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GREEN SYNTHESIS, CHARACTERIZATION AND ANTIMICROBIAL ACTIVITY OF COPPER OXIDE NANOPARTICLES USING VACCINIUM MACROCARPON FRUIT EXTRACT

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ABSTRACT- *This study reports the green synthesis of copper oxide nanoparticles (CuO NPs) using Vaccinium macrocarpon fruit extract and evaluates their antimicrobial efficacy. Green synthesis represents a sustainable, eco-friendly, and non-toxic alternative to conventional chemical synthesis approaches. The synthesized CuO nanoparticles were characterized using UV–Visible spectroscopy, X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy coupled with energy-dispersive X-ray analysis (SEM–EDX). XRD analysis confirmed the monoclinic crystalline structure of the CuO nanoparticles, with an average particle size in the range of 37–43 nm. SEM images revealed predominantly cubic and flower-like morphologies.*

The antimicrobial activity of the biosynthesized CuO nanoparticles was assessed against selected bacterial strains (Vibrio cholerae, Klebsiella pneumoniae, Staphylococcus epidermidis, and Enterococcus faecalis) and fungal strains (Aspergillus niger, Candida albicans, Candida glabrata, and Aspergillus brasiliensis) using the agar well diffusion method. The green-synthesized CuO nanoparticles demonstrated notable antibacterial and antifungal activity, particularly against Klebsiella pneumoniae and Candida albicans.The findings indicate that Vaccinium macrocarpon-mediated CuO nanoparticles possess strong antimicrobial potential and may serve as effective alternatives for various biomedical applications.

Keywords: **Vaccinium macrocarpon, Copper oxide (CuO) nanoparticles, Antimicrobial activity, Calcination, UV–Visible spectroscopy.**

INTRODUCTION:

Cranberries (Vaccinium macrocarpon) are well known for theirVibrant colour , pleasant flavor , and high nutritional value.They are rich in natural compoundsSuch as phenolic acid, flavonoids,and tannins, which play an important role in promoting humanHealth. Cranberry – based products have been widely studied for their ability to prevent andManage urinary tract infections (UTIs).In addition to supporting urinary health,regularconsumption of cranberry and other polyphenol- rich foods as been associate with reduced risk of cardiovascular disease , diabetes, certain cancers, and inflammation.Cranberry extracts have alsoshown promising antibacterial, antiviral, antioxidant, and anti-inflammatory activities , making them valuable in medical and nutritional applications.

Fig. no.1 Cranberry fruit

In recent years , nanotechnology has emerged as a powerful field with Application in medicine , agriculture, industry, and environmental science. Nanoparticles which range in size from 1 to 100 nm, exhibit unique physical, chemical, and bio logical properties that differ from their bulk counterparts. Among various nanoparticles, copper oxide nanoparticles (CuO NPs) have gained significant attention due to their excellent antimicrobial, antioxidant, and anticancer properties. They are widely used in fields such as bio sensing, water treatment, Food preservation, and drug delivery systems.

Traditional methods for synthesizing nanoparticles often involve the use of toxic Chemicals and high energy process, which can be harmful to both human health and the Environment. To overcome these limitations, green synthesis method using plant extracts having Gained popularity. These eco-friendly approaches are cost-effective, safe, and sustainable. Plant extract act as natural reducing and stabilizing agent, enabling the synthesis of nano particles without harmful by-products.

Cranberry fruit extract is particularly suitable for green synthesis due to its rich phytochemical content. In this study, cranberry-mediated green synthesis copper oxide nanoparticles was carried out for the first time. The synthesized nanoparticles were characterized using various analytical techniques, and their antimicrobial potential were evaluated against selected bacterial and fungal pathogens. The findings of this research aims to contribute to the development of environmentally safe nano materials with effective antimicrobial application.

Fig.no.2 Cranberry powder

MATERIALS AND METHODS

Materials for Green synthesis

Vaccinium macrocarpon fruit powder, Methanol, Distilled water, Soxhlet apparatus, Rotary evaporator.

Identification and collection of Vaccinium macro carpon fruits

Vaccinium macrocarpon fruit powder was purchased from Maduras Herbals, Salem, Tamilnadu and authenticated by a botanist. The powder was stored in an airtight container and kept in a cool, dark and dry place for further analysis.

Synthesis of copper oxide nano particles(CuO NPs)

The chemical approach was used for the synthesis of CuO NPs in which copper chloride was dissolved in deionized water and continuous stirred on magnetic stirrer. The NaOH solution was prepared to attain the pH upto 11 of copper chloride solution. The prepared solution was continuously stirred magnetic stirrer for 2 hrs to get black color homogeneous mixture. After that, prepared solution was filtered using a filter paper with the help of deionized water. Finally, the black colour product was calcinated at 400˚C for 2 hrs. The black colour precipitate (powder) was ground in a mortar and pestle.

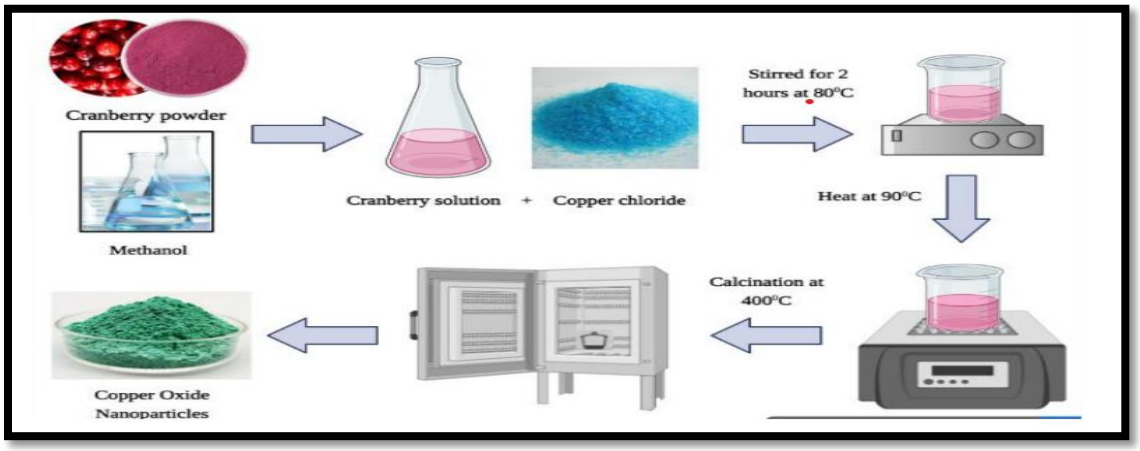

Fig.no.3 Green synthesis of copperoxide nanoparticles using aqueous Vaccinium macrocarpon fruit extract.

ANTIMICROBIAL ACTIVITY

The antimicrobial activity of the Vaccinium marcocarpon was tested individually on gram-positive and gram-negative bacterial strains. The well diffusion method of antibacterial test was performed on eight microbial strains Vibrio cholerae, Klebsiella pneumonia, Staphylococcus epidermidis, Enterococcus faecalis, Aspergillus niger, Candida albicans, Candida glabrata, Aspergillus brasiliensis strains.

Culture preparation and media

Bacterial and fungal cultures were prepared using appropriate nutrient and growth media under sterile conditions. The cultures wereincubated at suitable temperature to promote optimal microbial growth before performing antimicrobial assays.

RESULTS AND DISCUSSION

UV-Visible Spectroscopy Analysis

The formation of copper oxide nanoparticles was confirmed using UV-Visible spectroscopy. The chemically synthesized CuO nanoparticles showed a characteristic absorption peak at 376 nm, while the green-synthesized nanoparticles exhibited a similar peak at 377 nm. These peaks confirm the successful formation of CuO nanoparticles. The close similarity in absorption values indicates that both synthesis methods produced comparable nanoparticles, with the green method showing equally efficient results.

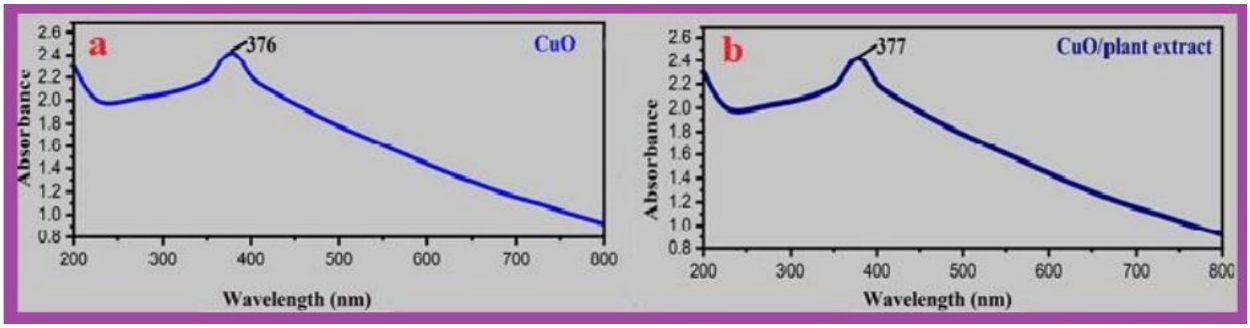

Fig.no.4 UV-Vis spectrum of copper oxide nanoparticles synthesized via a) chemical and b) green synthesis

X-ray diffraction analysis

XRD analysis revealed that the synthesized copper oxide nanoparticles possessed a well-defined crystalline structure. The diffraction peaks obtained matched standard reference patterns, confirming the monoclinic phase of CuO. No impurity peaks were detected, indicating high purity of the synthesized nanoparticles. The average particle size calculated using the Debye-Scherrer equation was approximately 43 nm for chemically synthesized nanoparticles and 37 nm for green-synthesized nanoparticle.

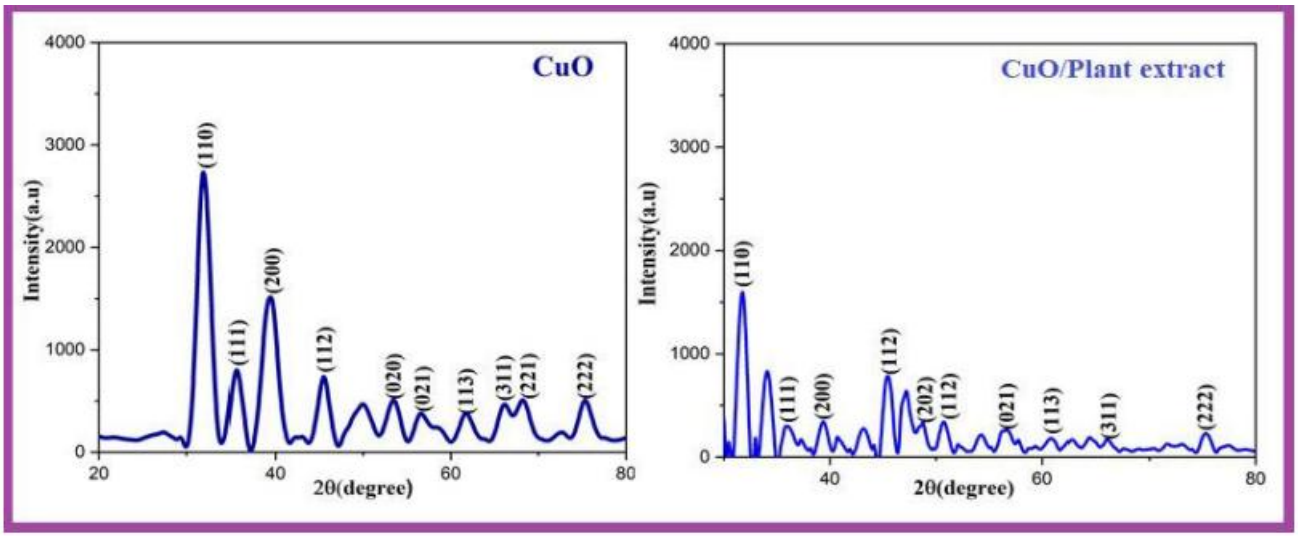

Fig .no.5 X-ray diffraction of CuO NPs a) CuO chemical b) CuO plant extract NPs

ANTIMICROBIAL ACTIVITY

The antibacterial activity of copper oxide NPs synthesized using Vaccinium macro carpon extract was evaluated by the well diffusion method. A 24 hours old culture was inoculated for the assay. Four bacterial pathogens and four fungal pathogens were in the antimicrobial study.

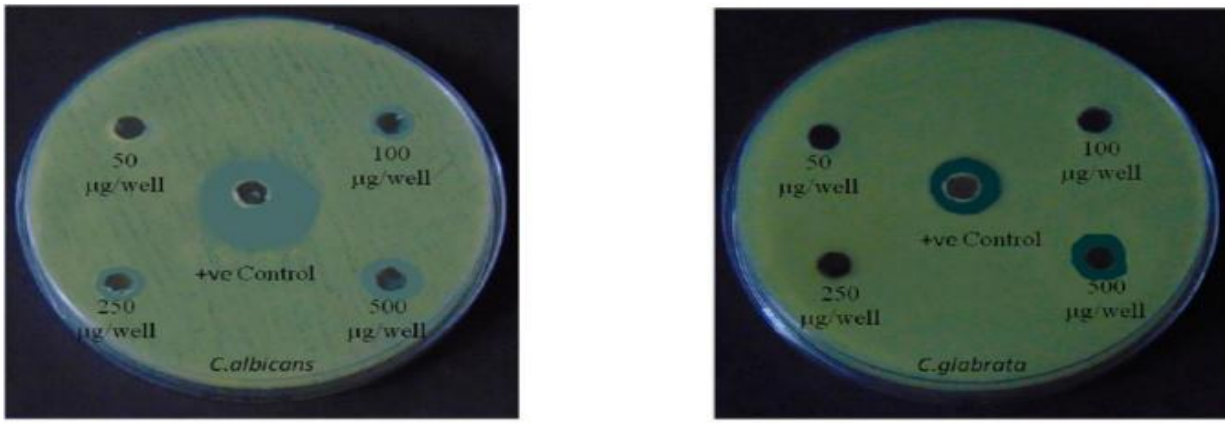

Fig no.6. Antifungal activity of CuO NPs against Candida albicans and candida glabrata.

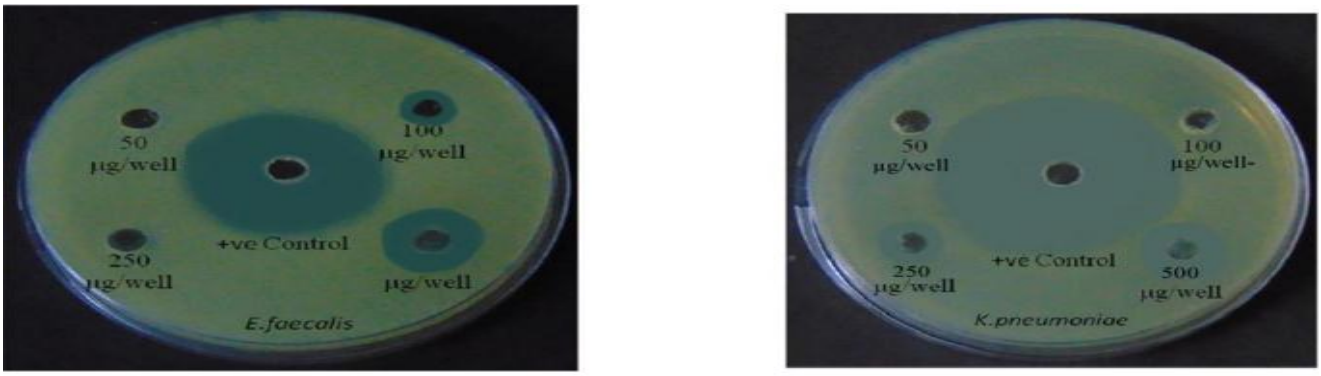

Fig no.7. Antibacterial activity of CuO NPs against Enterococcus faecalis and Klebsiella pneumonia

Table 1. Antibacterial activity of CuO NPs

Bacterial pathogens	Zone of inhibition mm				
	50 µl	100 µl	250 µl	500 µl	Positive
Vibrio cholera	-	9mm	12mm	15mm	25mm
Staphylococcus epidermidis	7mm	9mm	12mm	14mm	18mm
Enterococcus faecalis	-	10mm	12mm	16mm	24mm
Klebsiella pneumonia	9mm	14mm	17mm	19mm	23mm

Table 2. Antifungal activity of CuO NPs

Fungal pathogens	Zone of inhibition mm				
	50 µl	100 µl	250 µl	500 µl	Positive
Candida albicans	-	8mm	12 mm	14mm	30 mm
Candida glabrata	-	8mm	10mm	12mm	14mm
Aspergillus niger	-	9mm	12mm	16mm	25 mm
Aspergillus brasiliensis	-	-	-	-	-

CONCLUSION

Copper oxide nanoparticles with a cubic morphology were successfully synthesized using the non-toxic and eco-friendly plant extract of *Vaccinium macrocarpon*. The synthesized copper oxide nanoparticles were characterized using UV–visible spectroscopy and X-ray diffraction (XRD) analysis. Green synthesis of copper oxide nanoparticles using natural resources such as *Vaccinium macrocarpon* offers a promising alternative to conventional chemical synthesis methods, as it is environmentally benign and free from hazardous pollutants.

The biosynthesized copper oxide nanoparticles exhibited significant antimicrobial activity against a wide range of microorganisms, including *Staphylococcus epidermidis*, *Klebsiella pneumoniae*, *Vibrio cholerae*, *Enterococcus faecalis*, *Candida albicans*, *Candida glabrata*, *Aspergillus niger*, and *Aspergillus brasiliensis*. These results demonstrate that the synthesized copper oxide nanoparticles act as effective antimicrobial agents. Based on these findings, copper oxide nanoparticles produced through green synthesis may have broad potential applications in various scientific and technological fields

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