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GREEN SYNTHESIZED GOLD NANOPARTICLE: A NOVEL APPROACH TOWARDS BIOMEDICAL AND PHARMACEUTICAL APPLICATIONS

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ABSTRACT: Green synthesized gold nanoparticle is one of the most promising drug delivery approaches with biocompatibility and biodiversity. Various plant sources such as *Aegle marmelos*, *Eugenia jambolana*, Soursop, *Persea Americana*, *Terminalia chebula*, *Aloe arborescens*, *Musa paradisiacal*, *Alternanthera philoxeroides*, *Cissus quadrangularis*, *Sterculia acuminate*, *Garciniaindica choissy*, *Eucalyptus globulus*, *Rosmarinus officinalis*, *Punica granatum*, *Pistacia atlantica*, *Pistacia integerrima*, *Juglans regia*, *Curcumae kwangsiensis*; fungal sources as *Pleurotus cornucopiae* var. citrinopileatus, *Cladosporium cladosporioides*; other microbial sources as *Magnusiomyces ingens* LH-F1, *Micrococcus yunnanensis*, *Padina tetrastromatica* are used to develop biocompatible gold nanoparticle with veritable diversified particle size and applicability profile as anticancer (especially against breast cancer, liver cancer, ovarian cancer and lung cancer), antibacterial agent, photo luminescent, heavy metal sensor, *etc*. If biogenic sources are composed of a large number of hydroxyl and carboxylic acid groups, it can behave as reducing agents to develop gold nanoparticles with immense biomedical and pharmaceutical applications. This novel approach and data are very much encouraging and may be considered as one platform for searching all the important green synthesized gold nanoparticles and might be an index for evaluating drug activities.

INTRODUCTION: Since time immemorial, people in India, Europe, Egypt, Greece, and other South American countries have used plants, fungi, and moulds as traditional medicine [1-2]. Traditional herbal medicines are naturally occurring derived substances with minimal or no industrial processing that have been used to treat illness within local or regional healing practices [3-6].

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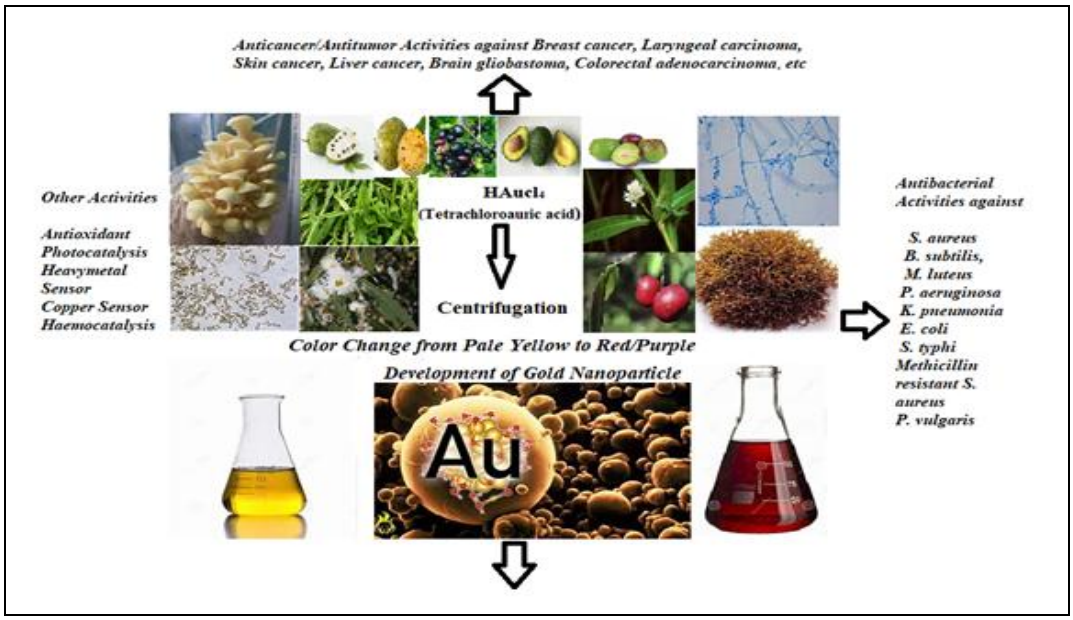
In ancient India and Himalayan regions, sages triturated medicines with gold for better efficacy, as gold was known as 'Amrita' because of its cell rejuvenating [7-8], antibacterial [l9-11] and immuno-modulatory properties [12-13].

In the 17th century, Nicholas Culpepper demonstrated the use of gold elixir in the treatment of melancholy, and fever [14-15]. The composition of gold and sodium chloride [Na (Aucl4)] was effective in the treatment of syphilis. In 1890, Robert Koch developed potassium gold cyanide [K{Au(CN)2}] as bacteriostatic agent. At that time, sodium aurothiomalate and aurothioglucose were considered highly effective agents in chrysotherapy for rheumatoid arthritis.

During this period, the chemistry of gold elucidated that it had six oxidation states as –I, 0, +I, II, IV, V, and amongst them, gold (0) was found more stable than gold (I & III). But gold (I) was more thermodynamically sound than gold (III) and it produced high protein interaction with albumin and metallothioneins [16]. Auranofin was the first gold molecule found active against cancer but not effective against solid tumours as compared to cisplatin, whereas its digold phosphine complex displayed good anticancer activity [17]. [$AuCl_2$ (damp)] was endowed as the effective molecule against colon, breast, rectum, bladder, and ovarian cancer, and [Au(OAc)2damp] was considered as a powerful inhibitor against *S. aureus*, *E. coli*, *E. facealis*, and *P. aeruginosa*. Nowadays, gold nanoparticles have become the most prima choice for formulating active ingredients [18]. In the synthesis of gold nanoparticles, various synthetic reducing agents such as sodium borohydrate, amino acids, CTAB (cetrimonium bromide), BDAC (Di-tertbutoxy-diacetoxysilane), ascorbic acid are extensively used. In this manuscript, we have made a thorough literature review on various plants, fungus, and algal sources that are used to stabilize and reduce the gold nanoparticle. This technique for using natural sources to develop gold nanoparticle increases the acceptability and lowers the adverse effects of the formulation, whereas the activity of the formulation will increase. This manuscript highlights the process of biosynthesis of gold nanoparticles obtained from green sources and mentions the activity profiles. On the other hand, the fact that nanoparticles reside in the nano range of particle size is correlated with greater absorption, biodistribution and bioavailability with optimum therapeutic index for the active pharmaceutical ingredients. In the previous successful experiments, it was observed that when the essence of gold and technology of nano formulation were triturated in a single malt, gold nanoparticle was developed, which metaphorically spreaded its fragrance in the field of drug discovery. In the synthesis of gold nanoparticle, reduction and stabilization were the most important factors wherein various natural objects such as plants, fungi, algae were used as reducing and stabilizing agents. In this article, we have emphasized on the green synthesized gold nanoparticle and their corresponding activities.



ANTIFUNGAL ACTIVITES: *CANDIDA ALBICANS, PUCCINIA GRAMINIS, PLEUROTUS CONRNUCOPIE* VAR. CITRNIOPILEATUS, *CLADOSPORIUM CLADOSPORIODES*

Green Synthesized Gold Nanoparticles Obtained From Plant Sources:

Fruit Extract Reduced and Stabilized Gold Nanoparticle Active against Breast Cancer: Three different gold nanoparticles were developed duly reduced and stabilized by extracts of *Aegle marmelos*, *Eugenia jambolana*, and Soursop and acted as anticancer agents. The nanoparticles were developed upon reaction between tetra chloroauric acid and extracts of fruits extracts with aurum chloride. The colour of the mixture was turned red to pale yellow, which indicated the formation of

gold nanoparticles [19]. The formulations were characterized by Fourier transformed infrared spectroscopy, zeta potential analysis, transmission electron microscopy, and they were evaluated biologically against (MCF-7) breast cancer cell line.

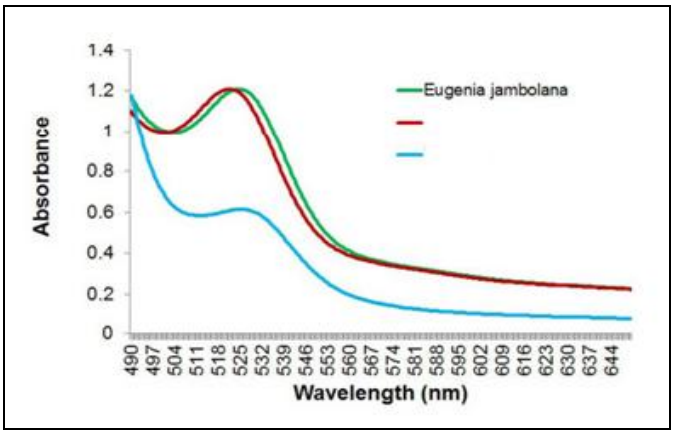


FIG. 1: UV-VISIBLE SPECTROSCOPIC SPECTRUM OF AEGLE MARMELOS, *EUGENIA JAMBOLANA* AND SOURSOP MEDIATED GOLD NANOPARTICLE

The particle size of the gold nanoparticles stabilized by *Aegle marmelos*, *Eugenia jambolana*, and Soursop were 18 nm, 28 nm and 16 nm, respectively. MTT assay results revealed that gold nanoparticle reduced and stabilized by Soursop exhibited greater inhibition against breast cancer cell lines **Fig. 1**.

Avocado Oil Stabilized Gold Nanoparticle as Antioxidant and Photocatalyst: Quasi-spherical, spherical, decahedron and triangular gold nanoparticles were developed upon reaction between *P. americana* oil and aurum chloride solution in the presence of sunlight. The formation of nanoparticles was indicated by the colour change from colourless to magenta. The formulation was *in-vitro* evaluated by free radical scavenging property and photocatalytic activity through methylene blue decomposition [20].

The formulation was characterized by UV-visible spectroscopy, transmission electron microscopy and X-ray crystallography. The UV-visible spectroscopic data revealed that after 120 min of photo exposure, Au^{3+} turned into Au0, which indicated the photocatalytic efficiency and antioxidative properties of the formulation **Fig. 2**.

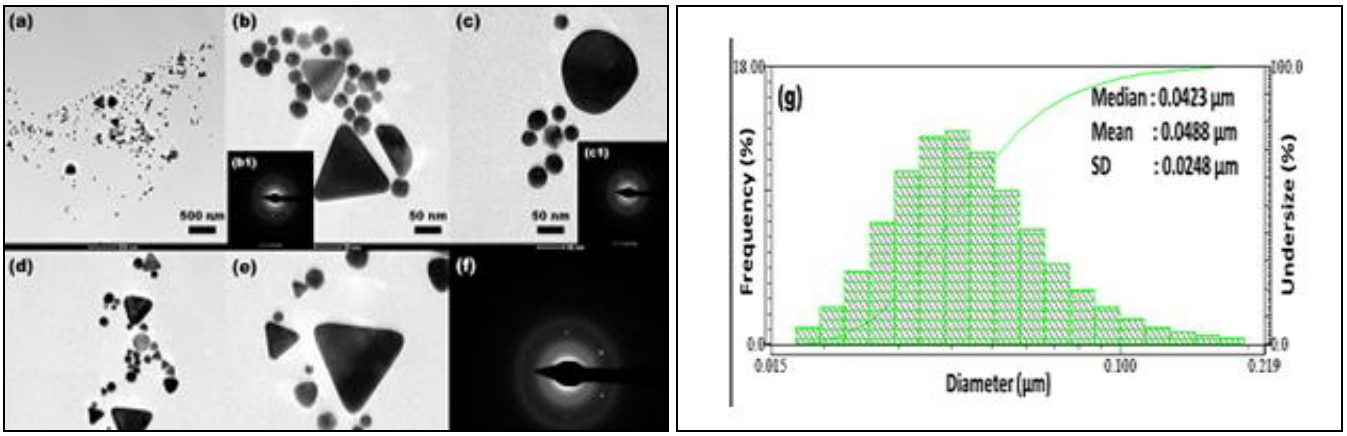


FIG. 2: TEM IMAGES (A-E), SAED (B1, C1, F) AND (G) DLS SIZE DISTRIBUTION PATTERN OF AS-SYNTHESIZED AUNPS

Green Synthesized Gold Nanoparticles Stabilized by *Terminalia chebula* Acts as Antibacterial Agent: Gold nanoparticle was developed by *T. chebula* with green synthesis approach for the inhibition of bacterial strains.

The formulation was developed by manual shaking between chloroauric acid and *T. chebula* extract. The colour change from yellow to pink indicated the formation of the construction. The formulation was evaluated by ultraviolet spectroscopy, X-ray diffraction analysis, transmission electron microscopy, and antibacterial activity against *E. coli* and *S. aureus* [21].

A band near 535 nm in surface plasmon resonance and a single peak for gold in energy dispersive X-ray analysis confirmed the constitution of the product. Antibacterial activity data confirmed the dose-dependent action of the product towards inhibition of bacterial strains **Fig. 3**.

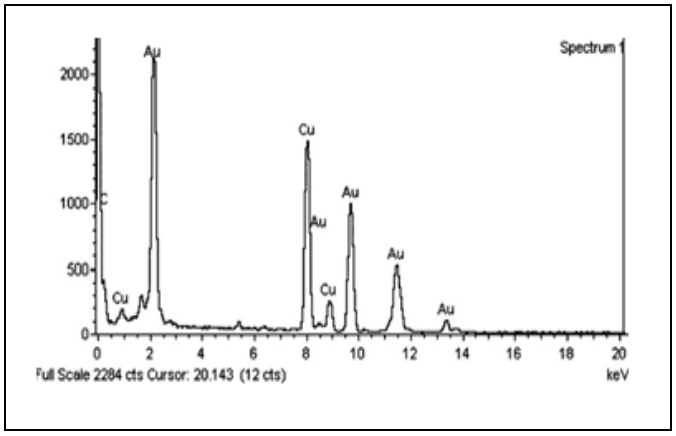


FIG. 3: EDAX PATTERN OF AU NPS

Green Synthesized Gold Nanoparticle Mediated by *Aloe arborescens*: *A. arborescens* was used as a reducing agent to stabilize and develop the triangular shape of gold nanoparticle, followed by chemical characterization UV-visible spectroscopy with surface plasmon resonance, transmission electron microscopy, and fourier transformed infrared spectroscopic techniques [22].

A band near 966 nm observed in UV-Visible spectroscopic and transmission electron microscopic data confirmed the triangular shape of the nanoparticle. Characteristic Fourier Transformed Infrared spectroscopic data and other analyses hypothesized its anticancer efficacy and usefulness in optical coatings.

Green Approaches towards Formation of Gold Nanoparticle Mediated through Banana (*Musa paradisiaca*) Peel Extract as Antifungal and Antibacterial Agent: Newer generation gold nanoparticle was developed using reduction and stabilization by *M. paradisiaca* extract and chloroauric acid solution. The nanoparticle was further optimized by maintaining different ratios of chloroauric acid and banana peel extract with varying pH solutions [23]. The formulation was chemically characterized by UV-visible spectroscopy, X-ray diffraction and Fourier transformed infrared spectroscopic techniques.

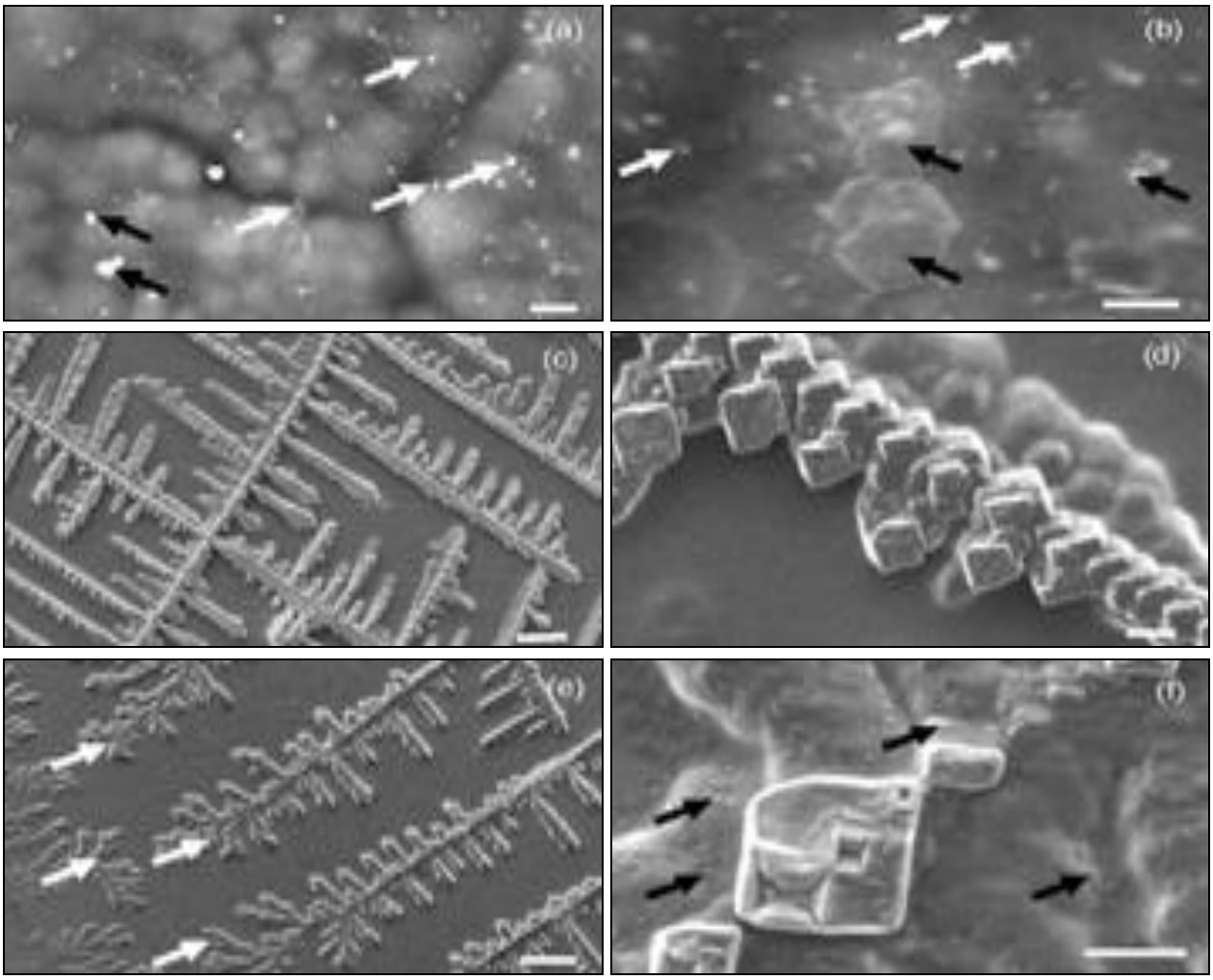


FIG. 4: SCANNING ELECTRON MICROGRAPHS OF GOLD NANOPARTICLES

Antifungal and antibacterial characterizations of nano formulation were assessed against *Candida albicans* (BX and BH) and *Citrobacter kosari*, *Escherichia coli*, *Proteus valgaris*, *Pseudomonas aeruginosa*, *Enterobacter aerogenes* and Klebsiella species. A colour change of pink to red with shifting pH values from 3.0 to 5.0 and average particle size of 300 nm were the characteristics property of this composition. A remarkable inhibition against *Candida albicans* BX, *Citrobacter kosari*, *Escherichia coli*, *Proteus vulgaris*, and Klebsiella species **Fig. 4** confirmed the antifungal and antibacterial efficacies of the formulation.

Green synthesized Gold Nanoparticle Tagged with *Alternanthera philoxeroides* as Antimicrobial Agent: *A. philoxeroides* extract coated gold nanoparticle was developed by using centrifugation between chemically synthesized gold nanoparticle (reaction between chloroauric acid and trisodium citrate) and green gold nanoparticle (reaction between gold chloride and A. philoxeroides extract) followed by lyophilization. The formulation was chemically characterized by UV-Visible spectroscopy, elemental analysis, and Fourier transformed infrared spectroscopy and evaluated microbiologically against *Pseudomonas aeruginosa*, *Escherichia coli*, *Micrococcus luteus*, *Acinetobacter lwoffii* and *Bacillus subtilis* by disc diffusion assay method [24]. Two peaks at 284 and 535 nm in UV-visible spectroscopic data confirmed the formation of green gold nanoparticle. Peaks were observed due to phenolic hydroxyl group present in *A. philoxeroides* extract and gold nanoparticle. The particle size of the formulation was 35 nm and 81 nm respectively after and before tagged with extract. The antimicrobial data clearly stated that strains of *P. aeruginosa*, *E. coli*, *M. luteus* and *B. subtilis* were observed with dose-dependent inhibition.

Green Approached Haemocompatible Gold Nanoparticle Mediated Through *Cissus quadrangularis* Extract: A centrifugation between *C. quadrangularis* extract and hydrogen tetra-chloroaurate at 10,000 rotations per minute for 20 min, developed the nanoparticle, which was characterized by electron microscopy, X-ray diffraction, dynamic light scattering, and haemolytic activity [25]. A hump near 650 nm as per UV-Visible spectra confirmed the formation of aggregates; the hydrodynamic diameter between (20-512) nm confirmed the particle size of the product. Haemolytic activity was less than 5% which confirmed the haemocompatible activity of the constituents. So, this green synthesized gold nanoparticle was used in the treatment of inflammatory diseases **Fig. 5**.

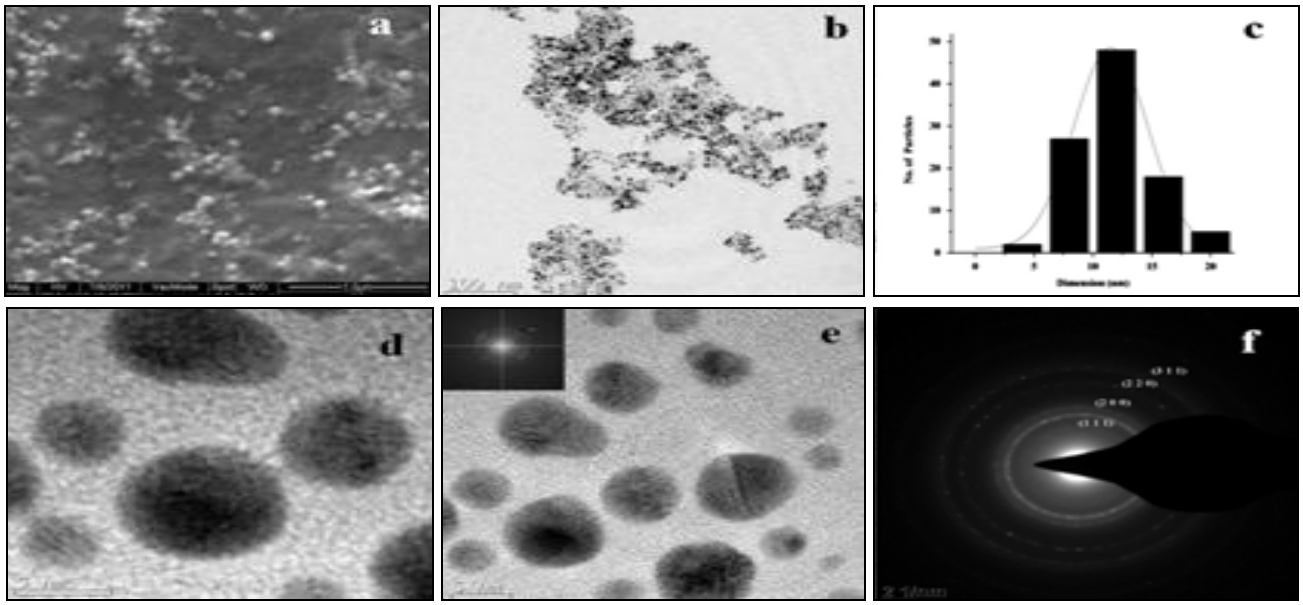


FIG. 5: ELECTRON MICROGRAPHS OF AUNP FORMED FROM CQE AND [AU] = 0.25 MM (PH 9) USING MICROWAVE IRRADIATION. (A) SEM IMAGE, (B) TEM LOW MAGNIFICATION, (C) SIZE DISTRIBUTION HISTOGRAM OF PARTICLES FROM TEM IMAGES, (D) AND (E) HR-TEM IMAGE, INSET FFT IMAGE AND (F) SAED PATTERN

***Sterculia acuminata* Mediated Gold Nano-particle as Reducing Agent:** Gold nanoparticle was developed through a reaction between chloroauric acid and *S. acuminate* extract with (1:5) ratio. The formation was observed with distinguished colour change from light yellow to violet. The nanoparticle was characterized by ultraviolet spectroscopy, X-ray diffraction analysis, transmission electron microscopy, dynamic light scattering property, potentiometric analysis and catalytic activity [26].

A band near about 539 nm at surface plasmon resonance data corresponds with the formation of nanoparticle and particle size within (9.37-38.12) nm with an average size of 26.5 nm, which was observed by transmission electron microscopic data. The reducing times for the formulation were 36 min, 12 min, 12 min, and 18 min against 4-nitrophenol, methylene blue, methylene orange, and DB24, respectively. Hence, this green approached gold nanoparticle confirmed the catalytic activity against experimental dye **Fig. 6**.

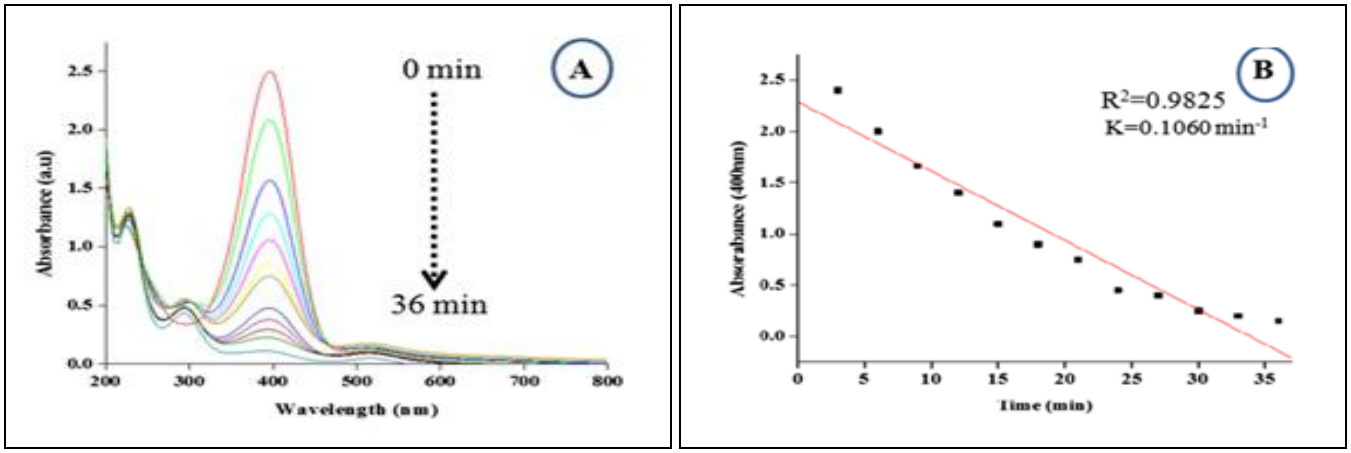


FIG. 6: CATALYTIC ACTIVITY OF SYNTHESIZED AUNPS (A) AND KINETICS OF CATALYTIC REDUCTION OF 4- NITROPHENOL BY AUNPS (B)

Green Synthesized Gold Nanoparticle Mediated by Kokum Fruit: Gold nanoparticle was green synthesized by the reaction between (0.2-1.5) mM chloroauric acid and kokum (*Garcinia indica* Choissy) fruit extract with a range from [1:1 to 1:5]. The respective colour change from yellow to red affirmed the formation. Nanoparticle was characterized by ultraviolet spectroscopy with surface plasmon resonance technology, energy dispersive x-ray spectrometer, photoluminescence and photolytic degradation of methylene blue [27]. A peak near about 540 nm observed by surface plasmon resonance supported the formation of a gold nanoparticle. The optimized particle with (20-30) nm was obtained with variable concentration of chloroauric acid between (0.2-0.36) mM, pH of 4.0, and 80 °C temperature, and they were endowed with good photo luminescent activity **Fig. 7**.

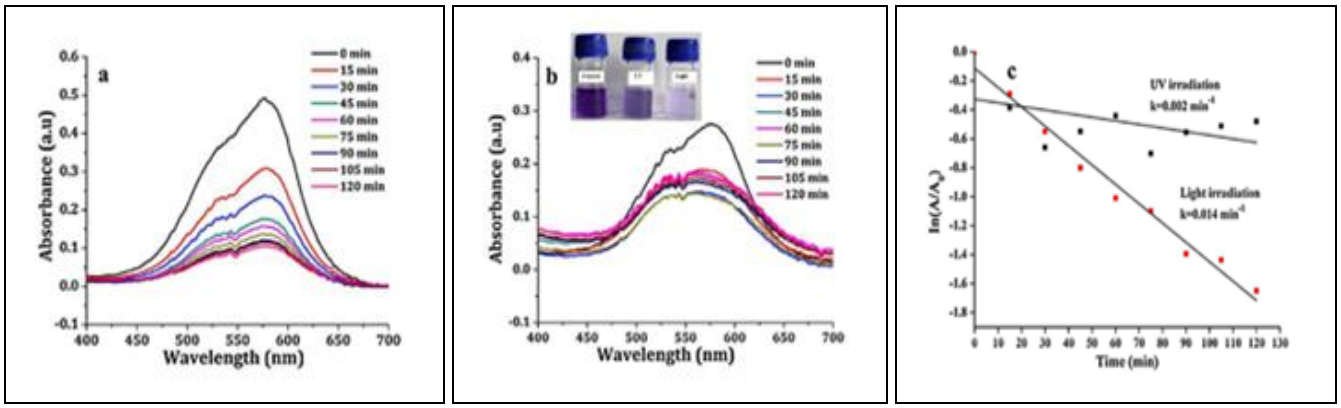


FIG. 7: PHOTOCATALYTIC DEGRADATION OF MV BY BIOGENIC AUNPS. UV VISIBLE SPECTRA SHOWING DEGRADATION OF MV UNDER (A) VISIBLE LIGHT IRRADIATION, (B) UV IRRADIATION AND (C) PLOTS OF LN (A/A0) AGAINST TIME SHOWING LINEAR CORRELATION BETWEEN DEGRADATION AND TIME. INSET SHOWS THE REDUCTION IN COLOUR INTENSITY OF MV ACHIEVED UNDER VISIBLE AND UV IRRADIATIONS

Green Approached Gold Nanoparticle Mediated by *Eucalyptus globulus* and *Rosmarinus officinalis*: Gold nanoparticle was green integrated with the reaction between *E. globulus* and *R. officinalis* extracts with tetrahydrate chloroauric acid. The formulation was optically and morphologically characterized by ultraviolet spectroscopy, transmission electron microscopy and energy dispersive spectroscopy; the chemical composition of the product was defined by attenuated total reflection-fourier transform spectroscopic techniques. The localized surface plasmon resonance data of gold nanoparticle was observed with peaks at 534.6 nm and 544.2 nm, respectively by *E. globulus* aqueous leaf extract and essential oil [28]. Transmission electron microscopic data revealed average particle size of 12.8 nm and 42.2 nm from *E. globulus* aqueous extract and *E. globulus* essential oil respectively. Likewise, the average particle size of 8.66 nm was the observed with aqueous extract of *R. officinalis* whereas that for gold nanoparticle with essential oil of *R. officinalis* was 60.7 nm. These outcomes ascertained the formation of biocompatible gold nanoparticle with *E. globulus* and *R. officinalis*.

Green Synthesized Gold Nanoparticle Mediated *Punica granatum* for Cancer Therapy: Gold nanoparticle was constructed by ultra-centrifugation of *P. granatum* and hydrochloroauric acid; 5-flurouracil, *P. granatum* and hydro-chloroauric acid; folic acid conjugated 5-flurouracil loaded with *P. granatum* and hydrochloroauric acid using casein as biocompatible polymer. At pH 7.4 using sodium phosphate buffer, absorbance was measured at 266 nm by ultraviolet spectroscopy. The compositions were biologically characterized by haemolytic assay, *in-vivo* toxicity studies against zebrafish embryos and *in-vitro* cytotoxicity evaluation against breast cancer cell line [29]. The outcomes revealed that mean particle diameters were 70.0 nm and 70.90 nm for green approached gold nanoparticle and 5-flurouracil loaded gold nanoparticle, respectively; whereas long-term stabilization was observed with (-) 18.3 mV of zeta potential in case folic acid conjugated 5-flurouracil loaded green approached gold nanoparticle.

A concentration of around 1.625 µg/ml was observed with haemolytic potential. The concentration between (500-750) µg of green approached gold nanoparticle and (250-750) µg of 5-flurouracil loaded green approached gold nanoparticle were associated with a decreased survival rate of the zebrafish embryo. The MTT assay outcomes reached a conclusion that 5-flurouracil loaded green approached gold nanoparticle was effective than 5-flurouracil against breast cancer cell line **Fig. 8**.

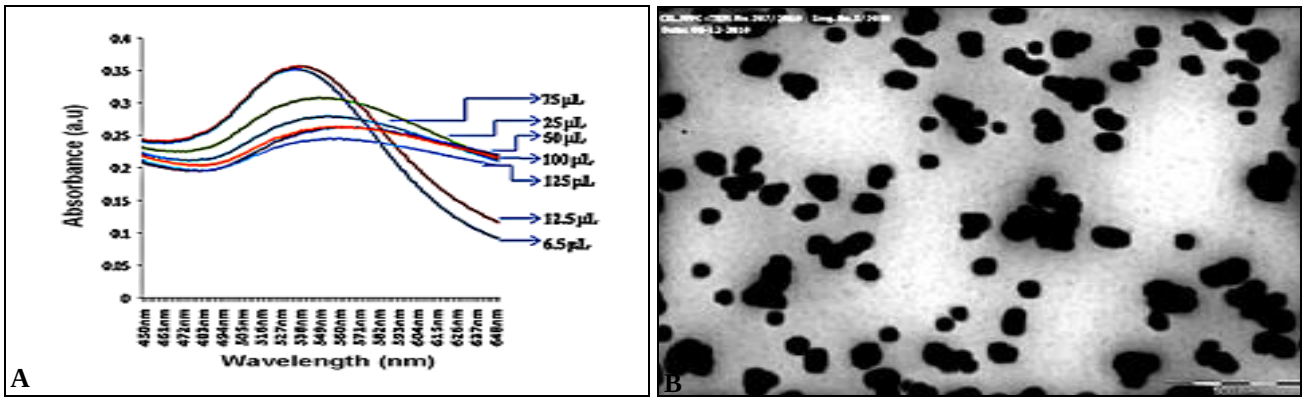


FIG 8: (A) OPTIMIZATION OF PAUNPS BY CHANGING VARIOUS CONCENTRATIONS OF POMEGRANATE PEEL EXTRACTS WHILE KEEPING GOLD SOLUTION AS CONSTANT. (B) TEM IMAGE OF PAUNPS

Green Approached Gold Nanoparticle Mediated *Punica granatum* Juice as Antioxidant Agent: One pot synthesized gold nanoparticle was developed by centrifugation between chloroauric acid and *P. granatum* juice at 7000 rotations per minute for 10 min. Then it was characterized using ultraviolet spectroscopy, scanning electron micro-scopy, x-ray diffractive analysis, and biologically characterized by antioxidative assessment using DPPH and hydrogen peroxide scavenging methods [30]. The outcomes revealed that between variable pH of 2-12, the surface plasmon resonance data observed with a characteristic peak at 577 nm corresponds the formation of the nanoparticle.

Furthermore, the formulation was assured nontoxic when tested against skin, human dermal fibroblast and human microvascular endothelial cells, the result of which was directly applied through the sunscreen ointment **Fig. 9**.

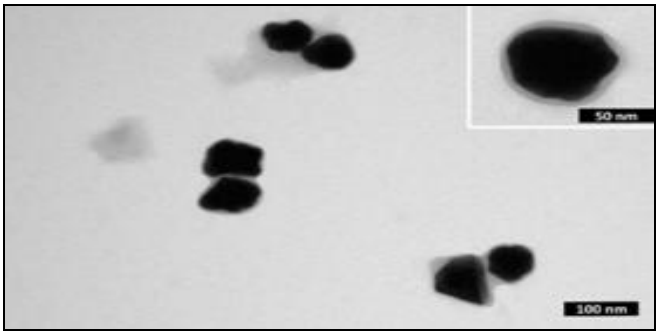


FIG. 9: TEM MICROGRAPHS OF AUNPS. THE INSET SHOWS A DETAIL OF A SINGLE AU NPS SURROUNDED BY A CONTINUOUS ORGANIC COATING EVIDENCED BY THE LIGHT GREY LAYER AROUND THE NPS

Green Stabilized Gold Nanoparticle Mediated through *Pistacia atlantica* Extract: Gold nanoparticle was developed using *P. atlantica* extract upon centrifugation between *P. atlantica* extract (10 ml) and chloroauric acid for 15 min at 10,000 rotations per minute followed by washing with deionized water.

The formulation was evaluated with antioxidative properties following DPPH radical scavenging method and cytotoxicity assessment through human cervical carcinoma cell line. Antibacterial evaluation was performed against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Bacillus subtilis* [31].

The outcomes observed that average particle diameter lied between (40-50) nm with spherical shape and a characteristic peak at 530 nm as per surface plasmon resonance was noted. The biological outcome displayed dose-dependent antioxidative and antibacterial properties without any induced cytotoxic behaviour **Fig.10**.

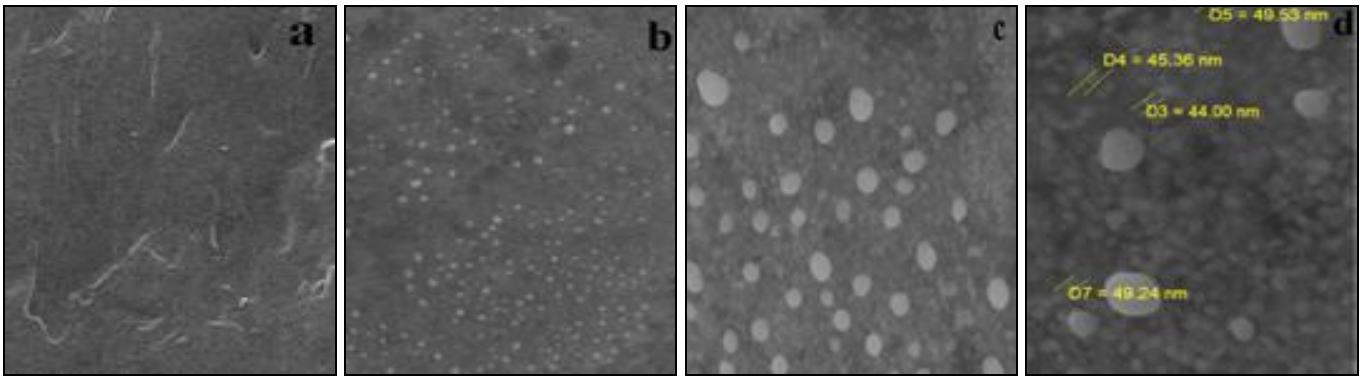


FIG. 10: SEM IMAGE OF (A) *PISTACIA ATLANTICA* EXTRACT; AND (B–D) DIFFERENT MAGNIFICATION OF BIOSYNTHESIZED AU NPS

Green Synthesized Gold Nanoparticle Mediated through *Pistacia integerrima* Gall Extract: Gold nanoparticle was developed by the interaction between *P. integerrima* gall extract and hydrated hydrogen tetrachlorocuprate.

The reductive nature of aurum was measured by ultraviolet spectroscopy within (200-900) nm wavelength. Stability testing was checked in hypertonic solution within pH range of (4-5) and (10-11).

The formulation was biologically evaluated as enzyme inhibitor against urease, xanthine oxidase, carbonic anhydrase-II enzyme and inhibitory concentration 50% were observed as 96.3 µg/ml, 21.45 µg/ml and 23.45 µg/ml, respectively; antimicrobial activity was assessed against *Klebsiella pneumonia, Bacillus subtillis, Staphylococcus aureus, Alternaria solani*, *Aspergillus niger*, *Aspergillus flavus* followed by antinociceptive effects with 80.76 writhing at 20 mg/kg dose, muscle relaxant and sedative activities [32].

The outcomes indicated that a peak was observed at 540 nm for plant extract as per scanning electron microscopy with (20-200) nm of average particle size. These outcomes confirmed the greater applications of the nanoparticle in the field of biomedical utilizations **Fig. 11**.

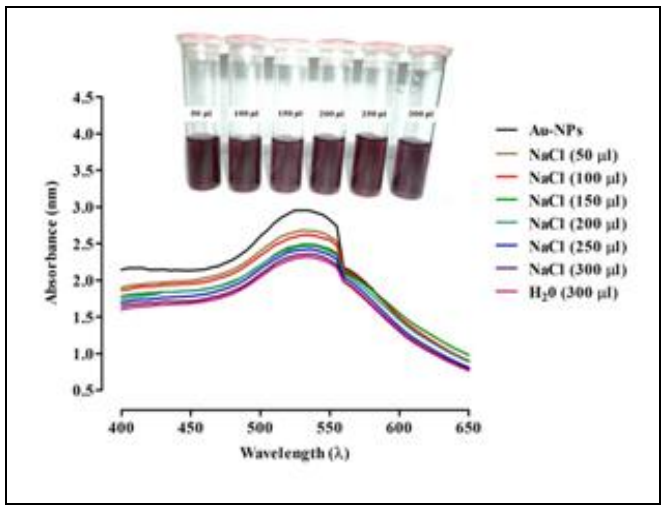


FIG. 11: UV-VIS ABSORPTION SPECTRA SHOWING THE EFFECT OF DIFFERENT VOLUME OF 0.1 M NACL ON THE STABILITY OF *PISTACIA INTEGERRIMA* GOLD NANOPARTICLES

Green Synthesized Gold Nanoparticle Mediated Through *Juglans regia* Green Husk Extract: Gold nanoparticle was obtained through *J. regia* green husk extract. The husk extract was reacted with hydrate gold chloride followed by characterized with ultraviolet spectroscopy, transmission electron microscopy. Cytotoxic assessment was done by MTT assay against 3T3 and HT-29 cell lines [33]. The outcomes were observed with spherical shape nanoparticle with an average particle size of 14.32 nm without any cell toxic behaviour. So, this formulation will be effective for biomedical applications.

Green Stabilized Gold Nanoparticle with *Abelmoschus esculentus* extract as Antifungal Agent: Green synthesized gold nanoparticle was developed by centrifugation using aqueous seed powder extraction of *A. esculentus* and hydrochloroauric acid at 10,000 rotations per minute for 10 min. The nanoparticle was chemically characterized by ultraviolet spectroscopy, X-ray diffractive analysis and scanning electron microscopy and antifungal assessment was done against *Puccinia graminis*, *Aspergillus flavus*, *Aspergillus niger*, and *Candida albicans*. The synthesized nanoparticles were observed with intense peak at 536 nm as per ultraviolet spectroscopy, and a spherical shape nanoparticle with (45-75) nm size range was observed with scanning electron microscopy [34]. Antifungal activity was observed with greater zone of inhibition of 17 mm and 18 mm observed against *Puccinia graminis* and *Candida albicans*, respectively. So, this nano formulation confirmed the greater potentiality of it as antifungal agent.

Green Synthesized Gold Nanoparticle Mediated through *Muntingia calabura*: Gold nanoparticle was developed with green advent using *M. calabura* and used as anticancer agent for laryngeal carcinoma. The formulation was synthesized by centrifugation process between crude extract of *M. calabura* and tetra chloroauric acid at 14,000 rotations per minute for 15 min followed by isolation of violet coloured nanoparticles. The nanoparticle was characterized chemically by ultra-violet-spectroscopy, Fourier transformed infrared spectroscopy, transmission electron microscopic techniques and biologically by cytotoxicity studies against laryngeal carcinoma cell line (Hep2) utilizing African green monkey kidney cell (Vero) as control, followed by BrdU proliferation assay and cell morphological studies [35]. The outcomes expressed that surface plasmon resonance band at 531 nm authenticated the formation of gold nano-particle. Again, (-) 18 millivolt of zeta potential coming out with this result indicated the less chance of agglomeration which is further strengthened by the spherical 27 nm average particle sized nano formulation. From the biological experiments, it was understood that green approached gold nanoparticles noticed with observable cell toxic behaviour and BrdU incorporation as compared to that of 5-flurouracil. In addition, with this formulation greater possibility of cell cycle arrest was observed at G2 phase. So, this nano formulation exhibited good anti-proliferative properties against laryngeal cancer.

Green Accessed Gold Nanoparticle Mediated through *Solanum nigrum* Leaf Extract with Antimicrobial Efficacy: Newer generation of gold nanoparticle was developed using *S. nigrum* leaf extract as active against gram+ve (*Staphylococcus saprophyticus* and *Bacillus subtilis*) and gram -ve (*Escherichia coli* and *Pseudomonas aeruginosa*) bacterial strains. The nanoparticle was developed upon reaction between *Solanum nigrum* leaf extract and chloroauric acids. The visible colour change from violet to purple pink was indicative of the formation. The preparation was chemically characterized by ultraviolet spectroscopy, dynamic light scattering and zeta potential analysis which

was followed by anti-oxidative and antibacterial evaluations [36]. The outcomes revealed that surface plasmon resonance was observed at 537 nm. The average particle diameter around 50 nm and zeta potential around (-) 17.80 mV confirmed the formation with average stability. The outcomes ascertained that green synthesized nanoparticle observed with better anti-oxidative and antibacterial efficacies than *Solanum nigrum* leaf extract alone.

Green Approached Gold Nanoparticle Stabilized through *Vitis vinifera* Peel Polyphenols as Anticancer Agents: Gold nano-particle was developed by incubation between *V. vinifera* peel extracts (10 ml) and (90 ml) of hydrogen chloroauratetrihydrate, followed by centrifugation at 14,000 rotations per minute for 20 minutes. The nanoparticle was discriminated by ultraviolet spectroscopy, transmission electron microscopy, particle size distribution, and zeta potential analysis [37]. The fallout observed with a characteristic surface plasmon resonance band near 540 nm along with hydrodynamic particle size between 20-80 nm, 52.2 nm of mean particle diameter, and (-) 20 miliVolt of zeta potential assured the formation of particles with a lesser tendency for aggregation. The anticancer efficacy of the nanoparticles was measured against A431 skin cancer cell lines. The results confirmed that concentrations of 15 µM, 20 µM, and 25 µM were correlated with better inhibition against A431 as compared to standard 5-flurouracil with modified cell morphology. These data stated the efficiency of the green advanced gold nanoparticle with anticancer efficacy.

Green Synthesized Gold Nanoparticle Mediated through *Rosa hybrida* Petal Extract: Gold nanoparticle was developed with stabilization through *R. hybrida* petal extract upon reaction between aqueous rose petal extract (10-100) % and chloroauric acid (2 mM) at room temperature within 5 min. The colour change from yellow to violet confirmed the formation, followed by characterization using ultraviolet spectroscopy, Fourier transformed infrared spectroscopy, transmission electron microscopy associated with energy-dispersive X-ray spectroscopic analysis [38]. The fallout revealed that a peak at 750 nm confirmed the formation of a triangular, spherical, hexagonal anisotropic gold nanoparticle with 10 nm average particle size. These data confirmed the formation of green approached gold nanoparticle with an inexpensive method.

Green Synthesized Gold Nanoparticle Mediated by *Crescentia cujete* L. as Antibacterial and Anticancer Agents: Gold nanoparticle was green synthesized upon the interaction between 1mM chloroauric acid and 10% of *C. cujete* L in a (9:1) ratio at 60 °C for 25 min with the maintenance of pH value near to 7.0 and the formation was confirmed by colour change from yellow to pinkish-violet.

The nanoparticle was chemically characterized by ultraviolet spectroscopy, transmission electron microscopy, dynamic light scattering, and zeta potential analysis. A characteristic band near 560 nm, particle size distribution between (30-40) nm with 32.89 nm of average size diameter and (-) 26.4 mili Volt of zeta potential confirmed the formation of particles within nano range and greater stability [39].

The nanoparticle was microbiologically assessed by bactericidal effects against *E. coli*, *P. aeruginosa*, *V. cholerae*, *S. typhi*, *S. flexneri*, *B. subtilis*. Its cytotoxic efficacy was evaluated against HeLa cell line.

The results displayed that greater bactericidal inhibition was evidenced against *E. coli*, *P. aeruginosa*, *V. cholerae*, *S. typhi*, *S. flexneri*, and a concentration of 316 µg/ml was required to produce static half of growth of HeLa cell line. These findings cumulated the potential use of green entranced gold nanoparticle as a good antibacterial and anticancer agent.

Gold Nanoparticle Mediated by *Momordica chirantia* fruit Extract with Colorimetric Application: Gold nanoparticle was green accessed using *M. chirantia* fruit extract and hydroxylated gold (III) particles [40].

The confirmatory peak at 520 nm was noticed with the limit of detection of cadmium in an aqueous environment with thiophenol target was 0.154 µM. These data confirmed the formation and efficiency of *Momordica chirantia* stabilized gold nano-particle as a significant heavy metal ion sensor.

Green Synthesized Gold Nanoparticle using Aqueous *Citrus limon, Citrus reticulata* and *Citrus sinensis*: Gold nanoparticle was green synthesized involving citrus fruits (*C. limon*, *C. reticulata* and *C. sinensis*) upon centrifugation between 1 mM (50) ml of tetrachlorocuprate trihydrate and citrus fruits concentration (1 ml, 2 ml, 3 ml, 4 ml, 5 ml, 6 ml) at 15,000 rotations per minute for 20 min. The colour change from colourless to purple to ruby red and characteristic band between (530-550) nm ascertained the construction of the formulation. The preparation was identified by transmission electron microscopy, X-ray diffraction analysis, and zeta potential measurements [41]. The event produceda prism and spherical shaped particle with average particle size of 32.2 nm, 43.4 nm and 56.7 nm observed for *C. limon*, *C. reticulate* and *C. sinensis*, respectively. So, in the near future, this nanoparticle may be consumed for biomedical applications.

Green Stabilized Gold Nanoparticle Mediated Through *Artemisia vulgaris* L. Leaf Extract: Gold nanoparticle was greenly entranced by centrifugation process between (10) ml of *A. vulgaris* and (90) ml of hydro chloroauric acid at 10, 000 rotations per minute for 15 minutes. The colour change from yellow to red confirmed the formation. Then the formulation was chemically described by ultraviolet-spectroscopy, X-ray diffraction, dynamic light scattering, transmission electron microscopy, zeta potential analysis, and ^{13}C NMR studies [42]. The preparation (25 ppm, 50 ppm, 100 ppm, 200 ppm, 400 ppm) concentrations were used to evaluate the mortality studies of the formulations against *Aedes aegypti* L dengue larva. A specific surface plasmon resonance band at 544 nm, 32.92 nm of average particle diameter and (-) 19.3 millivolt of zeta potential provided confidence about the formation and stability of the formulation. After 24 h, green approached gold nanoparticle produced a greater mortality rate against *A. aegypti* L. dengue larva with LC_{50} value of 62.47 ppm. These findings and data confirmed the effectivity of nanoformulation against dengue.

Green Synthesized Gold Nanoparticle using *Barbated skullcap* Herb Extract as Sensor: Gold nanoparticle was green synthesized with the reaction between chloroauric acid (0.01 M) and aqueous *Barbated skullcup* herb extract. The best formulation was observed with formulation of 15.2 nm particle size and (6.85×10^{-4}) M of chloroauric acid [43]. After 3 h of incubation, a characteristic peak near 540 nm was observed with greater intensity. The particle size of most of the formulation was lied between (5-30) nm. These data concluded that near about 3 h was required to convert gold ion into nanoparticle. Cyclic voltammetry data showed possible interaction between electrodes and p-nitrophenol. Hence, this green stabilized gold nanoparticle was observed as good sensor for electrochemical industries.

Green Mediated Gold Nanoparticle using *Mimosa pudica* as Anticancer Agent: Gold nanoparticle was green synthesized upon reaction between *M. pudica* leaf extract and chloroauric acid (1.6: 10) ratio at 55 ºC with confirmatory colour change from pale yellow to ruby red [44]. The formulation was chemically characterized by ultraviolet spectroscopy, Fourier transformed infrared spectroscopy, X-ray diffraction, and high resolute transmission electron microscopy. The *in-vitro* cytotoxicity properties were evaluated against breast cancer cell line (MDA-MB-231 and MCF-7).

The outcomes were observed with cell cycle arrest between G0/G1 to S phase with increase in tail length by comet assay followed by translocation of phosphatidyl serine from inner membrane with DNA damage in the stained cells by PI and DAPI staining. MTT assay revealed inhibitory concentration (50%) with 4 µg/mL and 6 µg/mL against MDA-MB-231 and MCF-7 cells breast cancer cell lines; respectively. These data confirmed the efficiency of the green synthesized gold nanoparticle as anticancer agent.

Green Synthesized Gold Nanoparticle using *Sargassum wightii* Greville: Gold nanoparticle was developed adopting reaction between marine algae biomass *S. wightii* Greville and hydro chloroauric acid at room temperature with confirmatory final colour of ruby red [45].

A peak at 527 nm by surface plasmon resonance, (8-12) nm of particle size and four peaks around 38°, 45°, 65°, 82° were the identifying characters of the nano-particle. These data confirmed the possible applicability of the gold nanoparticle.

Green Approached Gold Nanoparticle using Dragon Fruit: Gold nanoparticle was developed upon centrifugation between an aqueous solution of dragon fruit and hydro chloroauric acid at 15,000 rotations per minute and biologically characterized by cytotoxicity assessment against L929, MCF-7 and MDA-MB-231 cell lines [46]. A peak at 560 nm by surface plasmon resonance, (10-20) nm of particle size, (-) 25.88 mili Volt of zeta potential and four peaks at 38.3°, 44.5°, 64.5°, 77.8° as per X-ray diffractive analysis were the characteristic features of the formulation. The biocompatible study results reflected that the MDA-MB-231 cell line was highly compatible with newer gold nanoparticle followed by L929 and MCF-7 cell lines. These data confirmed the formation of biologically compatible gold nanoparticle with the above procedure.

Green Integrated Gold Nanoparticle using *Ginkgo biloba*: Gold nanoparticle was developed with the extraction between chloroauric acid and *G. biloba* leaf extract and the colour change from pale yellow to ruby red was the confirmation towards production of the particle [47].

The nanoparticle was outlined by ultraviolet spectroscopy, transmission electron microscopy, scanning electron microscopy, X-ray diffractive analysis. A peak at 545 nm by ultraviolet spectroscopy, (10-40) nm of particle size and four peaks at 38.12°, 44.26°, 64.68°, 77.42° and 81.40° were the ancillary points for the formation of gold nanoparticle.

Green Synthesized Gold Nanoparticle using *Cassia auriculata*: Gold nanoparticle was developed by the reaction between aqueous extract of *C. auriculata*, methanol and auric chloride solution. The formation was confirmed by the colour change from orange to ruby red with the reduction of Au^{3+} to Au0. The nanoparticle was represented by ultraviolet spectroscopy, transmission electron microscopy, scanning electron microscopy, X-ray diffractive analysis48. A distinguish peak around 536 nm a per surface plasmon resonance data and spherical, (15-25) nm particle sized hexagonal and triangular shaped nanoparticles with three distinct peaks as per X ray diffraction analysis confirmed the creation of the nanoparticle.

Green Synthesized Gold Nanoparticle using *Cinnamomum zeylanicum* leaf broth: Gold nanoparticle was craeated by the reaction between leaf broth of *C. zeylanicum* and hydrochloroauric acid (2×10^{-4}M), and the dark purple color was confirmed the formation. The aurum nanoparticles were obtained in various sizes and shapes with varied concentrations of broth [49]. The nanoparticle was characterized by ultraviolet spectroscopy, transmission electron microscopy, scanning electron microscopy, X-ray diffractive analysis. A characteristic peak near 540 nm, spherical shaped 25 nm of average particle size, and three peaks around 38, 45, and 65 in X-ray diffraction data were confirmed the nanoparticle formation.

Green Stabilized Gold Nanoparticle using *Elettaria cardamomum* Seed as Antibacterial and Anticancer Agents: Green approached gold nanoparticle was created by a reaction between *E. cardamomum* seed extract and hydrochloroauric acid. The formation was indicated by a violet colour. The preparation was chemically characterized by ultraviolet spectroscopy, transmission electron microscopy, X-ray diffractive analysis. Anti-oxidative assessment was performed by DPPH, nitrous oxide, and hydroxyl free radical scavenging methods followed by antibacterial assessment against *S. aureus*, *E. coli*, *P. aeruginosa* and anticancer assessment against HeLa cancer cell line [50]. A sharp peak at 527 nm and an average particle size of 15.2 nm were the characteristic features of the gold nanoparticle. At 5 µL, 100 µL, 50 µL respectively, the formulation was observed with 50% antioxidative nature as per DPPH, nitrous oxide and hydroxyl free radical scavenging methods. The antibacterial study revealed that *S. aureus* and *P. aeruginosa* were the most sensitive bacterial strains against formulation. Furthermore, at 42.6 µL concentration of the preparation, the growth of HeLa cancer cell line was 50% inhibited. These data confirmed the remarkable anticancer and antibacterial efficacy of gold nanoparticle avenue through *E. cardamomum*.

Green Approached Gold Nanoparticle using *Camellia japonica* L. Leaf Extract as Antimicrobial Agent: Green stabilized gold nanoparticle was developed by ultracentrifugation procedures between *C. japonica* L. leaf extract and chloroauric acid (0.5 mM), which was detected

with colour change from yellow to red. The formulation was attributed chemically by ultraviolet spectroscopy with surface plasmon resonance, Fourier transformed infrared spectroscopy, X-ray diffractive analysis and microbiologically against *Bacillus subtilis*, *Staphylococcus aureus*, *Streptococcus faecalis*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Escherichia coli*, and *Candida albicans* using agar well diffusion method [51]. The surface plasmon resonance peak at 539 nm and four peaks at 38.12°, 44.12°, 63.34°, 79° as per X-ray diffractive analysis data were the prominent features for this formulation. Electron microscopic data revealed the spherical shaped nanoparticle with 20 nm average particle size, and all the microbial strains showed dose-dependent antimicrobial activity. These data strongly support the formation of gold nanoparticle stabilized by *C. japonica* L. leaf extract as promising antimicrobial agent.

Green Stabilized Gold Nanoparticle using *Anacardium occidentale* Leaves Extract as Antimicrobial and Anticancer Agents: Gold nanoparticle with green approached was developed by centrifugation between *A. occidentale* leaves extract and (0.01 M) of chloroauric acid, and the formation was indicated by colour change from yellow to red. Then the formulation was chemically characterized by ultraviolet spectroscopy, transmission electron microscopy, X-ray diffractive analysis. Antibacterial and anticancer assessment were done against *E. coli*, *B. subtilis* and breast cancer cell line, respectively [52]. A peak at 540 nm by ultraviolet spectroscopy, five characteristic peaks at 38.4°, 44.6°, 64.7°, 77.7°, 81.5° in X-ray diffractive analysis and spherical shaped particles with (10-30) nm of particle size were the characteristic features of the nanoparticle. Antibacterial assessment data confirmed that *E. coli* was the sensitive strain against nanoparticle which markedly decreased the cell viability of breast cancer cell line. These data confirmed the greater antibacterial and anticancer efficacies of the gold nanoparticle stabilized by *A. occidentale* leaf extract.

Green Synthesized Gold Nanoparticle using *Nerium oleander* Leaf Extract as Antioxidant: Gold nanoparticle was mediated through *N. oleander* leaf extract upon stirred between leaf extract and (0.003 M) hydro chloroauric acid. Furthermore the black colour of the solution was the identification point of the formation. The formulation was chemically characterized by ultraviolet spectroscopy, X-ray diffractive analysis, high resolution transmission electron microscopy and free radical scavenging activity through DPPH method [53]. A characteristic peak at 560 nm as per ultraviolet spectroscopy, three peaks at 38.3°, 44.4°, 64.5° as per X-ray diffractive analysis with (2-10) nm spherical particle size were the identifying features for the creation of gold nanoparticle with proper inhibition of free radical generation. These data confirmed the formation of newer gold nanoparticle with significant anti-oxidative property.

Green, Synthesized Gold Nanoparticle using Croton, *caudatus* Geisel as Anticancer Agent: Gold nanoparticle was developed by the reaction at room temperature between *C. caudatus* Geisel leaf extract and (0.001M) of chloroauric acid; the confirmatory colour change was yellow to pink54. The formulation was characterized chemically by ultraviolet spectroscopy, scanning and transmission electron microscopic techniques and biologically by anticancer efficacy against HeLa cell line. A peak at 537 nm by ultraviolet spectroscopy, four peaks at 38.1°, 44.0°, 64.4°, 74.4° as per X-ray diffraction, (20-50) nm of particle size distribution with spherical shaped with cytotoxic behaviour were the characteristics parameters for this green synthesized gold nanoparticle.

Green Synthesized Gold Nanoparticle using *Curcumae kwangsiensis* as Anticancer Agent: A new generation gold nanoparticle was synthesized by mixing leaf extract of *Curcumae kwangsiensis* Folium and 1 mM of hydrochloroauric acid sodium hydroxide at 25 ºC temperature for 1 h. The formation of the gold nanoparticle was confirmed by its yellow colour. The formulation was characterized chemically by ultraviolet spectroscopy, scanning and transmission electron microscopic techniques and biologically by anti-oxidative and anticancer efficacy against ovarian cancer cell line. The outcomes showed that an absorption band near 539 nm in ultraviolet-visible spectroscopy and particle size ranges from (8-25) nm with spherical shape in transmission electron microscopy [55].

The biological activities showed that nanoparticle observed with perfect dose dependent inhibition of ovarian cancer cell lines with pose antioxidative property. The observation stated the importance of the formulation as anticancer agent.

Green Synthesized Gold Nanoparticle Obtained from Microbial Source:

Green stabilized gold nanoparticle mediated by yellow oyster mushroom *Pleurotus cornucopiae* var. Citrinopileatus: Gold nanoparticle was developed by reaction between (10) ml 0.8 mg/ml extract of yellow oyster mushroom *P. cornucopiae* var. citrinopileatus and (0.005) M aqueous tetrachloroaurate solution at 25 ℃ in dark condition. The colour change into dark purple confirmed the formation. The nanoparticle was characterized by ultraviolet spectroscopy, transmission and field emission scanning electron microscopy, Fourier transformed infrared spectroscopy and energy dispersive X-ray spectroscopy [56]. Two peaks around 540 nm and 550 nm were detected in ultraviolet spectroscopy with (23-100) nm and (16-91) nm particle sizes which were observed from dried and fresh oyster mushroom. A peak between 17-25 keV was noticed in energy dispersive analysis which confirmed the formation of newer green approached gold nanoparticle with the promising futuristic approach.

Green Mediated Gold Nanoparticle using *Fusarium oxysporum* as Antibacterial Agent: Gold nanoparticle was biosynthesized by centrifugation between chloroauric acid (1 mol/L) and supernatant of *F. oxysporum* hyphae culture at 6000 rotations per minute followed by conjugation of tetracycline (50 µL) to obtain the final gold nanoparticle. The formulation was characterized chemically by ultraviolet spectroscopy, Fourier transform infrared spectroscopy, transmission electron microscopy and biologically by bacterial inhibition against gram positive strain (*B. cereus*, *S. aureus*), gram negative strains (*E. coli*, *P. aeruginosa*) and methicillin resistant *Staphylococcus aureus* [57]. The outcomes revealed that characteristic peak at 530 nm, spherical shape, particle size between (22-30) nm confirmed the formation of gold nanoparticle. The microbiological outcomes stated that conjugated formulation observed with greater susceptibility against *S. aureus* (inhibitory concentration 6.25 µg/mL). These data confirmed the antibacterial efficacy of green synthesized gold nanoparticle.

Green Approached Gold Nanoparticle using *Gordonia amarae* as Sensor of Copper: Gold nanoparticle was developed by the reaction between *G. amarae* cell free supernatant and chloroauric acid in the different temperature and pH. The formulation was identified chemically by ultraviolet spectroscopy, X-ray diffraction analysis, and transmission electron microscopy and biologically by colorimetric assessment of copper [58]. At pH 10.0 and 90 ℃, the formulation was observed as ruby red with spherical shaped nanoparticles with (15-40) nm of particle size range followed by higher sensitivity against copper ions in nanomolar concentration range. Totally, all these parameters justified the efficiency of the green synthesized gold nanoparticle.

Green Stabilized Gold Nanoparticle using *Micrococcus yunnanensis* Strain J2 with Cytotoxicity and Antibacterial Effects: Gold nanoparticle was developed by centrifugation between *M. yunnanensis* strain J2 supernatant and chloroauric acid at 19500 rotations per minute for 30 min. The product was featured by ultraviolet spectroscopy, transmission electron microscopy, X-ray diffraction and thermogravimetric analysis.

The formulation was biologically evaluated through cell toxicity assessment against human brain glioblastoma (U87), epithelial-like lung carcinoma (A549), breast cancer (MCF7), fibrosarcoma (HT1080), colorectal adenocarcinoma (Caco-2), pheochromocytoma (PC12), mouse fibroblast (3T3) and Vero cells followed by antibacterial assessment against *Staphylococcus aureus*, *Bacillus subtilis*, *Micrococcus luteus* and *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, *Escherichia coli*, *Salmonella typhi* [59].

The outcomes revealed that more than 90% of particles were within nonorange with 53.8 nm of average particle size. The zeta potential (-) 17.6 mV was also reflected as the stability of nanoparticle. The thermogravimetric data observed with three weights loss humps at (80-200) ℃, (200-340) ℃ and (350-700) ℃ confirmed the complete degradation of the formulation. The inhibitory concentration (50%) of green

synthesized gold nanoparticle were 73.6 µg/mL, 85.6 µg/mL, 63.5 µg/mL, 65.2 µg/mL, 105.3 µg/mL, 88.4 µg/mL against U87, HT1080, PC12, $CaCo_2$, MCF7 and A549 cell lines, respectively. Antibacterial activity showed greater inhibition against *Micrococcus luteus, Bacillus subtilis* strains. These data confirmed the effectivity of *M. yunnanensis* strain J2 mediated gold nanoparticle as good anticancer and antibacterial agent.

Green Approached Gold Nanoparticle using *Cladosporium cladosporioides* as Antimicrobial agent: Green approached gold nanoparticle was developed by the reaction between aqueous solution of marine endophytic fungus *C. cladosporioides* (isolated from seaweed *S. wightii*) and hydrochloroauric acid.

The nanoparticle was chemically characterized by ultraviolet spectroscopy, field emission scanning electron microscopy, light scattering analysis and microbiologically evaluated against *E. coli, Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginos*a, *Aspergillus niger* followed by antioxidative assessment [60]. A sharp peak at 540 nm, average particle size of 60 nm and four distinct peaks at 38.11, 44.15, 64.71, and 77.69 in X-ray diffractive analysis were the characteristics features of the gold nanoparticle. The antimicrobial data suggested that *B. subtilis* was the most inhibited bacterial strain. So, these experimental findings confirmed the antibacterial efficacy of the green approached gold nanoparticle.

Green Synthesized Gold Nanoparticle using Yeast *Magnusiomyces ingens* LH-F1 as Reducing Agent: Gold Nanoparticle with green approached was developed upon centrifugation between chloroauric acid (50 mM) and yeast suspension (aqueous cell culture of M. *ingens* LH-F1) at 3000 rotations per minute; characterized by ultraviolet spectroscopy, transmission electron microscopy, zetasizer analysis followed by catalytic reduction using (4/3/2)-nitrophenol as substrate molecule [61]. A peak around 540 nm with spherical shaped 80.1 nm of average particle size ascertained of the formation of nanoparticle. The catalytic reduction data showed that 4-nitrophenol was easily reduced into its amino derivative within 3 mins followed by 2-nitrophenol and 3-nitrophenol. These data confirmed the reducing ability of gold nanoparticle stabilized by *M. ingens* LH-F1.

Green Synthesized Gold Nanoparticle using Macroalaga *Padina tetrastromatica* as Cytotoxic Agent: Biogenic gold nanoparticle was developed upon shaking between hydrochloroauric acid (1mM) and 10 ml Fucoidan extracted from using macroalaga *Padina tetrastromatica* for 4 days under room temperature; characterized by ultraviolet spectroscopy, scanning electron microscopy, transmission electron microscopy, X-ray diffraction analysis [62].

A peak around 540 nm with spherical shaped (10-70) nm of average particle size confirmed the formation of the nanoparticle. The percent viable cell was calculated using cyclophosphamide as standard against lung and liver cancer cell lines.

The outcomes revealed that in both cases prepared gold nanoparticle showed similar activities without any major differences as in case of cyclo-phosphamide. These data stated the formation and claimed activity of the biogenic gold nanoparticle.

Green Synthesized Gold Nanoparticle Obtained from Marine Source:

Green Synthesized Gold Nanoparticle using *Gracilaria verrucosa* with Activity against Normal Human Embryonic Kidney (HEK-293) Cell Lines: Gold nanoparticle was developed upon vigorous reaction between *G. verrucosa* extract and chloroauric acid (0.0199 mol/L) in different pH and temperature. The formulation was chemically characterized by ultraviolet spectroscopy, transmission electron microscopy, X-ray diffraction and zeta potential analysis.

The biological compatibility was also tested against human embryonic kidney cell lines using MTT assay [63]. The characteristic peak at 520 nm with less than 20 nm spherical, rhombus, triangular, oval and pentagonal shaped particle confirmed the formation of green synthesized gold nanoparticle with more than 95% survival rate against HEK-293 cell line after 24 h of contact.

These data assured the biological compatibility of gold nanoparticle against normal human embryonic kidney cell line **Fig. 12**.

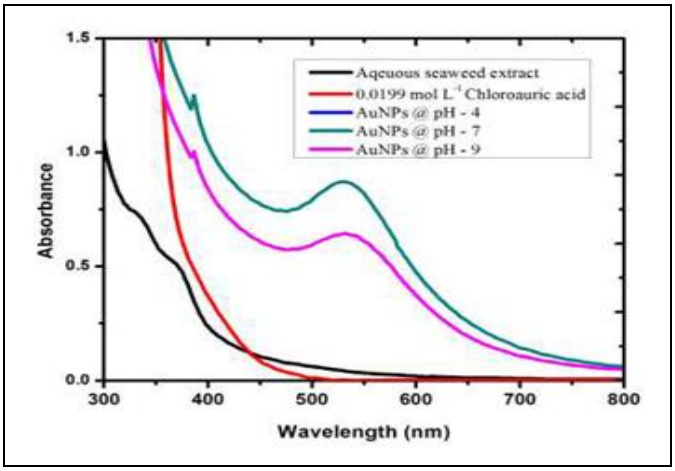


FIG. 12: UV-VISIBLE SPECTRUM OF VARIOUS COMPONENTS. THE AQUEOUS SEAWEED EXTRACTS (BLACK LINE) AND 0.0199 MOL L-1 CHLOROAURIC ACID (RED LINE) SHOWING NO SPR PEAK. A SIMILAR TREND OF SPR PEAK AT 520 NM IS OBSERVED FOR PH 4 (BLUE LINE) AND PH 7 (GREEN LINE). AT THE SAME TIME, A REDUCTION IN ABSORBANCE INTENSITY IS NOTICE FOR PH 9 (ROSE LINE) WITH A SPR PEAK CENTERED AT 520 NM

Green Mediated Gold Nanoparticle using *Galaxaura elongata* as Antibacterial Agent: A set of gold nanoparticle was developed by the reaction of *G. elongatared* algae powder and its ethanolic extract with chloroauric acid (0.001 M). Then the formulation was characterized by particle size analysis, transmission electron microscopy and ultraviolet spectroscopy. Antimicrobial efficacy was evaluated against *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumonia* and *Pseudomonas aeruginosa* using agar diffusion method [64]. The colour change from colourless to red, characteristic peak at 536 nm with particle size between (3.85-77.13) nm were successfully indicated the formation of gold nanoparticle. Antimicrobial study data showed greater potency against *E. coli* followed by K. pneumonia, methicillin-resistant *S. aureus*. These data exhibited the significant antibacterial efficiency of algae mediated gold nanoparticle.

Recent Patents on Green Synthesized Gold Nanoparticles:

Green Synthesized Gold Nanoparticle from Natural Citrus Fruits: Here gold nanoparticle was developed by centrifugation between citrus fruit juice (lemon and orange) and chloroauric acid at room temperature at 4000 rotations per minute, followed by storing at 4 ºC temperature. The wine red colour of the solution indicated the formation of the nanoparticle. A peak near 530 nm confirmed the formation of the nanoparticle.

The particle size of the nanoparticle obtained from lemon and orange juice was 7.8 nm and 11.8 nm respectively. These data justified logically the claim for the synthesis of gold nanoparticle obtained from citrus fruit juice without any chemical reducing or stabilization agent65.

Green Synthesized Gold Nanoparticle from Kiwi Fruit: Gold nanoparticle was developed by stirring chloroauric acid (0.01%) with (0.5-4.0) ml of fresh kiwi berry juice for (0.5-3.0) h. The final red wine colour assured the formation of gold nanoparticle. A peak near 530 nm and particle size range within (5-50) nm confirmed the creation of the nanoparticle. So, the gold nanoparticle from kiwi berry juice was generated without any type of chemical stabilization66.

Green Synthesized Gold Nanoparticle from *Fructus lycii* Extract: Gold nanoparticle was developed by stepwise process such as formation of lixiviate of *Fructus lycii* followed by addition of chloroauric acid and maintenance of pH within 4.0 to 5.0. Then the chloroauric acid-Fructuslycii lixiviate was centrifuged to obtain the final product. The nanoparticle was showed 50 nm of particle size [67].

Green Approached Gold Nanoparticle using *Physalis pubescens*: Gold nanoparticle was developed by centrifugation between gravy liquid of *Physalis pubescens* and chloroauric acid. The colour change from purple to yellow confirmed the formulation. A characteristic peak at 530 nm was observed. The different concentrations of 100%, 50% and 20% of fruit juice were observed with 7.3 nm, 7.1 nm and 11.8 nm, respectively68.

Green Approached Gold Nanoparticle using Lognan polysachharide: Gold nanoparticle was developed by centrifugation between lognan polysaccharide (0.1-30) mg/ml and chloroauric acid (0.1-20) mM with molar ratio between (1:10-100) at (500-1000) rotations per minute in a (40-70) ºC temperature. The outcomes revealed that the particle size of the gold nanoparticle was (5-25) nm [69].

Green Approached Gold Nanoparticle using Red Jujube Polysaccharide: Gold nanoparticle was developed by centrifugation between red jujube polysaccharide (0.1-20) mg/ml and chloroauric acid (0.1-50) mM with molar ratio between (1:10-500) at (200-600) rotations per minute in a (10-80) ˚C temperature within (2-8) h. The outcomes exhibited the particle size of the gold nanoparticle with (8-10) nm [70].

Green Approached Gold Nanoparticle using Polygonumpolysachharide: Gold nanoparticle was developed by centrifugation between polygonum polysaccharide (0.1-30) mg/ml and chloroauric acid (0.1-20) mM with molar ratio between (1:10-40) at (400-1000) rotations per minute in a (50-70) ˚C temperature within (4-8) h. The results revealed that the particle size of the gold nanoparticle was (16-25) nm [71].

CONCLUSION: Nowadays, gold nanoparticle is the most prominent formulation exhibiting versatile application. Gold nanoparticle-mediated by various biogenic sources such as plant, fungi, algae plays an important role in the biosynthetic process. Various plant sources such as *Aegle marmelos*, *Eugenia jambolana*, Soursop, *Persea americana*, *Terminalia chebula*, *Aloe arborescens*, *Musa paradisiacal*, *Alternanthera philoxeroides*, *Cissus quadrangularis*, *Sterculia acuminate*, *Garciniaindica choissy*, *Eucalyptus globulus*, *Rosmarinus officinalis*, *Punica granatum*, *Pistacia atlantica*, *Pistacia integerrima*, *Juglans regia*; various fungal sources as *Pleurotus cornucopiae* var. citrinopileatus, *Cladosporium cladosporioides*; microbial sources such as *Magnusiomyces ingens* LH-F1, *Micrococcus yunnanensis* are used to develop biocompatible gold nanoparticle with very diversified particle size and applicability profile related to anticancer, antibacterial, photo-luminescent, heavy metal sensitizing activity. In present days, scientists are trying to focus on the natural sources for the extraction of biopolymer for treatment of devastative diseases so that less side effects are observed and product become much more useful and effective **Table 1**. As biogenic sources are composed of a large number of hydroxyl and carboxylic acid groups, they can behave as reducing agents for the development of gold nanoparticles with greater biomedical and pharmaceutical applications.

This article provides relevant and important information to know the environment of gold nanoparticles through green synthesis so that new researcher and academicians can find their path for the biosynthesis of gold nanoparticles in a fruitful manner. This novel approach and data are very much encouraging and may be considered as one platform for searching all the important green synthesized gold nanoparticles and might be an index for evaluating drug activities.

TABLE 1: SOURCE, PARTICLE SIZE, CHARACTERISTICS AND APPLICABILITY OF GREEN SYNTHESIZED GOLD NANOPARTICLES

S. no.	Biogenic Sources	Color change	Particle size of Gold Nanoparticle	UV-visible Absorbance Peak	Applicability
1	*Aegle marmelos*, *Eugenia jambolana* and *Soursop*	Pale yellow to wine red	18 nm, 28 nm, 16 nm	519 nm, 523 nm 526 nm	Anticancer
2	*Persea americana*	Colorless to magenta	48.8 nm	520 nm	Antioxidant and Photocatalyst
3	*Terminalia chebula*	Yellow to pinkish red	(6-60) nm	535 nm	Antibacterial
4	*Aloe arborescens*	Colorless to wine red	50 nm	540 nm	Anticancer
5	*Musa paradisiacal*	Yellow to brown (pH 2.0) Yellow to pink (pH 3.0) Yellow to ruby red (pH 4.0) Yellow to dark red (pH 5.0)	300 nm	(510-600) nm	Antifungal and Antibacterial
6	*Alternanthera philoxeroides*	Yellow to wine red	72.11 nm	535 nm	Antimicrobial
7	*Cissus quadrangularis*	Pale yellow to deep	12.0 nm	530 nm	Anti-inflammatory

		red			
8	*Sterculia acuminate*	Light yellow to violet	26.5 nm	539 nm	Reducing Agent
9	*Garciniaindica choissy*	Yellow to dark purple	(20-30) nm	540 nm	Photoluminescent
10	*Eucalyptus globulus* *Rosmarinus officinalis*	Yellow to ruby red	12.8 nm (*E. globulus aqueous extract*) 42.2 nm *(E.globulus essential oil*) 8.7 nm (*R. officinalis aqueous extract)* 60.7 nm (*R. officinalis essential oil)*	534.6 nm (*E.globulus aqueous extract*) 544.2 nm *(E.globulus essential oil*) 532.8 nm (*R. officinalis aqueous extract)* 528.9 nm (*R. officinalis essential oil)*	Biocompatibility
11	*Punica granatum*	Yellow to wine red	70.90 nm	532 nm	Anticancer
12	*Punica granatum*	Pale yellow to red	100 nm	577 nm	Antioxidant
13	*Pistacia atlantica*	Light yellow to dark red	(40-50) nm	530 nm	Antioxidant Antibacterial
14	*Pistacia integerrima*	Purple blue to ruby red	(20-200) nm	540 nm	Biomedical Applicability
15	*Juglans regia*	Pale yellow to dark purple	14.32 nm	531 nm	Biomedical
16	*Abelmoschus esculentus*	Ruby red	62 nm	536 nm	Antifungal Activity
17	*Muntingia calabura*	Stable violet	27 nm	531 nm	Anticancer
18	*Solanum nigrum*	Violet to purple-pink	50 nm	537 nm	Antibacterial Antioxidant
19	*Vitis vinifera*	Yellow to purple red	(20-80) nm	540 nm	Anticancer
20	*Rosa hybrida*	Yellow to violet	10 nm	750 nm	Biomedical
21	*Pleurotus cornucopiae var. citrinopileatus*	Vivid purple	(23-100) nm, (16-91) nm	540 nm, 550 nm	Biomedical
22	*Crescentia cujete L.*	Yellow to pinkinsh-violet	32.89 nm	560 nm	Antibacterial Anticancer
23	*Momordica chirantia*	Red wine	124 nm, 115 nm, 196 nm	520 nm	Heavy metal sensor
24	*Citrus limon, Citrus reticulate, Citrus sinensis*	Colorless to purple to ruby red	32.2 nm, 43.4 nm 56.7 nm	(530-550) nm	Biomedical
25	*Artemisia vulgaris L.*	Yellow to red	89.76 nm	544 nm	Anti larval
26	*Barbated skullcup*	Red	15.2 nm	540 nm	Chemical sensor
27	*Mimosa pudica*	Pale yellow to ruby red	12.5 nm	534 nm	Anticancer
28	*Fusarium oxysporum*	Purple	(22-30) nm	530 nm	Antibacterial
29	*Gracilaria verrucosa*	Colorless to ruby red	Less than 20 nm	520 nm	Biomedical
30	*Galaxaura elongata*	Colorless to red	(3.85-77.13) nm	536 nm	Antibacterial
31	*Gordonia amarae*	Ruby red	(15-40) nm	530 nm	Copper senso
32	*Micrococcus yunnanensis strain J2*	Purple	53.8 nm	520 nm	Cytotoxi Antibacteral
33	*Cladosporium cladosporioides*	Yellow to reddish violet	60 nm	540 nm	Antibacteral
34	*Elettaria cardamomum*	----------	15.2 nm	527 nm	Antibacteral Anticancr
35	*Camellia japonica L.*	Yellow to red	20 nm	539 nm	Antibacteial
36	*Anacardium occidentale*	Yellow to red	(10-30) nm	540 nm	Antimicrbial Anticancer
37	*Nerium oleander*	Yellow to black	(2-10) nm	560 nm	Antioxidant
38	*Croton Caudatus Geisel*	Yellow to pink	(20-50) nm	537 nm	Antimicrobial Anticancer
39	*Magnusiomyces ingens LH-F1*	Light yellow to purple	80.1 nm	540 nm	Reducing agent
40	*Sargassum wightii Greville*	Ruby red	(8-12) nm	527 nm	Biomedical
41	*Dragon fruit*	------	(10-20) nm	560 nm	Biocompatible
42	*Ginkgo biloba*	Pale yellow to ruby red	(10-40) nm	545 nm	Biocompatible

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