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Research Article

ANTIMICROBIAL EFFICACY OF SOME NATURAL COSMECEUTICALS, NEUTRACEUTICALS AND MEDICINAL PLANT EXTRACTS AND ULTRASTRUCTURAL ALTERATIONS IN FOOD BORNE PATHOGENS

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ABSTRACT

Twelve plant extracts extracted in Vidya herbs Pvt. Ltd., were studied for their antimicrobial potency against food borne pathogens viz. *Emblica officinalis, Moringa oleifera, Terminalia chebula, Coffea arabica, Withania somnifera, Cinnamomum verum, Gymnema sylvestre, Morinda citrifolia, Curcuma longa, Theobroma cacoa, Mucuna pruriens* and *Punica granatum* against food borne pathogens. *E. officinalis, Morinda citrifolia, W. somnifera, M. oleifera* and *P. granatum* have proved the best plant extracts by inhibiting all the bacterial growth evidenced by wider and clear zones of inhibition. *M. oleifera* inhibited *S.aureus, B. licheniformis, B. megaterium* and *L. acidophilus* at 46.66, 33.33 and 19.99mg/ml with zones of 17, 18, 17 and 17 mm, respectively. *B. licheniformis* was sensitive when treated with *W. somnifera* at 40, 20, 10 and 5 mg/100µl concentrations and inhibition zone was 24.45, 23.5, 21.7 and 19.25mm, against *S. aureus*, *B. licheniformis*, *B. megaterium* and *L. acidophilus,* respectively. *E. officinalis* inhibited *S. aureus* even at less concentration i.e. 24mg/60µl with wider zone 33mm comparable to standard. *M. citrifolia* was found to inhibit all the organisms with wide and clear zones. A sensitive bacterium was *S. aureus* with wider zone of 30.5, 20.25, 16.25 and 12 mm at 40, 20, 10 and 5 mg/100µl, respectively. SEM was performed in order to visualize the actual damage in treated fungi viz. *Aspergillus niger* and *Aspergillus fumigatus*. It is clear from the microscopic observation that the spores were totally emaciated with irregular size and shape when treated with extracts of the study. Thus, most of the plant extracts have shown the potential inhibitory activity against food pathogenic bacteria and could become promising natural antimicrobial agents with potential applications in neutraceutical/pharmaceutical industry for controlling the food borne pathogenic bacteria.

Keywords: Natural Cosmeceuticals, Neutraceuticals and medicinial plant, Food Brone Pathogens.

INTRODUCTION

In recent times, focus on plant research has increased all over the world and a large body of evidence has collected to show the immense potential of medicinal plants used in the pharmacopoeias of many countries of the world which include a large number of drugs of plant origin. While, it is true that purely synthetic compounds are being employed in increasing measure, in clinical practice, but still interest in the examination of plants as potential source of new drugs has never waned.

First, it is very likely that the phytochemicals will find their way into the arsenal of antimicrobial drugs prescribed by physicians; several are already being tested in humans[1]. India is a rich source of medicinal plants more than 7500 species, of which 4635 species are used and are utilized commercially on quite huge scale. We are fortunately endowed with a very rich flora, because of the size of our country and varieties of climatic and soil conditions obtained in the different parts and as such there are astonishing opportunities for working on plant products.

Food borne diseases are considered as the most common causes of food infection and intoxication, worldwide, which find their way in foods through cross contamination, improper handling and temperature mistreatment. Food spoilage microbes can adapt to survive and grow in a wide range of environmental conditions as well as in a large variety of raw and processed foods, including milk and dairy products, various meats and meat products or fresh produce. Food spoilage includes physical damage, chemical changes, such as oxidation, color changes, or appearance of off-flavors and off-odors resulting from microbial growth and metabolism in the product[2]. During the last decade, two consumer demands have arisen in the food industry. The first is the provision of fresh and natural food requiring minimal preparation and the second is the control of food safety[3]. The use of natural food preservatives has been improved on the basis of consumer demand[4]. Natural products are becoming gradually more popular for their wide variety of therapeutics, complementary medicine and food preservation. Current technologies for preservation and shelf life extension of food include chemical preservatives, heat processing, modified atmosphere packaging (MAP), vacuum packaging (VP) or refrigeration. Unfortunately, these steps do not eliminate undesirable pathogens such as *Listeria monocytogenes* from these products or delay microbial spoilage completely. Alternative preservation techniques such as novel non-thermal technologies and prevention of pathogenic and spoilage microorganisms in foods is usually achieved by using chemical preservatives. These chemical preservatives act as antimicrobial compounds which inhibit the growth of undesirable microorganisms.

However, the onset of increased demand for minimally-processed, extended shelf life of foods and reports of chemical preservatives as having potential toxicity, demand food manufacturers to find alternative sources of antimicrobial compounds[5]. *Staphylococcus aureus*, *Bacillus lichens*, *Listeria monocytogenes, Aspergillus niger, Rhizopus nigricans, Penicillium italicum, Bacillus megaterium, Lactobacillus acidophilus*, *Escherichia coli* etc., are few among the common food borne microorganisms that cause infection and intoxication. Food spoilage microorganisms, on the other hand, cause products to lose their quality which renders them unacceptable to consumers and directly responsible for short shelf-life of food products in the food industry. Because of the present day public perception on contamination of foods especially edible fruits, vegetables, oils, seeds, meat, processed foods there is need for development of eco-friendly, healthy and economical approaches for management of bacterial and fungal contaminations. To overcome this alarming problem, there is an urgent need for the discovery of novel active compounds against new targets. Keeping in view the above, an attempt was made to explore the antimicrobial efficacy of Vidya herbs plants extracts against a series of food borne pathogens.

In this context, there are no reports documented on the morphological changes of fungi grown in presence of the plant extract used in the present study. Hence an attempt was made to

study the morphological changes in *A. niger and A. fumigatus* under restraint with various plant extracts.

The plants used in the present exploration have a broad range of use to mankind. Table 1 reveals the same. Based on the literature the following plants were selected for the present investigation.

Table 1: Shows the uses of plants used in the present study

S. No.	Plant name/ solvent extract	Family/ common name	Traditional uses and biological activities
1	*Emblica officinalis Lam.* / water	Euphorbiaceae/ Amla	Valued in traditional Indian medicine, rich dietary source of vitamin C, minerals and amino acids and various phenolic compounds. critical components in 'triphala' rasayana, antiviral, antibacterial, hyper cholesterolemic, hypo-lipidemic, anti-carcinogenic, hypoglycemic, hepatoprotective, anti-pancreatitis, immunomodulatory, antidsyspepsia, antioxidant, anti-inflammatory and antipyretic. neutraceutical applications like aphrodisiac, haemostatic, nutritive tonic, an excellent brain tonic, rejuvenative. In cosmetics it is used as hair tonic, anti-aging.
2	*Moringa oleifera*/ 100% Ethyl alcohol	Moringaceae/ horse radish	*G*ood source of protein, amino acids vitamins, β – carotene and various phenolics, fatty acids, vitamins, and nutrients[6]. Anti-inflammatory[7], hepatoprotective[8], antihypertensive[9] and anti-cancerous. Antimicrobial properties[10] antioxidant, antidiabetic[11], antivirus[12]. An outstanding detoxifier, outstanding immune builder and is used in many countries to treat malnutrition and malaria. hypo-tensive, antibacterial.
3	*Punica granatum* L./ water	Punicaceae/ pomegranate	anthelmintic properties[13], antiviral[14], antiparasitic, antitumor[15], AIDS[16].
4	*Coffea Arabica* /70% Methanol	Rubiaceae/ coffee	Influenza, anemia, edema, asthenia and rage, hepatitis and liver troubles, externally for nervous shock, as a stimulant for sleepiness and drunkenness, as an antitussive in flu and lung ailment, as a cardiotonic and a neurotonic and for asthmas. Coffee is a palliative in spasmodic asthma, in whooping cough, it is highly recommended in cholera infantum, chronic diarrhea. Caffeine and coffee used in diuretic dropsy. Roasted coffee has disinfectant and deodorant effect.
5	*Withania somnifera* L. Dunal / water	Solanaceae/Ashwagandha	Mild laxative and astringent against wounds and abscesses. In the dental care dried powder is applied against stomatitis and against ulcers of the gum. It is excellent antidote against bites of snakes, antitussive, diuretic, homeostatic, laxative and cardiotonic treatments.Drug is a remedy against a sore throat and cough, against long during diarrhea connected with a prolapsed rectum, ulcers and dysentery. Antibacterial, antiviral, antimutagenic, anti-cancer, antioxidant, cytoprotective, antispasmodic, gastrointestinal, immunosuppressive, antidiabetic, cardiotonic. Preventive against atherosclerosis.
6	*Curcuma longa* L./ Ethylene dichloride	Zingiberaceae/ turmeric	Reduces blood cholesterol[17] prevents LDL oxidation[18], inhibits platelet aggregation[19], suppresses thrombosis[20] and myocardial infarction (MI)[21], suppresses symptoms associated with type II diabetes[22], rheumatoid arthritis[23], multiple sclerosis (MS)[24], and Alzheimer's disease[25], inhibits human immunodeficiency virus (HIV) replication[26], enhances Wound healing, protects from liver injury[27], protects from cataract formation[28] and an antiatherosclerotic[29].
7	*Gymnema sylvestre* R.Br./ 90% methanol	Asclepidaceae/	Antimicrobial[30], antihypercholesterolemic[31], antidiabetic activities[32], anti-sweetner[33].
8	*Cinnamomum verum*/ Water	Lauraceae/ cinnamon	antidiabetic, anti-nociceptive, astringent and diuretic activities; bark and leaves of *C. verum* contain antifungal substances[34], antioxidant[35]; allergic rhinitis[36], wound healing[37].
9	*Mucuna prureins* (L.) DC.,/ 1% Acetic acid in water	Fabaceae/ velvet bean	Carminative, hypotensive and hypoglycemic agent[38]; hyperglycaemic activity, antioxidant activity to increase testosterone levels; antibacterial activity[39] ; contains L-DOPA, a potent neurotransmitter precursor[40].
10	*Terminalia chebula* Retz./ 70% methanol	Combretaceae/ black myrobalan	Used in the treatment of asthma, sore throat, vomiting, hiccough, bleeding, piles, diarrhoea, gout, heart and bladder diseases[41] Black myrobalan has reported to have antioxidant and free redical scavenging activities[42]; anticancerous[43], antibacterial[44]. It used in dermal wound healing and improving gastrointestinal motility, antidiabetic activity[45].
11	*Morinda citrifolia* L./ Water	Morindaceae/noni	The leaves used to treat cough, nausea and colic, possibly due to its anti inflammatory activity[46], gout, tuberculosis and ring

			worm. It has antibacterial, antiviral, antifungal, antitumor, antihelminthic, analgesic, hypotensive, anti-inflammatory, and immune enhancing effects[47, 48.49.50].
12	*Theobroma cacoa L.*	Sterculiaceae/cocoa.	Cardiovascular and cancer chemopreventive activities[51] anti-inflammatory.

MATERIALS AND METHODS

Preparation of extract dilution series

Dissolve the desired amount of plant extract in respective solvents with glass beads, vortex to homogenize. As a precaution not to miss trace amounts of antibacterial for preliminary screening, a relatively high concentration of 50 to 400 mg/ml of each extracts was prepared for bioassays.

Test organisms

The bacterial cultures used in this investigation were *Staphylococcus aureus, Bacillus licheniformis, Bacillus megaterium and Lactobacillus acidophilus.* To obtain cultures, the bacteria, were inoculated into the nutrient broth and incubated overnight at 37°C. For bioassays, approximately $1.5x10^6$ CFU/ml bacterial cell suspensions were prepared in sterile normal saline as described by Forbes *et al*[52]. The fungal cultures *Aspergillus niger* and *Aspergillus fumigatus* were subcultured on PDA medium every 15 days to prevent pleomorphic transformations.

Agar well diffusion method

About 0.1 ml of each prepared bacterial suspension was uniformly seeded on sterilized nutrient agar petriplates. Left aside for 15 minutes and excess of suspension was then drained and discarded properly. Wells of 8 mm in diameter and about 2 cm apart were punctured in the culture media using sterile cork borer. As a precaution not to miss trace amounts of antimicrobials, a relatively high concentration of 400, 200, 100 and 50 mg/ml of the extract was prepared in respective solvents and solution was administered in each well. Culture plates were incubated 27°C for remaining all test bacteria. A positive control Amoxycillin (10 mg/ml) was used and negative control distilled water was used. After 24 h, bioactivity was determined by measuring diameter of inhibition zones (DIZ) in millimeter. All tests were performed in triplicate.

Minimum Inhibitory Concentration (MIC)

A primary factor in the decision to use an antibacterial drug *in vivo* is a minimum inhibitory concentration (MIC) of the drug *in vitro*, which suggests the target fungal species, is susceptible to that drug following the guidelines of The National Committee for Clinical Laboratory Standards (NCCLS) Subcommittee. The minimum inhibitory concentration was defined as the lowest concentration that substantially inhibited growth of the microorganism detected visually.

Agar Dilution Method (for fungi)

The *in vitro* antifungal activity of all the solvent extracts was done by poisoned food technique[53]. In this method, the prepared test sample was dissolved in respective solvents, and the required amount was added to the cool molten potato dextrose agar which was then shaken vigorously, and poured into 9-cm diameter culture plates. The medium without extract served as control. Plugs of 1 mm 7 days old fungal culture cut from edge of active growing colony were stabbed at the centre of each petriplate and incubated at 37±2° C. A control set was also maintained as mentioned above for each experiment. The diameter of each fungus was measured after 3-7 days of incubation. Each experiment was done as triplicate. The percent mycelial growth inhibition of the test fungus was calculated as followed:

$$I = \frac{C \times T}{C} \times 100$$

Where,

I= percent mycelial growth inhibition

C= diameter of fungal colony in the control.

T= diameter of fungal colony in the treated.

Scanning Electron Microscopy

Fungal material obtained from cultures grown either in presence of plant extracts or in absence was processed for morphological studies at Indian Institute of Science, Bangalore, Karnataka, India. Conidial samples were recovered from 15 days old cultures. The morphological changes in the conidia of fungi grown in presence of various plant extracts were analyzed after comparing with control groups grown in control. All the photographs were captured at the same magnification i.e. X10,000.

RESULTS

The antimicrobial activity of twelve Plant extracts is depicted in the following figures (fig.1, 2, 3, and 4). All the extracts have efficiently inhibited the organisms which are responsible for food spoilage. Of which, *E. officinalis, Withania somnifera* and *Morinda citrifolia* out performed a range of plants including *G. sylvestre, P. granatum, C. arabica, C. longa, C. verum, T. cacoa, M. oleifera, T. chebula* and *M. pruriens.*

Antibacterial activity

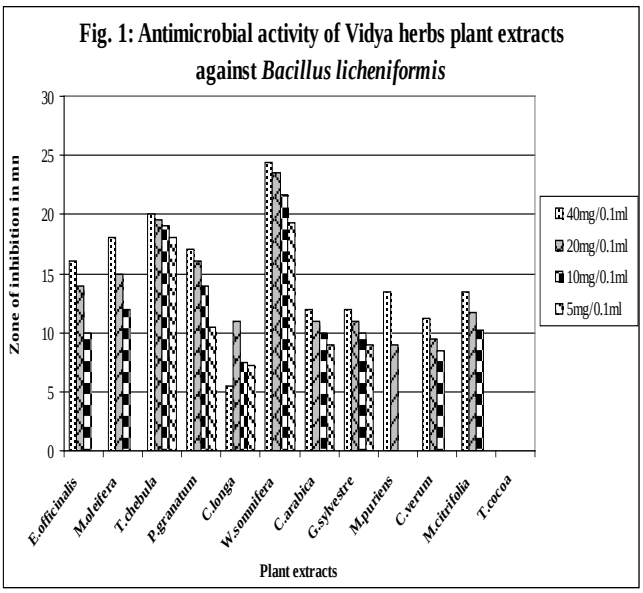
E. officinalis inhibited *S. aureus* even at less concentration i.e. 5mg/100µl with wider zone 14mm. at 40 mg/100µl the results are comparable to standard Amoxycillin which inhibited *S. aureus* (33 mm). MIC of *E. offiicnalis* was 0.1875mg/100µl. *M. oleifera* inhibited *S.aureus, B. licheniformis, B. megaterium* and *L. acidophilus* at 46.66, 33.33 and 19.99mg/ml with zones of 17, 18, 17 and 17 mm, respectively. MIC of *M. oleifera* against *S. aureus* was 20.8mg/100µl (Table-2). *C. arabica* could not inhibited the growth of *S. aureus*, but *B. licheniformis*, *B. megaterium* and *L. acidophilus* were inhibited with zones of 12, 17 and 15mm, respectively. Similar results were obtained for the activity of *P. granatum*. *T. chebula* inhbited the growth of *B. licheniformis* and *L. acidophilus* with equal clear and wider zones i.e. 20, 19.5, 19 and 18mm at 40, 20, 10, and 5mg/100µl, respectively (Fig 1 and 4). MIC against *S. aureus* was 0.3125 mg/100µl. *Curcuma longa* had least activity, but MIC against *B. megaterium* was 0.3125 mg/100µl. *B. licheniformis* was sensitive when treated with *W. somnifera* at 40, 20, 10 and 5 mg/100µl concentrations and inhibition zone was 24.45, 23.5, 21.7 and 19.25mm. MIC against *B. licheniformis* was 1.25 mg/100µl (Table-2).

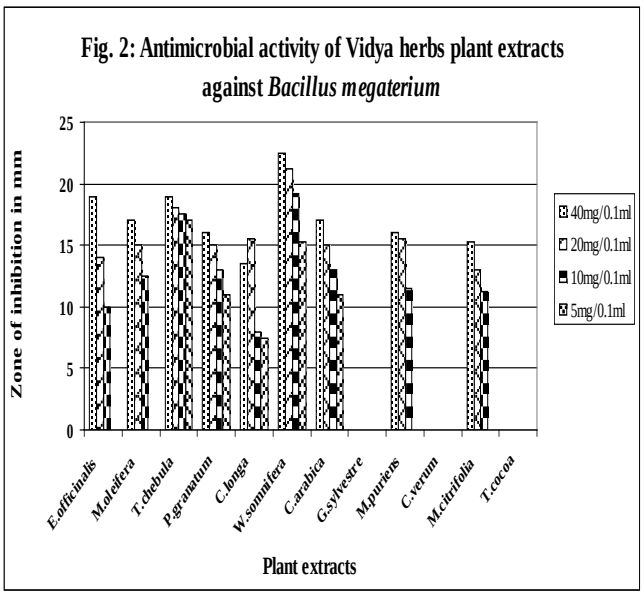
Table 2: Showing MIC Values of Plant Extracts

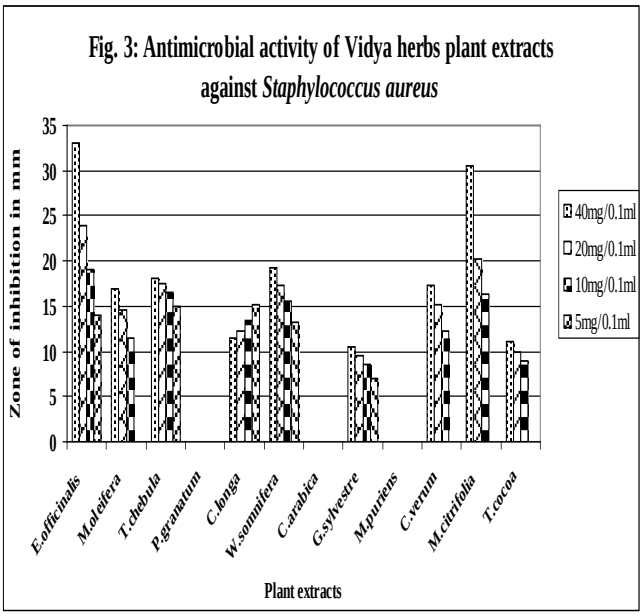
Plant extract	Organism	MIC (mg/0.1ml)
E. officinalis	*S. aureus*	0.1875
M. oleifera	*B. licheniformis*	2.08

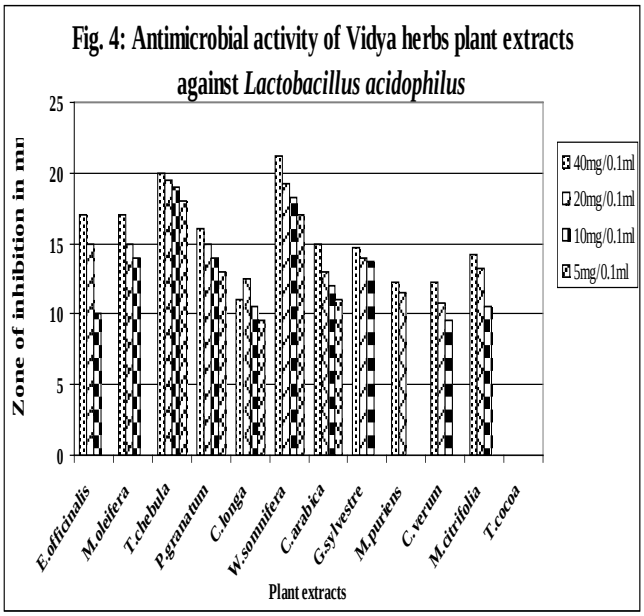
T. chebula	*B. licheniformis*	0.3125
P. granatum	*B. licheniformis*	0.625
C. longa	*B. megaterium*	0.3125
W. somnifera	*B. licheniformis*	1.25
C. Arabica	*B. megaterium*	15
G. sylvestre	*L. acidophilus*	0.625
M. pruriens	*B. megaterium*	10
C. verum	*S. aureus*	0.625
T. cacoa	*S. aureus*	6

G. sylvestre exhibited antimicrobial activity against only *S. aureus* (10.5mm), *B. licheniformis* (12mm) and *L. acidophilus* (14.75mm) at 40, 20, 10 and 5 mg/100µl concentration. The results are in agreement with the work of Deb Roy Saumendu *et al.,* (2010). MIC was 0.625 mg/100µl (Table-2). Widest inhibition zone was found with *S. aureus* (17.25mm) treated with 20 mg/100µl of *C. verum* followed by *L. acidophilus* (12.25mm) and *B. licheniformis* (11.25mm) (Fig. 1&4). MIC was 0.625 100 mg/100µl. *M. pruriens* could not inhibit *S. aureus*, but inhibited *B. megaterium, B. licheniformis* and *L. acidophilus* at 40 mg/100µl with wider zones of 16, 13.5 and 12.25mm, respectively. MIC of *M. pruriens* was 10 mg/100µl. *M. citrifolia* was found to inhibit all the organisms with wide and clear zones. A sensitive bacterium was *S. aureus* with wider zone of 30.5, 20.25, 16.25 and 12 mm at 40, 20, 10 and 5 mg/100µl, respectively. Similar results are reported by Khuntia Tapas Kumar *et al.,* (2010). No zones were found at 5 mg/100µl for *B. licheniformis, B. megaterium and L. acidophilus.* MIC was found to be 5 mg/100µl. *T. cacoa* was found to have the least activity where only *S. aureus* could be found to be inhibited with zone of 11, 10, 9 mm at 40, 20, 10 mg/100µl. MIC was 4 mg/100µl (Table 2)









Scanning Electron Microscopy (SEM)

There were remarkable morphological changes in conidiophores of *A. niger* and *A. fumigatus*. There was a deformation of conidiophores treated with plant extracts in both *A. niger* and *A. fumigatus* causing dwindling of cell wall, where shrunken and collapsed conidiophores were observed, which might be due to cell fluid leakage. In control *A. niger,* spores have many conspicuous echinulates. Some spores of *A. niger* treated with Coffee extract are seen totally broken with severe changes and those treated with Amla extract were bulged of varying size within the cells. Lesions observed on the structure and rigidity on conidial wall. Similar alterations were observed with Amla, *T. chebula, M. oleifera* and Pomegranate extracts (Plate I).

The spores of *A. fumigatus* treated with Coffee extract were noticed with bulged abnormal spores after the 4th day of treatment. *T. chebula* has potently acted on *A. fumigatus* where ruptured, shrunken and dissimilar shaped spores were observed. Similar changes were seen in fungi treated with Pomegranate extract (Plate I).

PLATE I:

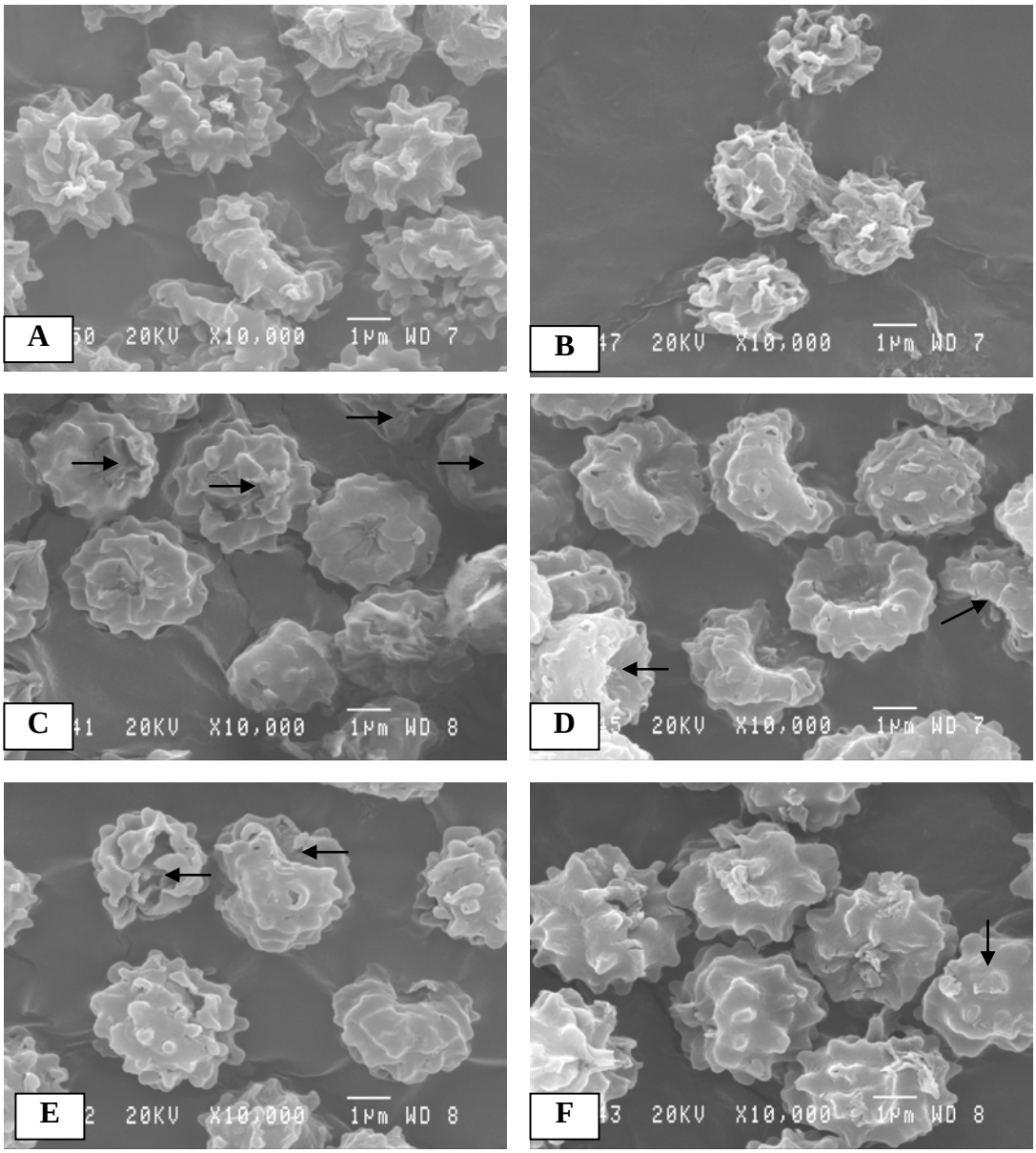


Plate I: Scanning electron microscopy study of *A. niger* treated with various plant extracts.

A= Control, spores with sharp points with a rough cell wall; B=spores completely broken thin, shrunken with severe changes treated with Coffee extract; C= broken spores treated with Amla extract; D & E= broken and emaciated spores treated with *T. chebula* and Pomegranate extract; F=slightly shrunken spores treated with *M. oleifera* extract.

DISCUSSION

Today, most pathogenic organisms are becoming resistant to antibiotics. Despite the huge information of uses of the plant extracts used in the present study, scanty literature is available on their use as preservatives in foods.

E. officinalis (Amla), *Withania somnifera* and *Morinda citrifolia* efficiently inhibited all the bacteria even at low concentrations. *E. offiicnalis* was found to be the potent inhibitor against all bacteria, but inhibited *S. aureus* to the largest extent with clear and wide zone when compared to other three bacteria. Similar studies were done by Sabahat and Perween[54], where Amla infusion and decoction inhibited *S. aureus* with 18.32 and 22.45mm zone of inhibition at 20 mg/100µl. Similarly, work of Raghu and Ravindra[55] depict that *S. aureus* was inhibited at 5, 10 and 20 mg/100µl concentration of Amla with zone of 8, 18 and 28mm. But, Vidya herbs amla extract of the present study has highest activity and more significant than the reports of the above authors. Even at low concentration i.e. 3 mg/100µl, it has inhibited *S. aureus*. This observation provides strong circumstantial evidence that *E. officinalis* has been used in the traditional method of treating a bacterial infection. These consequences suggest that *E. officinalis* Lam. used contain bio-components whose antibacterial potentials are highly comparable with that of the antibiotic Amoxycillin against all bacteria tested.

T. chebula is one of the major ingredient of 'triphala churna' and ayurvedic preparation used as health tonic, it plays a vital role in building immunity and also acts as a potent nutraceutical. In the present study, *T. chebula* (black myrobalan) has potentially inhibited all the organisms. Sumathi and Parvathi[56] studied antimicrobial activity of *T. chebula* against *S. aureus* including other bacteria. They report that *T. chebula* did not inhibit any of the test organisms. But the report of the present study strongly oppose the results of the above authors, where in the present study *T. chebula* has substantially inhibited *S. aureus* even low concentration i.e. 5 mg/100µl with 15mm inhibitory zone.

PLATE II:

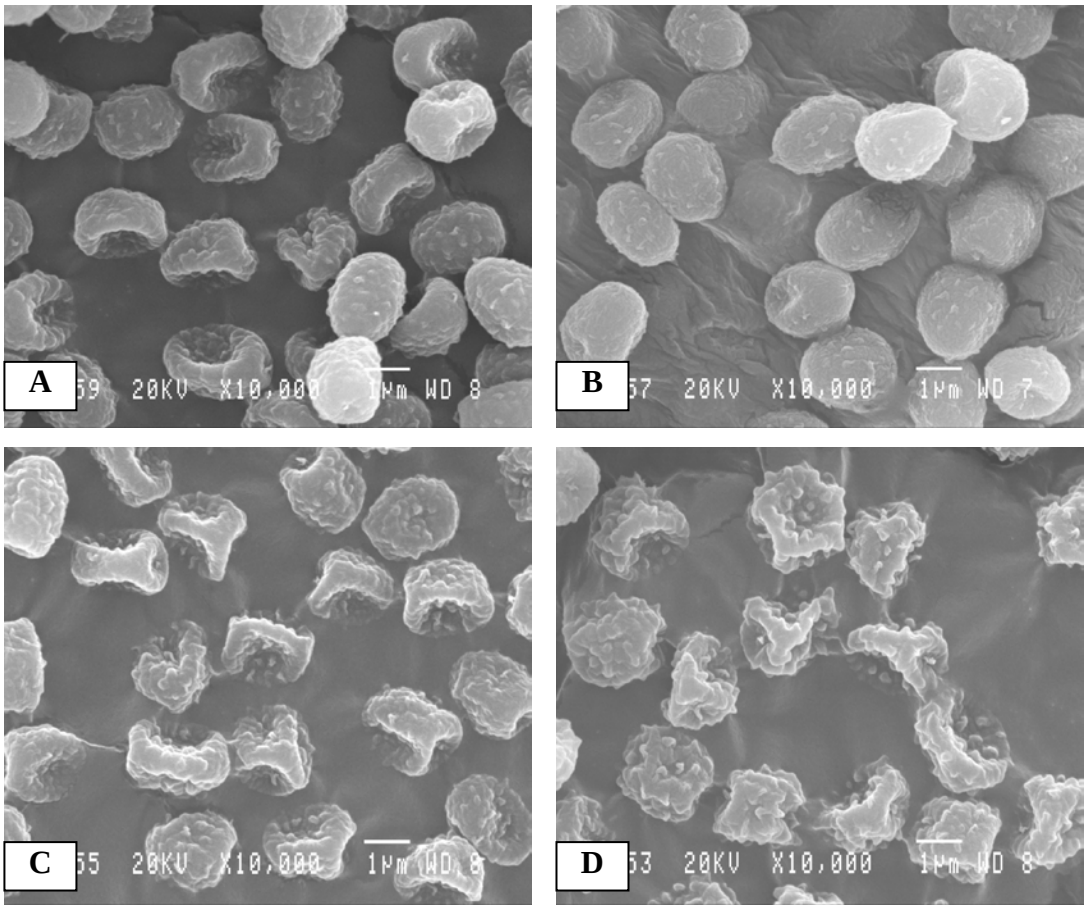


Plate II: Scanning electron microscopy study of *A. fumigatus* treated with various plant extracts.

A= Control, echinate spores with slight furrow; B= bulged spores of varying size treated with Coffee extract; C= shrunken and irregular shaped spores treated with Pomegranate extract; D= broken and more withered spores treated with *T. chebula* extract.

Pomegranate extract in the study of Gislene G.F Nascimento[57] report that hydro alcoholic extract of pomegranate extract could not inhibit *S. aureus*. The present study is in accordance with the above authors. Pomegranate pericarp (Peel, rind) Phenolic punicalagins; gallic acid and other fatty acids; catechin, EGCG; quercetin, rutin and other flavonols; flavones, flavonones; anthocyanidins[58]. On the basis of the knowledge of these properties, will be possible to use of pomegranate peel extracts to formulate new products to be used in food industry as natural antioxidant, replacing synthetic antioxidants, and also as natural food reservatives and pharmalogical studies.

Cinnamon extract showed inhibitory activity against all the test bacteria except *B. megaterium*. Highest activity was shown against *S. aureus* with wider and clear zones at 10mg/100µl. According to the report of Neeraj and Behl[59], *S. aureus* was inhibited by *Cinnamomum* species at 50mg/ml with 13 mm zone of inhibition. *C. verum* extract in the present investigation inhibited the growth of *S. aureus* at 10mg/100µl with 12.125 mm zone of inhibition. Whereas, Puangpronpitag and Sittiwet[60] reported that *C. verum* extract did not inhibit *S. aureus* even at 500, 250 and 125 mg/ml. The extract in the present study exhibited strong inhibitory activity against *S. aureus*, one of the very common food pathogens. *M. citrifolia* (noni) extract has substantially inhibited all the bacteria in the present study. The results are comparable to the standard antibiotic Amoxycillin. It is noticed that the activity was even more than the standard against *S. aureus*.

Most of the Plants used in the present investigation contain phenolic acid, tannin, flavonoids etc. viz., Coffee, Amla, Pomegranate, Black myrobalan, Noni, Horse radish, Cocoa contain high amount of total polyphenols which are responsible for good inhibitory activity against food borne bacteria used in the present study, there by preventing various disease such as diabetes, skin related infections, would healing, cancer etc. As a result, our report evidently proves that Vidya Herbs plant extracts can be exploited as potential preservatives in food. Thus they provide safe, easy, efficient and useful solutions for common diseases without any toxins leading to a pleasant, hygienic, ambiance.

SEM was performed in order to visualize the actual damage in treated fungi. It is clear from the microscopic observation that the spores were totally emaciated with irregular size and shape when treated with extracts of the study. SEM results supplement the *in vitro* antimicrobial activity studied.

The consistent inhibitory activity against food borne pathogens of the plant extracts used is concentration dependent. Few extracts have not shown inhibitory activity at even higher concentration and vice versa. They might have activity even at more high concentration.

Herbs and spices have been used for thousands of years to enhance the flavor, colour and aroma of food. In addition to boosting flavor, herbs and spices are also known for their preservative.

Thus, all the plant extracts of the present investigation have shown the potential inhibitory activity against food pathogenic bacteria and

could become promising natural antimicrobial agents with potential applications in neutraceutical/pharmaceutical industry for controlling the food borne pathogenic bacteria. Since most of the plants of the present study viz., Amla, Moringa, pomegranate, coffee, cocoa are well known food plants, neutraceuticals and cosmeceuticals as well, they can be explored as excellent food preservative which enhance the nutritive value of the food products. They also can be used as one of the ingredients in cosmetic cream preparation. It is suggested that further research should be conducted to test the preservative effect of the extracts on some food models and with other food borne pathogens. The interaction of plant extracts with different food models will be reported in our next communication. However, if plant extracts are to be used for medicinal purposes, issues of safety and toxicity are also to be considered.

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