**.

Table1: Mineral content of ginger

Minerals	Concentration(ppm)
Na	**50**
Ca	**257.6**
Fe	**34.6**
P	**125.6**
K	**2150**
Zn	**0.4**
Mn	**0.02**
Mg	**50**

1.2 Stages of formation of silver nanoparticles:

There are basically four stages by which silver nanoparticles are synthesized from garlic extract as shown in figure 1. These stages include:

i-Nucleation ii-Condensation iii-Surface reduction iv-Stabilization.

1.2.1-Nucleation:

In a solution consisting of Ag+ ions of $AgNO_3$, oxalic acid ($C_2H_2O_4$) and ascorbic acid ($C_6H_8O_6$) found in ginger undergoes reduction process. Chemical reduction induces electron transfer, resulting in the conversion of Ag+ ions to Ag and particle's nucleation.

1.2.2-Condensation:

More Ag nanoparticles are present during this stage, allowing them to condense into larger particles.

1.2.3-Surface reduction:

The layer of reducing agents such as oxalic acid and ascorbic acid bind to the particles quickly as they are produced, due to presence of the electrostatic force of attraction of the ginger extract.

1.2.4-Stabilization:

With reducing agents, other elements are also present in ginger extract as zingerones ($C_6H_8O_6$) and phenylpropanoids. Zingerone($C_6H_8O_6$) organizes around the layers of reducing acids and serve as barrier for the stability of Ag nanoparticles (Singh, Sadasivam, & Rakkiyappan, 2021).

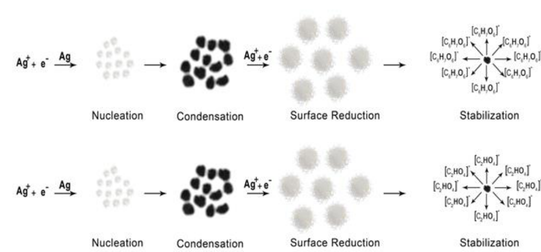


Fig 1: Stages of formation of AgNPs from ginger

2.0 Properties of garlic:

Antimicrobial and antioxidant properties of garlic (*Allium sativum*) have been reported. Garlic contains secondary metabolites such as allyl disulfide and allyl cysteine which provide protection against free radical damage**(Chung, 2006).** The sulfur compounds are the most significant chemical constituents reported from Alliums. More than 82 percent of the overall sulfur content of garlic is believed to be made up of cysteine sulfoxides and non-volatile glutamyl cysteine peptides. Allicin and sulphur-containing compounds such as diallyl sulphide (DAS) and diallyldisulphide (DADS), which have antitumor and antioxidant properties, are key elements of garlic **(Kaschula, Hunter, & Parker, 2010)**.

Garlic's organo sulphur compounds scavenge free radicals and also retard the growth of bacteria through connections with sulphur containing enzymes. Garlic exhibited strong reactions against *Salmonella typhi*, and *Staphylococcus* aureus and *Escherichia coli* **(Gull et al., 2012)**.

Fresh peeled garlic contain moisture (62.8%), carbohydrates (29%), protein (6.3%),minerals (1%), and fat (0.1%).Garlic powder contains carbohydrates (71.4%), protein (6.3%),moisture (5.2%), fiber (1.9%),and fat (0.6%).Garlic possess strong antibacterial and antifungal properties (Panpatil, Tattari, Kota, Nimgulkar, & Polasa, 2013). Mariam and Devi described that Moisture 3.91, crude fiber 1.73, protein 19.75, fat 0.49, Energy 348.85 k cals/100 g, Volatile oil content on dry basis 0.49 and Carbohydrate 66.36 g/100 g were the chemical composition of garlic **(A. A. El-Refai, G. A. Ghoniem, A. Y. El-Khateeb, & M. M. Hassaan, 2018).**

Table 2: Chemical composition of fresh and dried garlic

Elements	Fresh garlic (%)	Dried (powder) garlic (%)
Carbohydrate	29	71.4
Protein	6.3	6.3
Moisture	62.8	5.2
Fiber	0.3	1.9
Fat	0.1	0.6
Mineral	1	0.2

3.0 Synthesis of silver nanoparticle using ginger and garlic extract:

Stable and monodisperse silver nanoparticles were synthesized using garlic extract. Liu and Hurt demonstrated that enhancing the concentration of a capping agent (citrate) in solution or changing the pH of silver nanoparticle aqueous solution decreased oxidation and resulted in lower Ag+ release in biological materials **(Liu & Hurt, 2010).** During nanoparticle synthesis, Garlic extract acts as a silver salt reducer and post synthesis stabilizing ligand. By altering the synthesis parameters it is possible to control particle size, surface morphology, and particle composition kinetics. Allicin and several other carbohydrates present in the garlic extract are the central nanoparticle stabilizing subunits, confirmed by infrared spectroscopy, energy dispersive X-ray chemical analysis, and high-performance liquid chromatography. Synthesized silver nanoparticles exhibit potential for biomedical implementation because of resistance of nanoparticles to oxidation in the presence of H_2O_2, improved flexibility in metal ions, and inadequacy of harmful chemicals necessary for synthesis **(Von White et al., 2012)**.

Metal nanoparticles including silver, zinc, copper, and iron were synthesized using ginger and garlic extract. Due to collaboration of different categories of phytochemicals including the phenolics and flavonoids , the effectiveness of garlic and ginger extracts in the formation of stable nanoparticles offers a wide range of fascinating and worthwhile properties **(S. Kumar & Pandey, 2013)**. Synthesized nanoparticles were characterized by using TEM (Transmission Electron Microscope) and UV-vis spectroscopic analysis. Monodisperse nanoparticles have particle size of 10.10–18.33 nm. Maximum absorption peak was recorded at 280nm. The rich content of flavonoid and phenolic of ginger and garlic extracts confirmed by phytochemical analysis strengthens garlic and ginger's capacity to bioreduce Ag^{+}, Zn^{2+}, Cu^{2+}, and Fe^{3+} ions to AgNPs, CuNPs, FeNPs, and ZnNPs, respectively.Ag and Zn nanoparticles exhibited strong antibacterial activity against *Klebsiella pneumonia*. Silver nanoparticles are made up of silver atoms (Ag) that are larger than silver ions (Ag^{+}), allowing for more molecules to be involved in the reaction, resulting in increased antimicrobial activity **(Batarseh, 2004).** Gram +ve bacteria (*B. subtilis and S. aureus*) and Gram -ve bacteria (*E. carotovora, P. vulgaris, and K. pneumonia*) were examined with synthesized nanoparticles for antibacterial testing. Gram positive AgNP have the highest anti-Erwinia carotovora activity. Gram positive AgNp showed strong activity against Proteus vulgaris (PV), gram positive AgNP exhibited activity against *Klebsiella pneumoniae* (KP), and gram positive AgNP has highest activity against Bacillus subtilis (BS) **(Ahmed A. El-Refai et al., 2018)**.

Silver nanoparticles were synthesized from ginger root extract. The slow reduction process of Ginger root extract has been demonstrated by the analysis of non-uniform particle size in the initial stage of reaction and the continuous emergence of uniform size in the later phases. Stabilization and chemical reduction of Ag nanoparticles are driven by polyol (oxalic/ascorbic acid) and heterocyclic constituents of the root extract. 400nm of maximum absorption peak was measured using UV-Vis (Ultra Violet Visible) spectrometer. Ginger roots are composed of oxalic acid, ascorbic acid and heterocyclic constituents as vanillyl acetone ($C_{11}H_{14}O_3$) **(Bao, Deng, Li, Du, & Qin, 2010).** AFM image showed that these constituents were encircled around the particle. Slow reduction process observed in ginger extract but as time passes Ag+ ions interfere with the reducing agent, resulting in a greater number of nanoparticles with greater size stability. Synthesized nanoparticles exhibited strong antibacterial effect against E.coli strains **(Singh et al., 2021).**

Silver nanoparticles have slower reaction dynamics and can manipulate crystal growth and control suspension stability more easily. Green synthesis techniques of nanoparticles do not comprise any poisonous chemicals that could damage humans so they are appropriate for biomedical and pharmaceutical applications **(Hutter & Fendler, 2004).** The reports submitted by K.P Kumar et al showed that silver nanoparticles were synthesized using *Zingiber officinale* extract. Nanoparticles were characterized through UV-Visible spectrophotometer, DLS (Dynamic light scattering), TEM (Transmission Electron Microscope), FT-IR(Fourier Transform Infra Red Spectroscopy) and AFM (Atomic Force Microscopy). Synthesized nanoparticles were ranging from 6-20nm.FT-IR showed maximum absorption at 1,631.6 cm−1 which represented the stretching vibrations of alkanes (–C=C). 1,151 cm^{-1}, 1,033 cm^{-1} represented the stretching vibrations of –C=O, and other peaks were at 603, 1,190, 813, 850, and 723 cm^{-1} which were strongly demonstrating the heterocyclic compounds. Synthesized nanoparticles were highly compatible with blood and were able to be used as vectors for drug delivery, gene delivery, and bioimaging **(K. P. Kumar, Paul, & Sharma, 2012).**

3.1 Antibacterial properties of biosynthesized silver nanoparticles:

Silver chelation protects DNA from unfolding. Silver nanoparticles are made up of silver atoms (Ag) and have larger size than silver ions (Ag+) therefore many more molecules involve in the reaction and increase antimicrobial activity (Batarseh, 2004).The use of plant extracts in combination with sunlight to reduce Ag+ ions through silver nitrate provides an efficient, sustainable, cost effective, and energy saving AgNPs synthesis procedure **(Prathna, Chandrasekaran, Raichur, & Mukherjee, 2011)**.

Silver nanoparticles were synthesized using ginger extract in presence of sunlight. Different techniques were used to characterize the synthesized nanoparticles including FT-IR, UV-vis spectroscopy, XRD and TEM. Size range of synthesized nanoparticles was from 4 to 15nm. Antibacterial activity was examined against Staphylococcus aureus and *E.coli*. Through MIC and MBC, AgNPs' bactericidal properties were assessed. The MIC is the silver nanoparticle's smallest concentration that inhibits the growth of organisms. The MBC value is the concentration that could kill 99.9% of the bacteria in the final culture medium **(Zhou et al., 2016)**. Synthesized nanoparticles displayed strong antibacterial activity for *S. aureus*, MIC and MBC value was estimated 62.5 mg/mL and 500 mg/mL and for *E.coli*, both values were 125 mg/mL and 250 mg/mL, accordingly **(Mathew, Prakash, & Radhakrishnan, 2018).**

The implementation of quick, environmentally sustainable preparations of nanoparticles is highly beneficial to use as it contains nontoxic reagents (Dhand et al., 2015). For the synthesis of silver nanoparticles, several approaches have been used. Biocompatible strategies using organic ingredients such as micro or marine organisms, proteins, and plant extracts (PEs) have become common (Ag NPs) **(Khan, Zahoor, Jalal, & Rahman, 2016**). Various studies on the antibacterial, antifungal, and antimicrobial properties of Ag NPs derived from various plant extracts have been published **(Amooaghaie, Saeri, & Azizi, 2015).**

Silver nanoparticles were synthesized using two separate extracts of *Nigella sativa* and *Zingiber officinale.* synthesized nanoparticles were characterized using XRD, EDX, TEM and UV-vis spectroscopy. Nanoparticles synthesized using Nigella sativa L. seed extract (NSE) were of 8nm and NPs synthesized using ginger extract were of 12nm. Antibacterial activity of both extract mediated nanoparticles was examined. Ag NPs were examined to see how they affected the strains of *S. aureus*, *B. subtilis*, *E. coli*, and *P. aeruginosa*. The antibacterial activities of NPs derived from plant extracts are influenced by a number of factors, such as NP size, shape, and accumulation **(Erci, Cakir-Koc, & Isildak, 2018).**Ginger extract mediated nanoparticles exhibited strong antibacterial properties against all above mentioned bacterial strains because their size was comparatively larger than NSE mediated nanoparticles which exhibited mild antibacterial properties. The antimicrobial action of Ag NPs increased by increasing the concentrations of GE which may be attributed due to increased solubilization of the resulting Ag NPs **(Alkhathlan et al., 2020).**

Zingiber officinale root extracts were used as reducing and stabilizing agent for synthesis of silver and gold nanoparticles. Silver nitrate and chloroauric acid ($HAuCl_4$) were mixed with extract for preparation of nanoparticles. The pH, metal ion concentration, reaction temperature and reaction time were all analyzed as possible production enhancing parameters. The biosynthesis of AgNPs and AuNPs was considered to be affected by pH. Absorbance was increased by increasing pH. The findings indicated that increasing temperature stimulated the reduction process and synthesis of nanoparticles. pH was optimized at 8 and 9, reaction temperature was 50ºC and reaction time was 150-160 mins. Antibacterial activity of the synthesized AgNPs against bacterial foodborne pathogens was strong **(Velmurugan et al., 2014).**

Silver nanoparticles were synthesized using ginger rhizome extract and compared with nanoparticles synthesized via chemical method. Different techniques including XRD (X Ray Diffraction), SEM-EDX (Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy), FT-IR and UV-vis spectroscopy were used for characterization of synthesized nanoparticles. Ag nanoparticles were synthesized by two methods; one was synthesized by ginger rhizome and other by chemical, sodium citrate and both were compared. UV absorption of chemically synthesized nanoparticle was 415nm and of ginger mediated was 423nm.Against six common aquatic pathogens. Antibacterial activated of these synthesized nanoparticles was examined. Sodium citrate solution did not show any antibacterial activity against these pathogens, while ginger mediated nanoparticle exhibited excellent antibacterial activity in comparison to sodium citrate mediated nanoparticle which showed weak antibacterial property. Hence ginger extract was considered beneficial for stabilization of silver nanoparticles **(Yang et al., 2017).**

4.0 Synthesis of zinc oxide nanoparticles using ginger and garlic extract:

Zinc oxide nanoparticles were the subject of the research. Because of its unique physical, chemical, and physicochemical properties, zinc oxide is termed as metal oxide that could be used at the nanoscale. They are used in the food, biopharmaceutical and cosmetic industries, as well as solar cells and semiconductors **(Kołodziejczak-Radzimska & Jesionowski, 2014)**. ZnO nanoparticles are less toxic and stable than other nanoparticles, so they have more applications in industries **(L. F. A. Raj & E, 2015).**

ZnO nanoparticles were synthesized using ginger root extract. SEM, EDX and FT-IR were used for characterization of nanoparticles. The shape of the ZnO nanoparticle was clearly spherical in the SEM image, which corresponded to previous studies. The presence of zinc and oxygen indicators in zinc oxide nanoparticles was confirmed by EDX. The peaks correlated to the optical absorption of the synthesized nanoparticles were revealed by this analysis. Alkenes in the root extracts may have aided in the reduction of ZnO nanoparticles. The diffraction pattern analysis revealed 80 percent zinc and 19 percent oxygen, indicating that the nanoparticle was formed in its purest form. The mechanism that how ginger extracts can synthesize nanoparticle was unknown. It was concluded from previous studies that presence of flavonoids and polyphenolic compounds are responsible for synthesis of nanoparticles (**Kołodziejczak-Radzimska & Jesionowski, 2014)**.

In this study, ZnO nanoparticles were synthesized using root extract of ginger. Synthesized nanoparticles were confirmed through SEM. Antibacterial activity of synthesized nanoparticles was tested against *Eschericia coli, Pseudomonas aeruginosa, Klebsiella pneumonia, Staphylococcus aureus and Bacillus subtilus.* ZnO nanoparticles were used at concentration of 0.5 – 4 mg/ml. It was observed that by increasing the concentration of nanoparticles, zone of inhibition was increased. At 2mg/ml, a larger zone of inhibition was observed. It was concluded that ZnO nanoparticles could be used to treat diseases caused by pathogenic bacteria **(L. F. A. Raj, 2015).** According to previous research, the antibacterial activity of ZnO nanoparticles is due to an electrostatic interaction between the pathogen's negative charges and the positive charge of metal oxide, which causes the pathogen to oxidize and die **(Gunalan, Sivaraj, & Rajendran, 2012a).**

Metal nanoparticles including silver, zinc, copper and iron metal were synthesized using bulb extract of garlic and rhizome extract of ginger. Nanoparticles were characterized using TEM and UV-vis spectroscopy. The phenol and flavonoid components of extracts were fractionated using the HPLC technique. Plant extracts and nanoparticles were tested as anticancer agents in vitro against the Caco, HEPG2, and T47D cell lines at various concentrations of 100 – 500 μg/ml. Since the total polyphenols and antioxidant properties of ginger extract is greater than garlic extract therefore the inhibitory concentration of ginger extract was observed better than garlic extract. Nanoparticles with high antioxidant activity have been shown to be efficient anticancer agents and may be used because of strong anticarcinogenic properties in tumor cell lines in vitro **(A. A. El-Refai, G. Ghoniem, A. Y. El-Khateeb, & M. M. Hassaan, 2018).** Garlic bulb contain rich source of selenium, that is an antioxidant and act as chemopreventive agent (Lu et al., 1996).The active ingredient extracted from ginger is 6-gingrol, which has strong anticancerous properties **(Lee, Cekanova, & Baek, 2008).**

ZnO nanoparticles were synthesized using garlic skin extract also. Garlic skin is considered waste material and discarded. In this article, garlic skin extract was used as reducing agent for synthesis of ZnO nanoparticle. TEM, UV-vis spectroscopy, SEM with EDX and FTIR were used for confirmation of nanoparticles. Maximum absorption peak of ZnO nanoparticle was observed at 370nm using UV-vis spectroscopy. Around 600-450 cm-1, FTIR spectra showed the stretching band's functional groups. The composition of hexagonal nanoparticles with Zn and O elements was revealed by SEM-EDS analysis. The synthesis of extremely pure ZnO nanoparticles is confirmed by energy dispersive X-ray analysis (EDX).This process was considered economic for synthesis of nanoparticles **(Modi & Fulekar, 2020).**

Janaki etal did Green synthesis of zinc oxide nanoparticles was done using powder rhizome extract of dried ginger. 23 -26 nm nanoparticles were synthesized using green synthesis methods. Antibacterial and antifungal properties of synthesized nanoparticles were tested. The oxygen species are produced on the surface of ZnO and cause microorganisms to die. They generate H_2O_2 molecules as they react with hydrogen ions. The H_2O_2 produced can pass through the cell membrane and destroy bacteria **(Gunalan, Sivaraj, & Rajendran, 2012b)**. Antibacterial activity was examined against *Klebsiella pneumonia, Staphylococcus aureus*. Synthesized nanoparticles exhibited strong antifungal activity against *Candida albicans and Penicillium notatum* **(Janaki, Sailatha, & Gunasekaran, 2015).**

5.0 Role of citric acid in stabilization of nanoparticles:

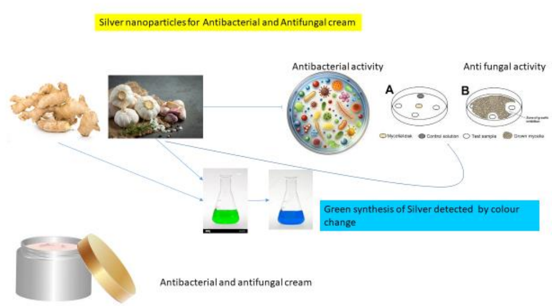
The introduction of molecules which cause adsorption are being used to regulate the stability and shear strength of colloidal dispersions and nanoparticles **(Monopoli, Aberg, Salvati, & Dawson, 2012)**. For processing of minerals and ceramics manufacturing, Citric acid and a tricarboxylic acid are examined as a stabilizer **(Mudunkotuwa & Grassian, 2010)**. As reducing agent, stabilizer and size controller they are used in silver and gold nanoparticles formulation **(Lin et al., 2003)**.

The isoelectric point is switched to low pH values by adsorption of citric acids. As a result, the particles with adsorbed citric acid have a strong negative charge at near neutral pH, resulting in stabilization of nanoparticles. Since citric acid is frequently present at substantial concentrations, nanoparticle stability in the existence of citrate ions will influence nanoparticle transport in vivo, in soils, and in aquatic world. Colloidal particles can flocculate at high ionic strength, resulting in heavy, smoothly redispersed aggregates. While nanoparticles stabilized by citric acid exist in stable form at high ionic concentrations **(Shinohara et al., 2018).**

Chen etal studied role of citric acid in synthesis of silver nanoparticle was studied. Citrate ions could serve as reducing, stabilizing, and complexing agents in the synthesis and stabilization of silver nanoparticles. Citrate ions may adhere to silver surfaces as stabilizers, allowing for shape control. Results concluded

that citric acid is suitable for shape controlled synthesis of silver nanoparticles with desired properties **(Jiang, Chen, Chen, & Yu, 2009).**
Kamali etal studied the effect of raising the pH value and found that increasing the concentration of citrate ion species, allowing nanoparticles to be smaller and more crystalline. The optimal requirements for the synthesis of nanoparticles were found at high pH levels with the highest percentage of citrate. Nanoparticles were developed with favourable size and crystallinity **(Kamali, Ghorashi, & Asadollahi, 2012).**

Fig 2: Synthesis of Antibacterial and antifungal cream from ginger and garlic extract



6.0 Effect of NaOH on properties of nanoparticles:

The NaOH have different effect on the nanoparticles formation. In one study SPR of silver nanoparticles at 420nm increased gradually as the concentration of sodium hydroxide was increased. Nanoparticle growth was noticed, with an increase in NaOH and reaction time resulting in a hyperchromic effect. That method might served as a platform for further research into novel ways to make silver nanoparticles **(Yadav, Jain, & Dandekar, 2017).**

The concentration of NaOH has greatly influenced the size of nanoparticles. The structure, size, and optical bandgap of achieved nanoparticles are influenced by the concentration of NaOH **(Siriphongsapak, Denchitcharoen, & Limsuwan, 2020)**. By increasing the concentration of NaOH, the size of nanoparticle is increased accordingly. Both have direct proportional relationship **(Xu & Wang, 2011).**
In another study, the results are opposite zinc oxide nanoparticles were developed using a co-precipitation system with changing concentration of NaOH (0.1 M–0.4 M). Different techniques including photoluminescence (PL) field emission, scanning electron microscopy (FESEM), Raman spectroscopy and XRD were used for characterization of nanoparticles. FESEM revealed a decrease in particle sizes from 40 nm to 23 nm with enhancing concentration of NaOH. The findings showed that the concentration of NaOH has an opposite effect on particle size and optical characteristics of ZnO nanoparticles. Reduction is size of nanoparticle could may be because of fast nucleation reaction during synthesis process **(Koutu, Shastri, & Malik, 2016).**

Fig 3: Effect of NaOH on the synthesis of ZnO particles

7.0 Application of nanoparticles in cosmetics:

Till 2006 just 5% of cosmetics included nanoparticles . In 2012, the global demand for nanotechnology based cosmetics was expected to hit around 155.8 million dollars. The profitability of nanoparticles containing cosmetics had increased dramatically by the end of 2015. Metal and metal oxide nanoparticles have broad applications in cosmetics such as creams, moisturizers, cleansers, shampoos, and haircare. Companies develop goods with innovative techniques, such as by using nanoparticles, as a result of increased marketing demand in cosmetology and dermatology. According to the results of the survey for distribution of products, cosmetics goods comprised of 70 to 80 percent TiO2NPs, 70 percent ZnONPs, and 20 percent AgNPs as shown in fig 2.**(Niska, Zielinska, Radomski, & Inkielewicz-Stepniak, 2018).**

8.0 Role of silver nanoparticles in antibacterial cosmetic formulation:

Some skin infections, such as atopic dermatitis, can be protected by silver nanoparticles. There seem to be no adverse effects on human health when silver nanoparticle concentrations are kept to a small and reasonable level. Silver nanoparticles are used as cosmetics preservatives and anti-acne formulations because of their antibacterial activities (Kim et al., 2008).

Gajbhiye et al documented applications and toxicity of silver nanoparticles in cosmetics. Silver nanoparticles showed possible antimicrobial impacts against irresistible organic entities including *Bacillus subtilis, Syphillis typhus, Escherichia coli, S. aureus and Vibria cholera*. The silver nanoparticles joined to the cell layer and furthermore enter inside the bacteria. The nanoparticles tend to target the respiratory chain, followed by cell division, and finally cell necrosis. Silver ions released into bacterial cells increase their antibacterial effect. The antifungal activity of silver nanoparticles against *Trichophyton mentagrophytes and Candida species* was crucial. Silver nanoparticles documented strong antibacterial, antifungal and skin repairing properties. In cosmetic formulations, silver nanoparticles can be safely used in preparations of anti-acne, anti-dandruff, and antibiotic products **(Gajbhiye & Sakharwade, 2016)**.

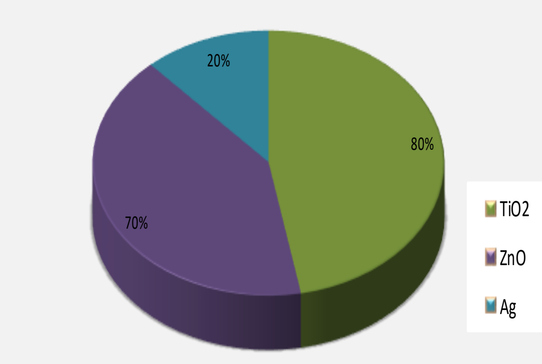


Fig 4:Survey results of mostly used nanoparticles in cosmetics

8.1 Lemon peels for silver nanoparticles formulations:

Silver nanoparticles were synthesized using lemon peels also. Synthesized nanoparticles were characterized using UV–visible spectrometer, EDAX (Energy Dispersive X-ray Spectroscopy) and FESEM (Field Emission Scanning Electron Microscopy) analysis. Dermatophytes were detached and characterized from skin scales that were obtained from patients those were suspected of having dermatophytosis. Lemon peels mediated nanoparticles were effective against the dermatophytes that were isolated from patient's skin. It showed that nanoparticles can be used as antibiotics. It was ecofriendly method for synthesis of silver nanoparticles **(Najimu Nisha et al., 2014).**

The efficacy of cosmetic preparations containing silver or gold nanoparticles is also investigated in this paper. Silver and gold suspensions were synthesized and applied to creams at concentrations of 20, 65, 110, 155, and 200 mg/kg. Synthesis of nanoparticles was confirmed through UV-vis spectroscopy and TEM-EDX. Both the silver and gold nanoparticle emulsions had sufficient fungicidal effects which were confirmed by microbiological studies. The emulsion containing 200 mg/kg gold nanoparticles obtained the highest ratings from survey participants in terms of consistency, penetration, color, and aroma. The emulsion with 200 mg/kg silver nanoparticles received the lowest rating in terms of homogeneity, color, and odor. Silver and gold synthesized cosmetic preparations had pH range of 6.85 t0 7.85. At 110-200 mg/kg, highest permeability for creams consisting of metallic nanoparticles was reported **(Pulit-Prociak, Grabowska, Chwastowski, Majka, & Banach, 2019).**

By reducing silver nitrate, silver nanoparticles were prepared in an aqueous solution utilizing oleic acid as a reducing and capping agent. Silver nanoparticles coated with oleic acid were incorporated as a foundation in cosmetic creams. UV-vis spectroscopy and TEM confirmed the presence of silver nanoparticles. Cosmetic cream and cotton gauze synthesized using silver nanoparticles were investigated for antibacterial properties against *Candida albicans* bacteria strains. AgNP mediated cream and cotton guaze exhibited strong antibacterial properties **(Elsherbini, 2015).**

Law, et al stated that Silver nanoparticle have strong antimicrobial properties because they trigger the generation of reactive oxygen species like hydrogen peroxide. When silver nanoparticles are used instead of nitrate, the surface area for microbes becomes sufficient to be exposed **(Law, Ansari, Livens, Renshaw, & Lloyd, 2008).**

Sondi, and Salopek-Sondi stated that Silver nanoparticles are used in a variety of antibacterial applications, little is known about how this metal interferes with microbes **(Sondi & Salopek-Sondi, 2004).**

African peach fruit botanical name of *Nauclea latifolia* is also tested for cold cream formulation. Cold cream was formulated using biosynthesized silver nanoparticles and its antimicrobial activity was examined. Phytochemical and antioxidant compounds of fruit extract were also studied. Biosynthesized nanoparticles were synthesized using UV-Vis spectrophotometer, SEM, EDX and FTIR. Saponins, flavonoids, terpenoids, tannins and glycosides were detected in methanolic extract of *Nauclea latifolia*. Presence of functional groups as alkyl halides, carboxyl, hydroxyl, amines, carbonyl, phenols and amide groups was confirmed by FTIR analysis. These compounds were crucial as reducing and capping agents of silver ions in nanoparticles. The formulated creams were durable, desirable, and had a pH, viscosity, and permeability that were satisfactory. As well as formulated cream represented moderate antimicrobial and antioxidant properties **(Odeniyi, Okumah, Adebayo-Tayo, & Odeniyi, 2020).**

The most commonly synthesized nanoparticles are gold, silver, copper, and platinum. While silver nanoparticles contributing for a quarter of all nanotechnology products available, indicating their suitability, protection, and significance in human applications **(Sanjenbam, Gopal, & Kannabiran, 2014).** In sunscreen creams, AgNPs have been used as chemopreventive agents. Earlier studies have indicated that in comparison to zinc oxide nanoparticles, AgNPs are more effective **(P.-J. Lu, S.-C. Huang, Y.-P. Chen, L.-C. Chiueh, & D. Y.-C. Shih, 2015).**

In this study, *Phoenix sylvestris* L. seed extract mediated silver nanoparticles were synthesized. Synthesized nanoparticles were characterized using techniques of SEM, DLS, TEM, XRD and FT-IR. Nanoparticles were tested against two skin pathogens, *Propionibacterium acnes and Staphylococcus epidermidis*. The study indicated that the extract mediated nanoparticles have phytochemical, antioxidant and antibacterial properties against those pathogens that cause skin infections. MIC and IC-50 values of P. acnes were 0.687 and 0.650 respectively, while for *S. epidermidis* these were 0.693 and 0.662. Silver nanoparticles exhibited excellent antibacterial properties. They have potential to be used in anti-acne preparations and have the potential to treat cosmetic embarrassment **(Qidwai, Kumar, & Dikshit, 2018).**

In present study, ginger essential oil mediated nanocomposite of ZnO-Ag was prepared. Nanocomposite was evaluated by comparing with biosynthesized ZnoNPs. FT-IR, TEM, EDX and UV-Vis spectroscopy were used for confirmation of nanoparticles. Antibacterial activity was investigated against gram positive and gram negative bacteria. It was observed that antibacterial potential of ZnO-NPs was enhanced by Ag doping. This technique was environmentally friendly and cost effective for making nontoxic massive development of metal oxide nanocomposite materials with strong antibacterial properties **(Azizi et al., 2016).**

In this review, efficacy of AgNPs was studied against skin cancer. Researchers wanted to check that against UVB-induced DNA damage and cell death whether AgNP size influenced their chemopreventive action. HaCaT cells were treated with difference doses of nanoparticles (1–10 μg/mL) with different size range of nanoparticles from 10 to 100nm with time interval of 12 and 24 hours. CPDs (cyclobutane pyrimidine dimers) were detected through dot-blot analysis as a sign of DNA damage. Nanoparticles having size range of 10-40nm were capable of fighting against UVB radiation-induced DNA damage on skin cells. While large sized nanoparticles (60-100nm) did not protected skin cells against damage. These findings elaborated the size-dependent inhibitory effects of silver nanoparticles against UVB-induced skin cancer in humans **(Palanki et al., 2015).**

In this article, the potency of Ag/Zno nanocomposite was tested against oral pathogen *Streptococcus mutans.* XRD, SEM, and TEM were used for characterization of rod-like Ag/ZnO nanocomposite that was prepared using a deposition precipitation process. Through MIC, MBC and GIC, the efficacy of nanocomposite was evaluated against *S.mutans*. The antibacterial action was evaluated by monitoring the bacterial membrane potential, intracellular K+ release, and oxidative degradation of lipids. In comparison to pure ZnONPs, the Ag/ZnO nanocomposite exhibited strong action against S. mutans **(Wang et al., 2017).**

The present study aimed to see whether the cream produced with *Ehretia cymosa*-AgNPs had anti-inflammatory properties. Different plant extracts (methanol, ME, n-hexane, NE, and ethyl acetate, EE) were used to make AgNPs. UV and FTIR spectroscopy were used to characterize the nanoparticles that had been synthesized. The properties of cream made with AgNPs were investigated. In comparison to the control, the cream has good anti-inflammatory properties and faster healing potential. Many studies have shown that biosynthesized silver nanoparticles have anti-inflammatory properties **(Olutayo et al., 2020).**

9.0 Role of zinc oxide nanoparticles in cosmetic formulation:

Sunscreens are widely known cosmetics that help defend against radiation. Sunscreens are subjected to extensive screening for efficacy and human protection prior to commercialization. Zinc oxide and titanium dioxide are used in modern sunscreens for protection against uv- rays **(Botta et al., 2011).**

As antibacterial properties of zinc oxide nanoparticles are well renowned, and silicon oxide nanoparticles have wide applications in medical and cosmetic industry. Present study aimed to produce nanocomposite of SiO2 and ZnO to get combined properties of both.

SiO2/ZnO nanocomposite were characterized by SEM and FTIR. Their antibacterial properties were investigated against *Staphylococcus aureus.* Nanocomposites exhibited excellent antibacterial properties which were determined by the Kirby Bauer disk diffusion method. To provide protection to the skin from UV rays and to repair the skin, SiO_2/ZnO nanocomposite were used to formulate cosmetic cream **(Spoiala et al., 2014).**
Insoluble titanium dioxide and zinc oxide nanoparticles (NP) commonly used in sunscreens because they are colorless and reflect UV rays better than larger particles. Both safe and damaged human skin are resistant to these insoluble nanoparticles. TiO2 and ZnO nanoparticles, which are currently used in cosmetics, pose no risk to human skin or health **(Nohynek, Lademann, Christele, & Roberts, 2007).**

The main objective of the current research was to encapsulate ZnO and quercetin within polymeric nanoparticles utilizing a miniemulsion polymerization method. To attain strong antioxidant effects and SPF for inclusion in sunscreen formulas, octocrylene and green coffee oil served as co-stabilizers. Uniform-sized spherical nanoparticles were created, varying between 169 and 346 nm. When quercetin and green coffee oil were manufactured with the help of polymeric nanoparticles, they results in robust antioxidant capabilities. In vitro SPF solutions for products containing ZnO nanoparticles were outstanding. The application of quercetin NPs and green coffee oil can boost SPF levels in vivo and aid in reducing UV-related skin harm (Fogaça et al., 2020)

The antifungal activity of ZnONPs is attributed to an increase in nucleic acid content caused by the stress response of fungal hyphae. Carbohydrate concentrations increased as a result of the fungi's defense mechanism against ZnONps. In the malformed structures of fungal hyphae, excessive quantities of nucleic acids and carbohydrates can cause fungal cell death **(He, Liu, Mustapha, & Lin, 2011).**

ZnO traces can also be found in dissolved state in the human body .Minimal concentrations of dissolved ZnO do not possess any harmful effects to human health while the toxic effects of ZnONPs are still unknown **(Gulson et al., 2010)**.
Many in vitro experiments on human and porcine skin revealed that TiO2 and ZnO NPs only penetrated to the outermost layer of skin that is stratum corneum and did not penetrate into the living skin **(Cross et al., 2007)**.

Multiphoton tomography was used in present in vivo research to examine the penetration of ZnO NPs in human skin that were 30 nm in size. The dispersion of ZnO NPs in the outermost layers of the skin, furrows, pores, and follicular orifices of the hair was observed using the second harmonic generation and hyper-Rayleigh scattering. This was the first in vivo analysis to demonstrate a limit of detection of 0.08 fg/ m3 for ZnO on human skin. Nanoparticles do not reach the epidermis's viable membranes that serve as a barrier for skin. The use of sunscreens incorporating ZnO NPs at the concentrations used in the study was considered safe for human skin **(Darvin et al., 2012).**

The sol-gel method was used to make the titanium dioxide, zinc oxide, and silver nanoparticles nanocomposites, which were then characterized with XRD, FT-IR, and SEM. The nanocomposite was 20–29 nm in size. The antibacterial properties of nanocomposite were assessed using the MIC test against Staphylococcus aureus and E. coli. Toxicity was also examined in a sunscreen cream. Minimum growth inhibitory concentration findings against both gram positive and Gram negative bacteria demonstrated the nanocomposite's powerful antibacterial activity. Nanocomposite toxicity was low and dose-dependent, suggesting that it could be used in formulation of high protection sunscreen cream **(Chegeni, Pour, & Faraji Dizaji, 2019).**

The photoprotective properties of organic nanoparticles synthesized using lignin in collaboration with ZnO nanoparticles in sunscreens was investigated in present study. Agave tequilana lignin was used to produce nanoparticles of lignin. The precipitation method was used to make ZnO nanoparticles. SEM, UV–Vis, and FT-IR spectroscopy were used to characterize synthesized nanoparticles. In-vitro sun protection factor (SPF) values were measured using nanoparticles incorporated in neutral vehicle in varying concentrations. SPF values ranging from 4 to 13 were obtained by combining all components. Lignin nanoparticles exhibited UVB and UVC absorption, potentially raising the SPF of sunscreens containing only zinc oxide nanoparticles. Brown color of lignin nanoparticles has advantage to adjust skin complexion of person **(Gutiérrez-Hernández et al., 2016).**

Laser scanning confocal microscopy, XRD, TEM and Atomic force microscopy, were used to evaluate titanium dioxide (TiO2) and zinc oxide (ZnO) NPs in non-modified sunscreens. The chemical compositions of sunscreens could not be determined using atomic force microscopy because the sunscreens needed to be pretreated or calibrated in phase analysis. Without any need for sunscreen pretreatment, XRD provided particle size and crystal details. Prior to imaging, TEM analysis necessitated the dilution and dispersion of commercial sunscreens. It was concluded that in commercial products, AFM is not adequate for analysis of ZnO and TiO2 NPs. The LSCM method is not considered suitable for determining particle size in cosmetics. The results indicated that size-related analysis of sunscreens can be appropriately done using both XRD and TEM **(P. J. Lu, S. C. Huang, Y. P. Chen, L. C. Chiueh, & D. Y. Shih, 2015)**.

ZnO is one of the few items that is regarded as secure (GRAS). ZnO is an effective antioxidant used in cosmetics to help protect against reactive oxygen species (ROS) by reducing the development of skin-damaging free radicals and improving cell repair and healing. Adhatoda vasica leaf extract was used to green synthesize ZnO nanoparticles, which were then characterized utilizing UV-Vis, FTIR, XRD, and EDX techniques. Clinical skin pathogens were used to test the microbicidal and antioxidant properties of the ZnONps incorporating cold cream formulation. Cream was found to be resistant to Candida fungus. ZnONps can be used in cosmetic products as possible colloidal drug carriers to treat human skin infections and cellular damage caused by cellular damage **(S, H, K, & M, 2017).**

Conclusion:

Producing metallic nanoparticles utilizing green method is cheap, feasible, and environmentally sustainable. Nanoparticles with controlled size and structure and nontoxic effects can be developed using green synthesis method. Silver and zinc oxide nanoparticles can be used in cosmetic formulations because of their promising antibacterial and antifungal properties. Antibacterial and antifungal activities of cosmetics are investigated through antimicrobial testing. This study will help future researchers to formulate innovative Ag and ZnO nanoparticles based antibacterial and antifungal cosmetics using green technology.

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