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Rapid biosynthesis and characterization of silver nanoparticles from the leaf extract of *Tropaeolum majus* L. and its enhanced *in-vitro* antibacterial, antifungal, antioxidant and anticancer properties

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ABSTRACT

Eco-friendly biosynthesis of nanoparticles from medicinal plants as reducing agent has gained importance due to its potential therapeutic uses. In the present study Silver nanoparticles (AgNPs) were eco-friendly synthesized using the leaf extracts of the medicinal plant *Tropaeolum majus*. The obtained AgNPs were characterized by UV - visible spectrum, FTIR, SEM and XRD which clearly showed the reduction of Ag^+ ions to Ag^0. In addition, the aqueous and ethanolic extracts were analyzed for phytochemicals and its antioxidant activities. GC–MS spectrum showed the presence of 25 compounds with benzeneacetic acid as the dominant contents. The synthesized AgNPs revealed maximum absorption spectrum at 463 nm and FTIR vibrational peaks at 3357.46, 21,966.52, 2118.42, 1637.27, 658.571 and 411.728 cm^{-1} respectively. SEM and XRD studies evidenced the nature of nanocrystalline with face centered cubic (fcc) crystal structure. Both AgNPs and plant extracts showed more inhibition activity against *Pseudomonas aeroginosa* compared to other bacteria with MIC value of 6.25 μg/ml. Antifungal activities was higher for *Penicilium notatum* with MIC value 31.2 μg/ml. The IC50 values for MCF7 for aqueous extract were found to be 4.68 μg/ml, ethanol extract 7.5 μg/ml, AgNPs 2.49 μg/ml, and doxorubicin 1.4 μg/ml. The IC50 values for VERO cell line for aqueous extract was 8.1 μg/ml, ethanol extract with 6.8 μg/ml, silver nanoparticles 5.3 μg/ml and doxorubicin 2.6 μg/ml respectively. Conclusively, the antibacterial, antifungal, antioxidant and anticancer properties of the synthesized AgNPs from *Tropaeolum majus* act as major therapeutic drug for microbial infectious disease and other health associated disorders.

1. Introduction

Herbal medicines are extensively used for curing various disorders and also widely involved for the development of new drugs. Around 20,000 species has been traditionally used as therapeutic medicine and they likely act as a probable source for discovery of new biologically active compounds [1]. In ancient period, different ethnic groups have used folk medicine as an alternative therapy for various disorders. Medicinal plants have been commonly preferred because of its wide level of functional chemical groups with comparatively poor toxic substances [2].

Tropaeolum majus L. (Nasturtium) is an herbaceous plant that belongs to family Tropaeolaceae which majorly grown in South America and it is cultivated throughout the world. It is commonly known as Garden nasturtium or Indian cress [3]. Various bioactive compounds have been abundantly found such as flavonoids (quercetin, and isoquercitrin), fatty acids (oleic and linoleic), vitamin C and benzyl is thiocyanate [4]. Lutein is largely present in both leaves and flowers.

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Table 1
Phytochemical analysis of solvent extracts of *Tropaeolum majus*.

S. No	Content	Plant extract (1 mg/ml)	
		ethanol extract	Aqueous extract
1.	Tanins	+	+
2.	Saponins	−	+
3.	Flavonoids	−	+
4.	Alkaloids	+	+
5.	Proteins	+	+
6.	Steroid	+	+
7.	Quinones	−	−
8.	Terpenoids	+	+
9.	Cardio glycosides	+	+

+; detected, −; not detected.

Leaves have been used as tea bag for the treatment of many diseases like hypertension, inflammation and urinary tract infection [5,6]. Hydro alcoholic extract of this leaves was majorly responsible for diuretic effect due to the rich source of isoquercitrin [7]. Glucosinolates and tetracyclic triterpenes has been isolated from leaves [8–11]. Fresh leaves of this plant are commonly used for the treatment of infected wound, gall bladder, aphrodisiac, chronic diseases such as obstructive pulmonary disease, infections of kidneys and bladder [12] and anti-carcinogenic potential [13,14].

Intake of natural antioxidant from fruits, vegetables and plant sources are increasing in recent years. Natural antioxidant has been vitally helpful in scavenging the free radicals [15]. There is also scientific evidence that consumption of fruits and vegetables showed decreased the risk of cardiovascular diseases and certain forms of cancer [16,17]. The important natural antioxidants groups are polyphenols or flavonoids. These compounds showed beneficiary effects towards human health by their ability to neutralize reactive oxygen species (ROS) and exhibited antioxidant activity [18]. Natural antioxidants are comparatively safer than the synthetic chemicals because they are effectively causing liver damage and are carcinogenic [19].

Many plant species are widely used to treat or prevent the development of cancer. Numerous researchers have focused to identify the plant species which have anticancer properties that have been used as herbal medicine in developing countries [20–25]. Currently, nanotechnology provides a natural approach for improving drug delivery system and bioactivity. The detailed methodology for the reparation of nano-materials using various metal ions such as silver, copper, gold, mercury, cadmium and palladium is widely available; however the application of chemicals resulted in the production larger volume of

Table 2
Phytochemical compounds identified from the solvent extracts of *Tropaeolum majus* by GC–MS.

Retention Time	Area %	List of identified compounds
7.593	1.38	1,4-Dioxane-2,5-dione,3,6-dimethy 1–2,2-dimethyl −1,3-butanediol cyclopentanone 2,2,5-trimethyl
8.180	3.16	1-Butathione sulfoximine 4(3H) – pyrimiinone,2,3-dimethyl pentane,2,3 –dimethyl
8.226	5.24	Benzoic acid Benzoic acid 2- chloroethyl benzoate
8.942	5.29	Benzafuran,2,3-dihydro-benzene,(ethenyloxy) N-Methyl-N-benzyl-4-oxo-4-phenyl-butyramide
9.492	26.09	Benzeneacetic acid Benzeneacetic acid Benzeneacetic acid
10.254	2.57	Benzenamine, 4-bromo-3-chloro-N-(4-methylthiobenzylydene)-2H-1,4-Benzodiazepin-2-one,7-chloro-1,3-dihydro-5-phenyl-1-(trimethylsilyl)-4-(4-chlorophenyl)-,6-diphenylpyridine
10.750	1.76	Phenol,2,6-dimethoxy-pyrazine,2-ethyl-3-(methylthio)-2,4,6-cycloheptatriene-1-thione-mercapto-
11.227	0.72	2-Penten-4-yne,2-methyl-Benzisoxazole-2-acetic acid,hydrazide Quinazolin-4(3H) –one,3-amino-2-benzyl-
11.419	1.70	Benzeneacetonitrile,3-fluro-
15.815	8.20	2-benzathiazolamine,5,6-dimethyl-methanimidamide,N′-(4-methoxyphenyl)-*N*,*N*-dimethyl-2-Benzothiazolamine,5,6-dimethyl-
16.035	3.08	9-Amino-1-methyl-3,6-diazohomodamanatane acetamide,*N*-acetyl-N-9H-fluoren-2-yl-cronaldehyde *O*-pentaflurophenyl metyl-oxime
17.696	5.75	Phenol,2-phenylmethyliminomethyl 4 nitro benzenemethanethiol Benzenemethanethiol
20.505	290	Benzene 6-heptynyl-cyclohexanol,2-phenyl-trans-2-henyl-1-cyclohexanol
22.074	1.83	Tricyclo(10.2.2.2.(5,8))octadeca-5,7,12,14,15,17-hexane,6-nitro-benzamide,N-((4–1-methylethyl)phenyl)methyl)-3,5-dinitro-silane,dimethyl (dimethyl(3-phenyl pro-2-enloxy)silyloxy)(3-phenylpro-2-enyloxy)
22.202	2.19	Trans-3-ethoxy-b-methyl-b-nitrostyrene Tricyclo(10.2.2.2.(5,8))octadeca-5,7,12,14,15,17-hexane,6-nitro-N-(3-chlorophenyl)maleimide
23.661	1.21	2-(acetoxymethyl)-3(methoxycarbonyl)biphenylene 3,5-ethanoquinolin-10-one, decahydro −1,7-dimethyl-,(3R-(3 alpha,4a beta,5 alpha,7 beta, 6a beta)) 1-(5- chloro-2-methylaminobenzoyl)-cyclohex-1-ene 2,3-dihydrobenzo (b) thiophene-3-carboxyl ic acid,methyl ester N-benzylformamide
11.575	2.49	Cycloprop(a)indine,6,bromo-1,1a,6,6a-tetrahydro- 2,6-Difluroaniline Benzeneamine,2,5-difluro-
11.924	0.47	Formamide,N-ethyl-*N*-phenyl-Furo(2,3-c)pyridine,2,3-dihydro-2,7-dimethyl-benzeneamine,4-butyl-
12.319	2.53	7H-1-Benzopyran-7-one,-methyl-2-phenyl-1-acetyl-2-amino-3-cyano-7-isopropyl-4-methylazulene 6-hydroxymethaqualone
12.466	1.78	Acetamide,N-(2-cyclopropylphenyl)-2–3(3-methylphenoxy)-3-isopropoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris(trimethylsiloxy)tetrasiloxane N-(4-isopropylbenzyl)-3-phenylpropionamide
12.5-21	3.17	2-Amino-1.1-dicarboxylic acid,N-(3-flurophenyl)- 4-(N′-(2-oxo-1,2-dihydro-indol-3-ylidene)-hydrazino)benzoic acid purine-2,6-dione,8-(3-ethoxypropylamino)-1,3-dimethyl-3,9-dihydro-
12.557	5.51	Cyclotetrasiloxane,octamethyl-benzoic a cid,5-methyl-2-trimetylsiloxy-,trimethylsisyl ester trisiloxane,1,1,1,5,5,5-hexamethyl-3,3-bis((trimethylsily) oxy)-
13.457	2.77	(−)-1-methylcholanthrene phenol,2-(4 diethylaminophenyliminomethyl)-phenol,2-(1,1-diethyl)-4-(1-methyl-1-phenylethyl)-
14.998	5.22	2,5-pyrolidinedine,1-(phenylethyl)- 5H-(1,4)oxazino(2,3,4-ij)quinolin-3(2H)-one,6,7-dihydro-5,7-indolinedicarboxaldehyde,1-methyl-
15.641	3.02	Cyclonona-1,2,6-triene pyrimidin-2-amine,4-chloro-6-(2,4-dimethylphenoxy)- 2-dimethylamino-6,7-dihydroimidazo (1,2–1)(1,3,5)triazin-4(8H)-one

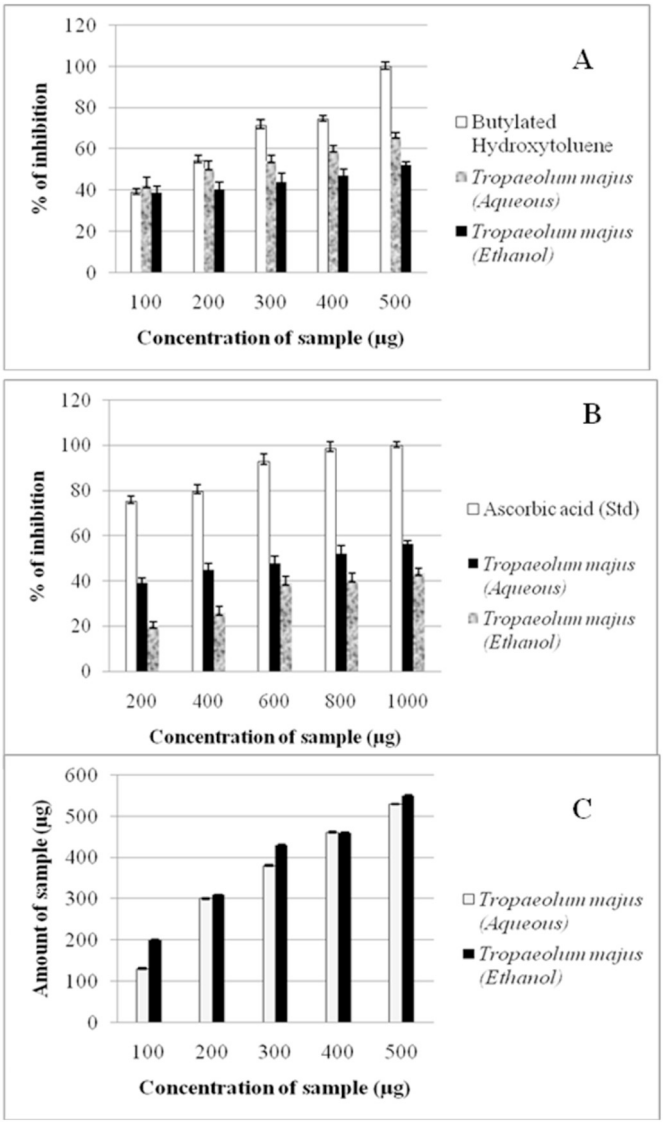

Fig. 1. Antioxidant activity of various extracts of *Tropaeolum majus*.
A: DPPH scavenging activity; B: ABTS assay; C: total antioxidant assay.

toxic components. To reduce the production of toxic components, green biosynthesis of the nano materials by biological samples were encouraged. Recently, the nanomaterials prepared using the metals and metal oxides such as CuO and MgO were used in various fields such as medical, chemical conversion, plastic industries, water purification system and energy production capacitors [26–29]. Recently medicinal plant extracts were commonly used as the starting material for the synthesis of nanomaterials wide various biomedical applications [29]. Especially the extracts of medicinal plants were used as an antibacterial, antioxidant and anticancer agents. Hence attempts were made to test *T.majus* an unexplored plant for synthesis of nanoparticles and its activity against microbial pathogen and cancer.

2. Materials and Methods

2.1. Plant Materials

Healthy fresh leaves of *Tropaeolum majus* L. were collected from the forest regions of Kolli Hills, Namakkal District, Tamil Nadu, India and

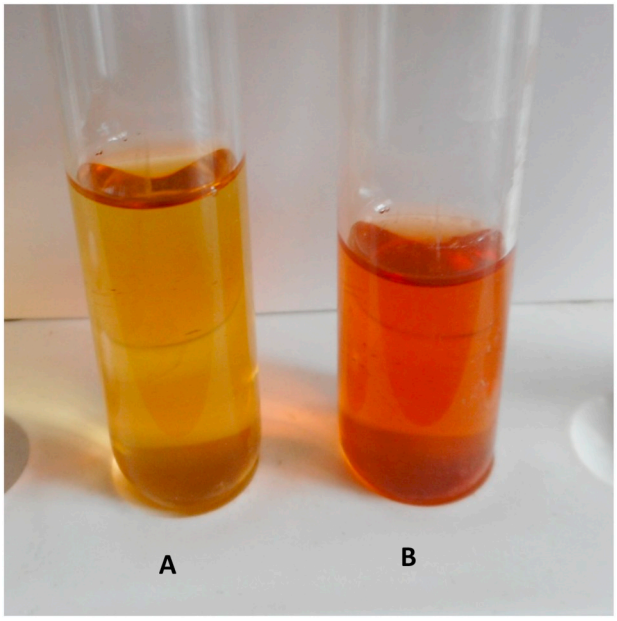

Fig. 2. Synthesis of Silver nanoparticles from the leaves extract of *Tropaeolum majus*.
A: Control; B: Ag nanoparticels.

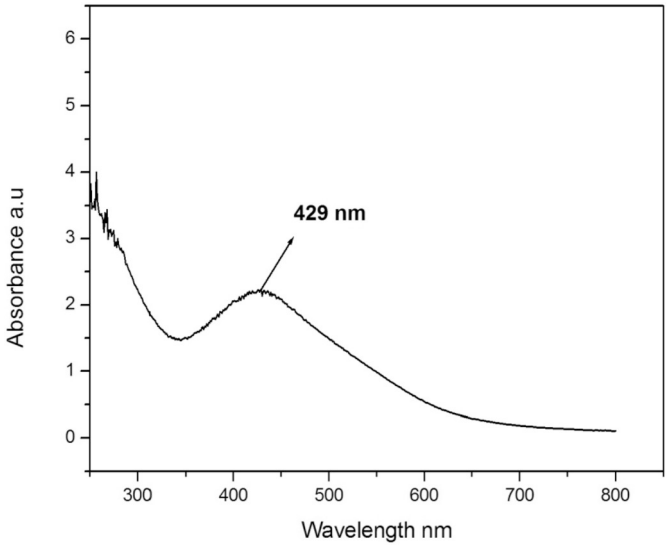

Fig. 3. UV–visible spectrum of the silver nanoparticles synthesized from the leaves extract of *Tropaeolum majus*.

transferred into the ice cold box. After that the fresh leaves were quickly transferred into the laboratory and washed thoroughly to remove the dust and infected leaves. Further, the leaves were kept in the table top and incubated at room temperature for one week and then powdered for the routine experimental usages.

2.2. Preparation of Extract (Soxhlet Method)

Ethanol extract and aqueous extract were prepared according to the methodology of Indian Pharmacopoeia. 25 g of dried sample extracted with 250 ml of solutions to calculate the yield.

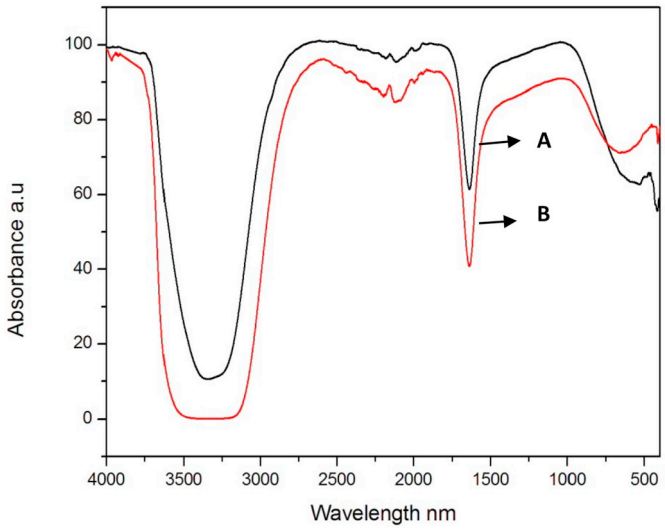

Fig. 4. FTIR spectrum of the silver nanoparticles synthesized from the leaves extract of *Tropaeolum majus*.
A: AgNP; B: *Tropaeolum majus* leaves extract.

2.3. Phytochemical Analysis

The filtrate was tested for the presence of phytochemicals using standard procedures.

2.4. Antioxidant Activity

The antioxidant properties of the plant extracts were performed by following various methodology such as DPPH assay, ABTS assay and total anti oxidant assays respectively [30,31].

2.5. Synthesis of Silver Nanoparticles

Silver nanoparticles are synthesized by mixing the freshly prepared extracts of *Tropaeolum majus* to the freshly prepared 1 mM Silver nitrate solution (1:9 ratio) at room temperature. The silver nitrate solutions were prepared by dissolving the chemicals into the sterile ice cold distilled water [32]. During the incubation, the synthesis of the nanoparticels was noted by alterations in the colur from pale yellow to reddish brown. After the incubation, the solutions were centrifuged at

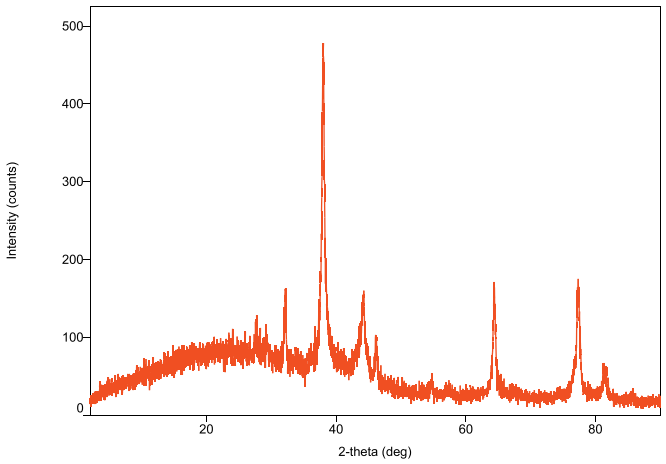

Fig. 6. XRD pattern of the synthesized silver nanoparticles from the leaves extract of *Tropaeolum majus*.

15000 rpm for 60 min to separate the nanoparticles and the collected nanoparticles were air dried and further washed with sterile distilled water and kept in the incubator for powder. The collected powder was stored in the refrigerator for routine chemical characterization and bioassay studies respectively.

2.6. Characterization of Silver Nanoparticles

The obtained nanoparticles were characterized by various analysis such as UV spectrum for measuring the maximum wavelength, FTIR for the identifying the functional group of the particles, SEM and TEM for measuring the size and shape of the nanoparticles, XRD for the studying the powder nature respectively.

2.7. Antimicrobial Activity

The pure culture of wound and urinary tract infection associated microorganisms (Bacterial cultures - *Staphylococcus aureus, Enterococcus faecalis, E. coli, Salmonella typhi* and *Pseudomonas aeruginosa.* Fungal cultures *Aspergillus niger, Candida albicans*, *Penicillium notatum*, *Trichoderma viridiae,* and *Mucor sp.,* were obtained from Royal Bio Research Centre, Chennai, Tamil Nadu, India and used for antimicrobial studies. Antimicrobial activity of solvent extracted samples

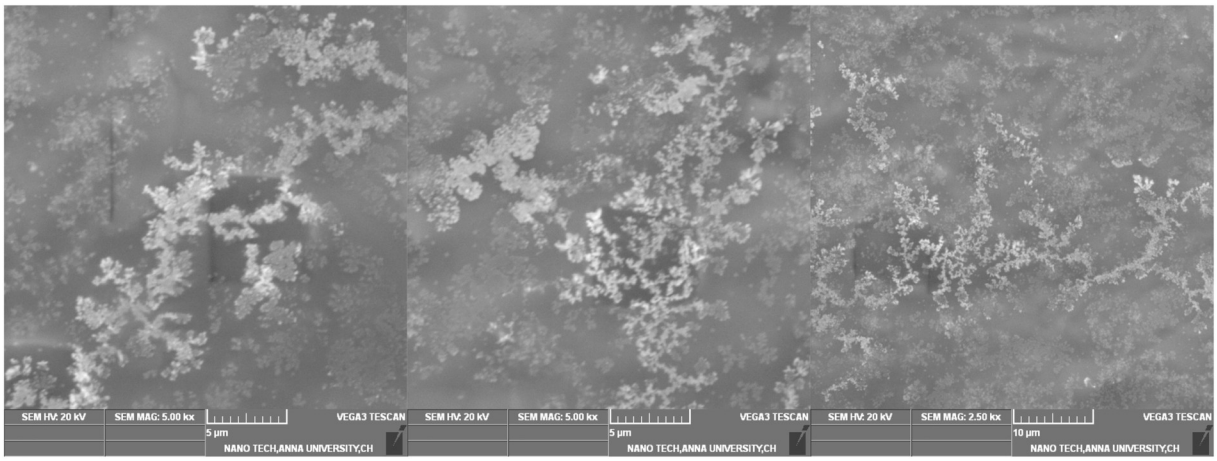

Fig. 5. SEM image of the synthesized silver nanoparticles from the leaves extract of *Tropaeolum majus*.

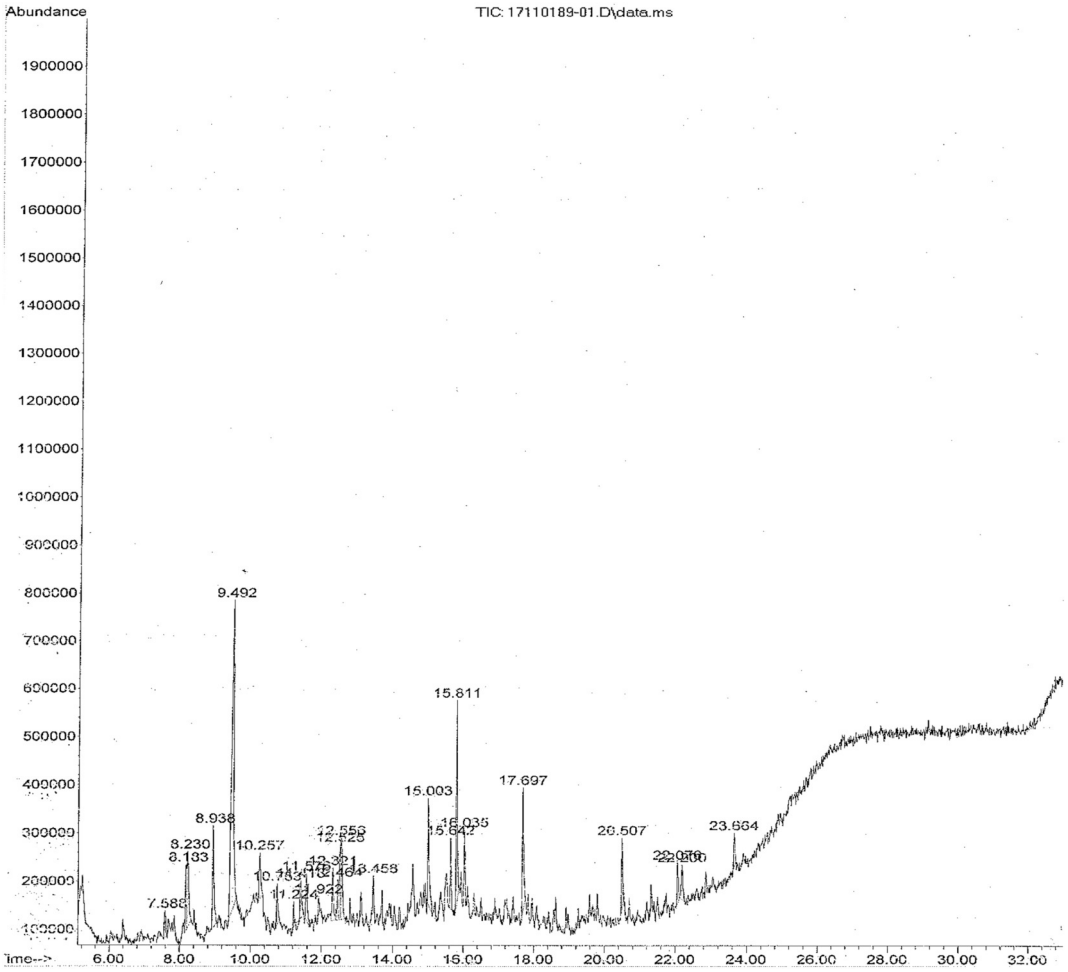

Fig. 7. GC–MS analysis of the aqueous extract of *Tropaeolum majus*.

and AgNPs were determined by resazurin method [33]. Briefly, the bacterial pathogens were cultivated in the nutrient broth and the fungal strains were cultivated in the potato dextrose agar. For the screening of the antibacterial activity, the mid log phase stage bacterial pathogens were used, whereas the antifungal screening, the spore suspension of the freshly grown fungal pathogens were used.

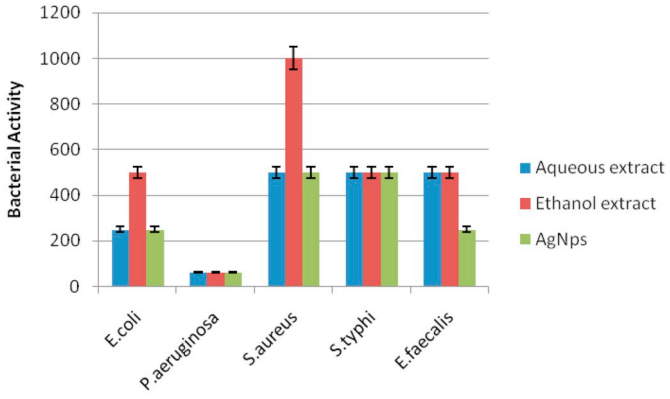

Fig. 8. Minimum inhibitory concentration of *Tropaeolum majus* against bacterial pathogens.

2.8. In Vitro Cytotoxicity Activity

Cell lines were obtained from National Centre for Cell Science Pune (NCCS). The obtained MCF7 and VERO cells from NCCS Pune were cultivated in the growth medium with 10% FBS and antibiotics. The activity of the fresh leaf extracts and the nanomaterials were determined by the MTT assay [34]. Assay was carried out using different concentration of samples to find out 50% of cell viability was calculated using the following formula:

$$\%\text{cell viability} = A_{540} \text{ of treated cells}/A_{540} \text{ of control cells} \times 100\%.$$

3. Results and Discussion

3.1. Extraction of Tropaeolum majus Leaves Extracts

The *Tropaeolum majus* leaves were collected, shade dried and extracted using ethanol and aqueous. The yields of these obtained extracts were measured in milligram and the maximum yield was observed in ethanol extract (900 mg/10 g) followed by aqueous extract (280 mg/10 g).

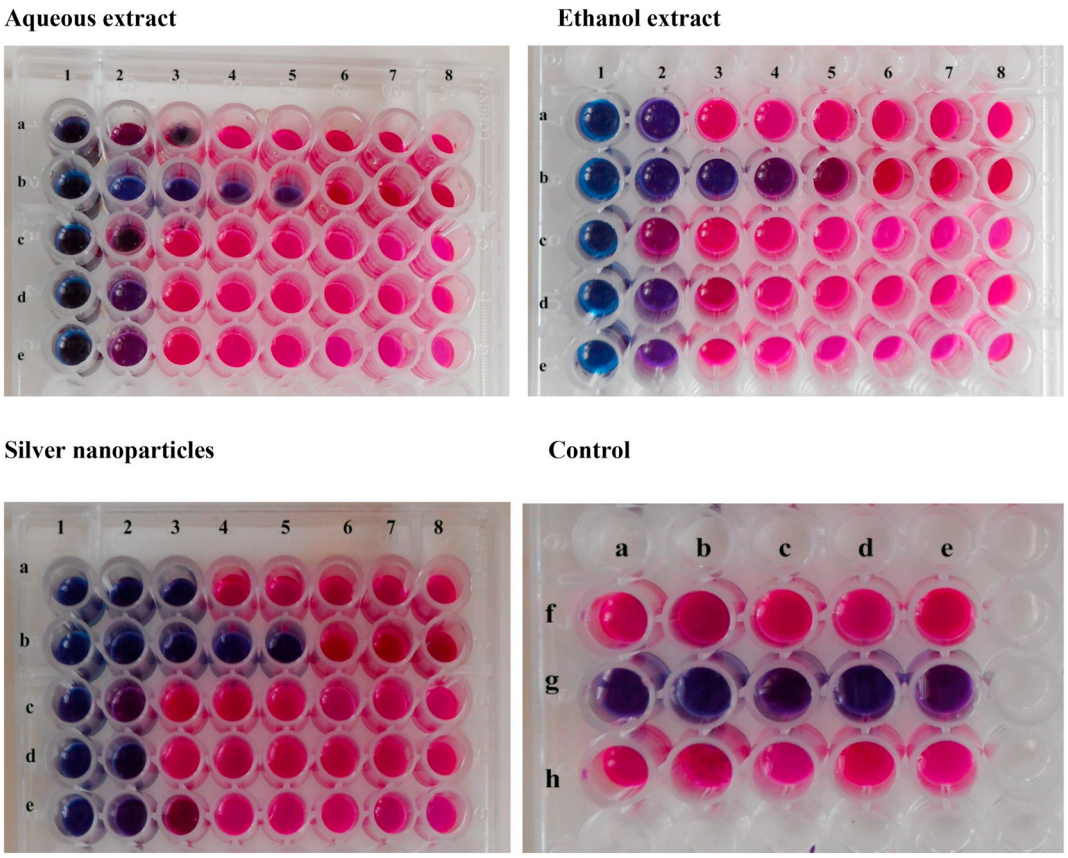

Fig. 9. Minimum inhibitory concentration of aqueous extract, ethanol extract, Silver nanoparticles obtained from the *Tropaeolum majus* against bacterial pathogens 1–500 µg, 2–250 µg, 3–125 µg, 4–62.5 µg, 5–31.2 µg, 6–15.6 µg, 7–7.8 µg, 8–3.9 µg; a- *E. coli* b- *Pseudomonas aeruginosa*, c- *Staphylococcus aureus*, d- *Salmonella typhi*, e- *Enterococcus faecalis*, f-Negative control (DMSO), g-Std (streptomycin 10 µg), h-Control.

3.2. Phytochemical Analysis

The extracts were qualitatively analyzed for its phytoconstituents. In the extracts tannins, saponins, proteins, alkaloids and phenols were present (Table 1). These phytoconstitutent might contribute therapeutic values to the chosen plant. Similarly, Carvalho et al., (2015) studied the methanolic extract of *Tropaeolum majus* seed alkaloid, flavonoid and tannin were present. Tannin and steroid where present in ethanolic extract of *T. majus*, whereas flavonoid was absent [35] (Table 2).

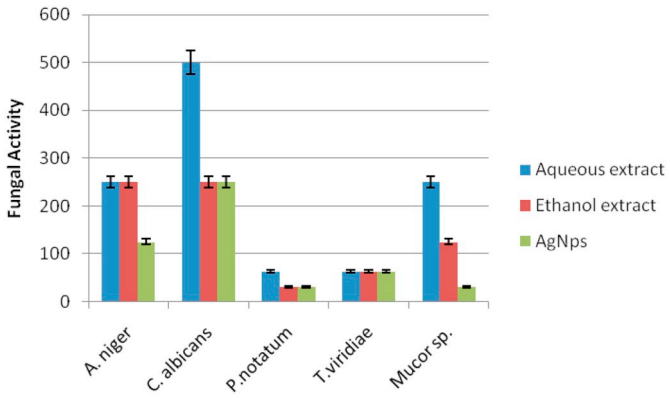

Fig. 10. Minimum inhibitory concentration of *Tropaeolum majus* against fungal pathogens.

3.3. Antioxidant Activity

Antioxidant capacity was analyzed using various methods. For DPPH scavenging assay ethanol extract showed 52.5% and aqueous extract showed 66.1% whereas BHT showed 98.9%, ABTS Ascorbic acid 81.46%, Aqueous extract 56.6% and ethanolic extract 43.4% and total antioxidant activity showed 550 µg/ml and 530 µg/ml. (Fig. 1). According to Carvalho et al., (2015) *Tropaeolum majus* flower showed 24.1%, 37.5% and 34.7% 100 g/mL) of DPPH activity for aqueous extract, ethanolic extract and juice [35].

3.4. Synthesis and Characterization of Silver Nanoparticles

The colour change from yellow to reddish brown indicates the reduction of Ag^+ to Ag^0.This indicates the conformation of silver nanoparticles (Fig. 2). The spectroscopic studies evidenced that the maximum absorption spectrum notice at 463 nm confirmed that the reduction of Ag^+ to Ag^0. Also the maximum spectrum was related to the surface plasmon resonance of the biologically obtained nanoparticles. Recently, Mukundan et al., (2015) synthesized nanoparticles from the extracts of *Bauhinia tomentosa* leaves noticed that surface plasmon resonance was at 441 nm [36]. FTIR spectrum of synthesized AgNP, is shown in Fig. 4. The band values were noted at 3357.46, 21,966.52, 2118.42, 1637.27, 658.571 and 411.728 cm^{-1}, which is related to hydroxyl, amino and disulphide groups. After the reduction Ag^+ ions, *Tropaeolum majus* leaf extract bands were found to be

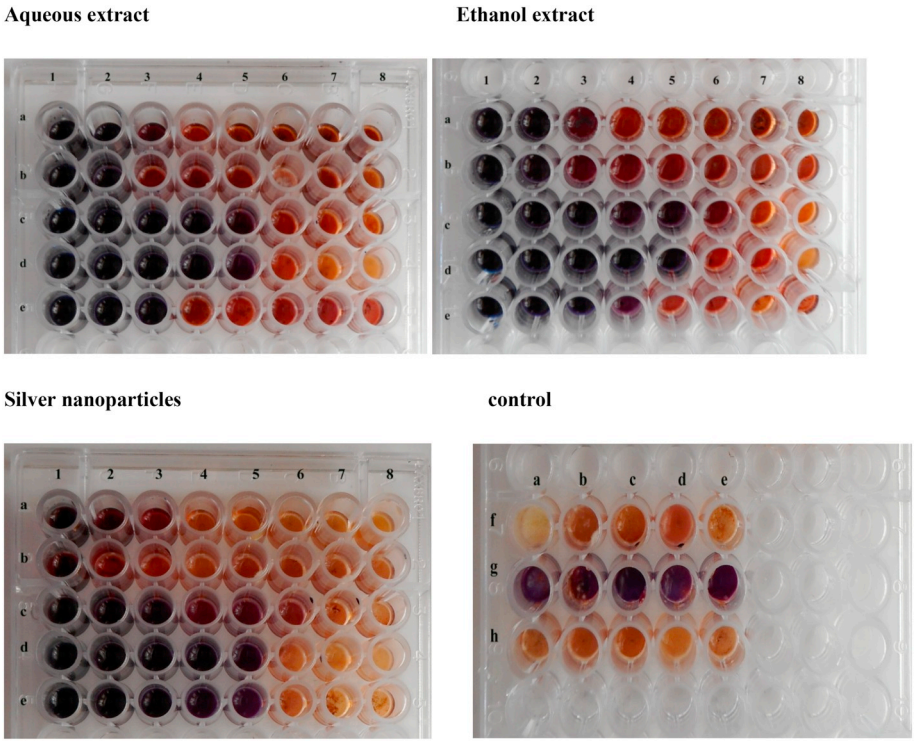

Fig. 11. Minimum inhibitory concentration of aqueous extract, ethanol extract, Silver nanoparticles obtained from the *Tropaeolum majus* against fungal pathogens 1–500 µg, 2–250 µg, 3–125 µg, 4–62.5 µg, 5–31.2 µg, 6–15.6 µg, 7–7.8 µg, 8–3.9 µg; a- *Aspergillus niger* b- *Candida albicans*, c- *Penicillium notatum*, d- *Trichoderma viridiae,* e- *Mucor sp.*, f-negative control (DMSO), g-Std (Amphotericin—B 10 µg), h-Control.

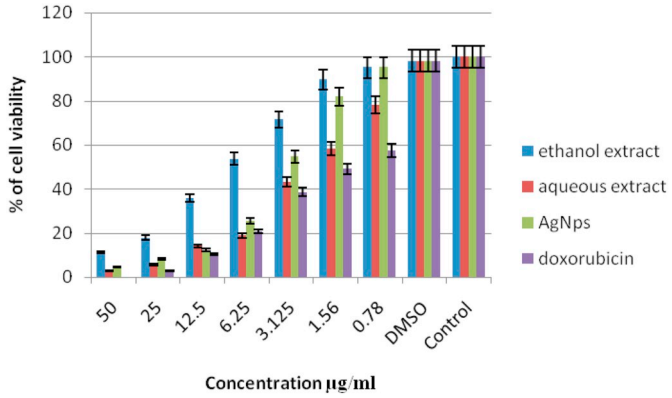

Fig. 12. Comparative anticancer efficacy of *Tropaeolum majus* against MCF7cell lines.

3341.07, 2114.56, 1636.3, 531.293 and 416.549 cm^{-1}, respectively (Fig. 4A and B). AgNPs showed the presence of polydispersed spherical particles (Fig. 5). Spherical nanoparticles with range size from 35 to 55 nm using leaf of *Catharanthus roseus* linn. Has been reported [37]. The XRD patterns at 37.961, 44.29, 64.34, 77.28 and 81.42 repressented to the lattice planes 2.3684, 2.0436, 1.675, 1.4467, 1.2336 and 1.1811 nm are in accordance with the reported data (Fig. 6). Similarly the report of Carvalho et al., (2015) [35] revealed the XRD pattern of the nanoparticels obtained from *Bauhinia tomentosa* (Fig. 3).

3.5. Gas Chromatography- Mass Spectroscopy Analysis

The major absorption peak was observed with retention time (RT) of 9.492 mins. From the NIST library, the major phytocomponent present in the aqueous extract of *Tropaeolum majus* was Benzeneacetic acid. The other major components was found at RT 15.811 and RT 17.69 2-Benzothiazolamine, 5,6-dimethyl-Methanimidamide, N′- = (4-methoxy phenyl)-N, N –dimethyl and Phenol, 2-phenylmethyliminomethyl-4-nitro-Benzenemthanethiol (Fig. 7). Similarly, several bioactive compounds using ethanolic extract of *Evolvulus alsinoides* (L.) also been reported by Gomathi et al., 2015 [38].

3.6. Antimicrobial Activity

3.6.1. Antibacterial Activity of Extracts and AgNps of Tropaeolum majus

The antibacterial activities of aqueous, ethanol extracts and silver nanoparticles of *Tropaeolum majus* were tested against the urinary tract infection and wound associated bacteria such as *Staphylococcus aureus*, *Enterococcus faecalis*, *E. coli*, *Salmonella typhi* and *Pseudomonas aeruginosa*. The results were given in Figs. 8 and 9. Among the tested organisms, all the samples had equally more bactericidal for *Pseudomonas aeruginosa*. AgNps showed inhibitory activity in the order of *E. coli*, *Enterococcus faecalis, Staphylococcus aureus* and *Salmonella typhi.* Aqueous extract had lowest activity for the tested microorganisms except *E. coli*. Likewise, in ethanol extract lowest activity was observed for *Staphylococcus aureus*, but other tested microorganisms had moderate activity.

3.6.2. Antifungal Activity of Solvent Extracts and AgNps of Tropaeolum majus

The antifungal activities of aqueous, ethanol extracts and silver nanoparticles of *Tropaeolum majus* were tested against fungus such as *Aspergillus niger, Candida albicans, Peniillum notatum, Trichoderma viridiae* and *Mucor spp.,* The results were presented in Figs. 10 & 11. AgNps highest inhibitory activity for *Peniillum notatum* and *Mucor spp.,* followed by *Trichoderma viridiae, Aspergillus niger* and *Candida albicans,* Ethanol extract showed highest fungicidal activity for *Peniillum notatum* followed by *Trichoderma viridiae, Mucor spp., Aspergillus niger* and *Candida albicans*. Aqueous extract exhibited highest activity for *Trichoderma viridiae* and *Peniillum notatum* followed by *Mucor spp., Aspergillus niger*

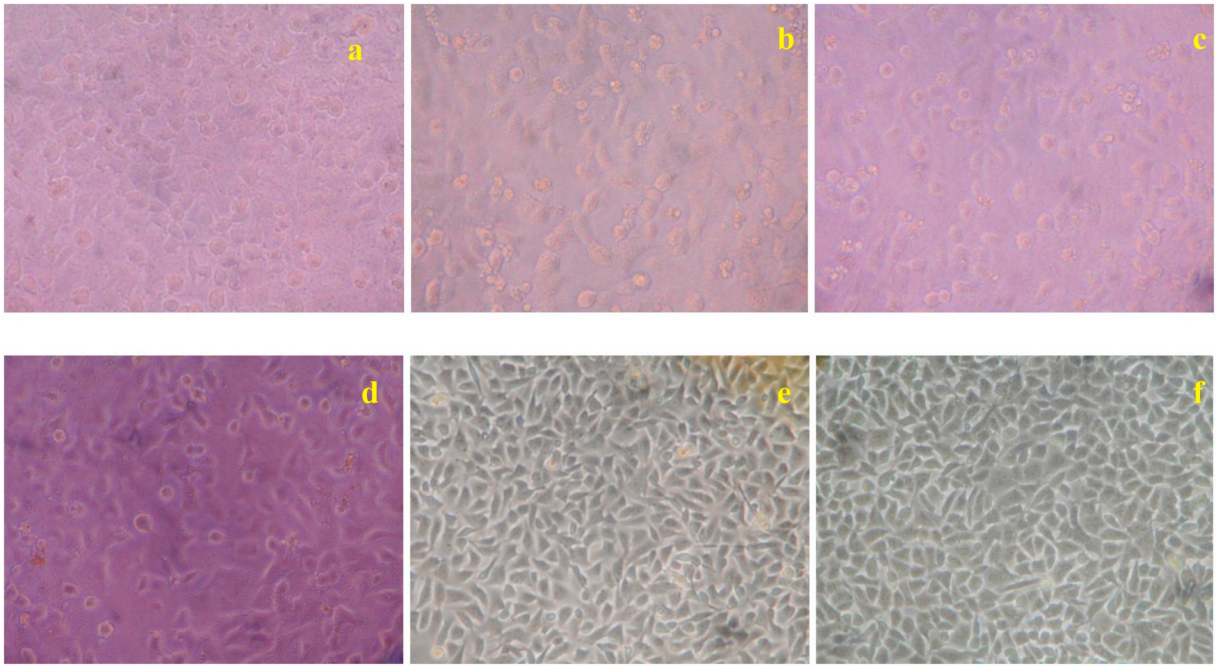

Fig. 13. IC50 values of *Tropaeolum majus* against MCF7cell lines.
a. Ethanol b. aqueous extract c. Silver nanoparticles, d. Doxorubicin, e. Vehicle control (DMSO) and f. Control against MCF7cell lines.

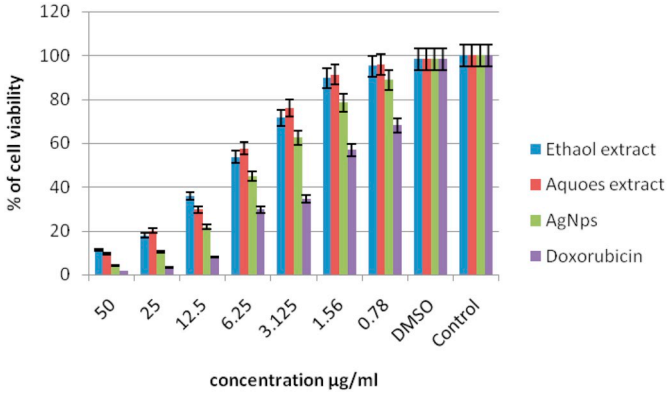

Fig. 14. Cytotoxicity of ethanol, aqueous extract, silver nanoparticles from *Tropaeolum majus* and doxorubicin drug treated using VERO cell lines.

and *Candida albicans*. In the study of Hassan et al., (2015) the solvent extract of *Lemna minor* showed best activity for *Shigella flexneri* (12 µg/ml), moderate activity will be *Bacillus subtilis* (40 µg/ml), *Micrococcus luteus* (60 µg/ml), *Pseudomonas aeruginosa* (90 µg/ml) and lowest activity for *E. coli* (115 µg/ml), *Salmonella typhi* (125 µg/ml) and *Staphylococcus aureus* (170 µg/ml) [39].

3.7. Anticancer Activity of Solvent Extracts and AgNps from Tropaeolum majus

The various concentrations of aqueous, ethanol extract, AgNps and Doxorubicin *viz.*, 50, 25, 12.5, 6.25,3.12,1.56 and 0.78 µg/ml and vehicle control (DMSO) control (without extract) were checked for anticancer activity in MCF7 and VERO cell line. For the cell lines, decrease in cell count was observed with increase in concentration of the samples. *In vitro* treatment of MCF7 cells with samples significantly suppressed MCF7 cancer cell growth. The IC50 concentration of MCF7 cells treated with ethanol, aqueous, AgNps and doxorubicin was found at 7.5 µg/ml, 4.68 µg/ml, 2.49 µg/ml and 1.4 µg/ml respectively. The results showed dose dependent response against MCF7 cell line. The same was followed in VERO cell lines and the 50% viability of the cells were calculated as at 6.8 µg/ml, 8.1 µg/ml, 5.3 µg/ml and 2.6 µg/ml for ethanol, aqueous, AgNps and doxorubicin respectively (Figs. 12,13,14,15 and 16). Aiyegoro et al., (2010) reported that methanol extract of seed has shown IC_{50} value at 156 µg/ml. In ethanolic extract 480 µg/ml and that of aqueous extract was 200 µg/ml from the plant [40].

4. Conclusion

Aqueous and ethanol extracts of leaves of *Tropaeolum majus* were studied for its phytochemical, antioxidant and GC–MS analysis. A simple, low cost synthesis of silver nanoparticles using aqueous extract of leaves of *Tropaeolum majus* as reducing agent was carried out. Characterization using UV, FTIR, XRD and SEM were done. Both aqueous and ethanol extracts and AgNPs were tested for its antimicrobial activity. Cytotoxicity and anticancer activity of the samples against VERO and MCF7 cell lines were performed. Anticancer activity was found to be at lower concentration compared to toxic effect. To evaluate the mode of action of plant and nanoparticle more investigation has to be carried out. However, further *in vivo* studies have to be done to confirm the current findings.

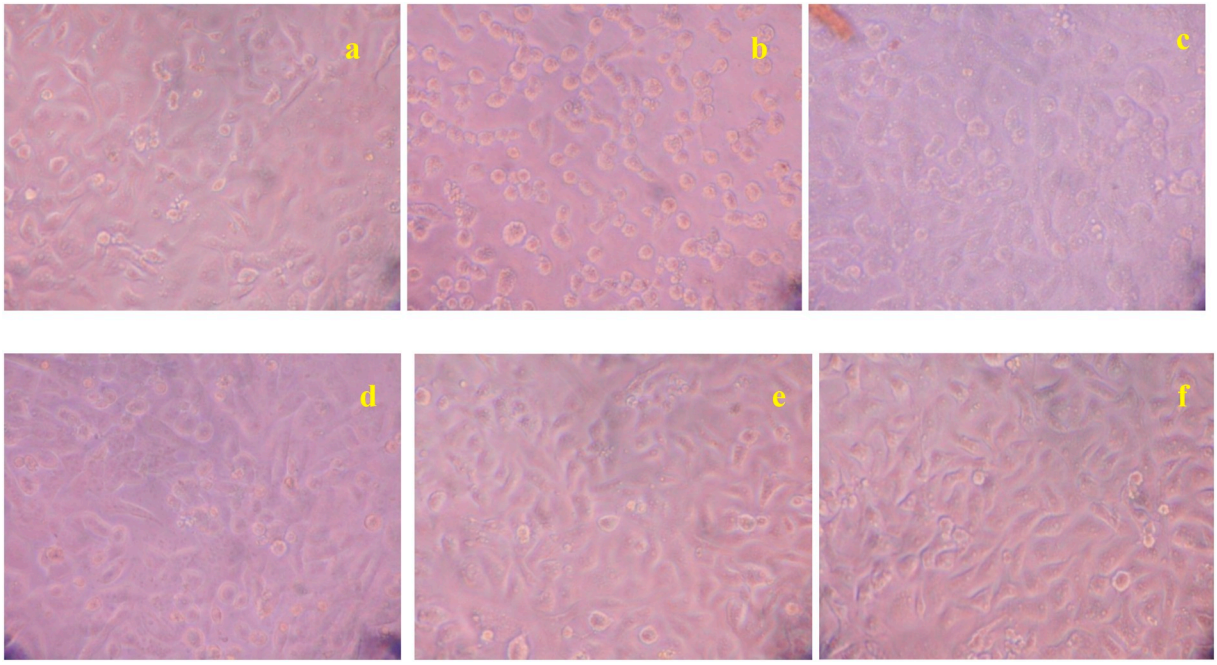

Fig. 15. IC50 values of *Tropaeolum majus* against VERO cell lines.
a. ethanol b. Aqueous extract c. silver nanoparticles, d. doxorubicin, e. Vehicle control (DMSO) and f. Control against VERO cell lines.

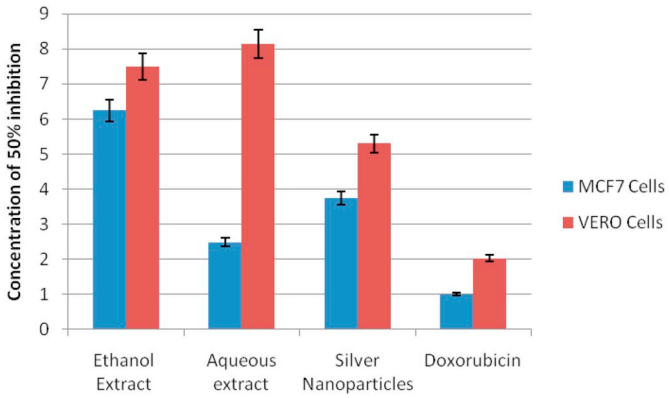

Fig. 16. IC50 values for MCF7 and VERO Cell Line from *Tropaeolum majus* and doxorubicin drug treated using MCF7 and VERO cell lines.

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