REVIEW OF LITERATURE

The major etiological agent responsible for diarrheal infections world wide among infants and animals is *E. coli*. Due to emerging threat of multidrug resistance among *E. coli* strains treatment becomes critical and therefore, it is quite essential to search an alternative and safest therapeutic healer to cure such infections. Studies on traditional medicinal plants and their antibacterial effect are frequently carried out in field of microbiology and pharmacology for development of a new antimicrobial agent to control growth of disease causing pathogens. However, very limited work were practicals for treatment of animals using medicinal plants associated with diarrheal infections and this traditional system of healing process is restricted only in villages. Very few farmers and live stock keepers use this thanoveterinary medicinal therapy to cure animals in India as well as in other countries.

Audu *et al.* (2000) made a comprehensive study on antibacterial effectiveness of methanolic, diethyl ether and cold aqueous extract of *Annona senegalensis* (root), *Nauclea latifolia* (stem bark), *Sclerocarya birrea* (stem bark) and *Zizyphus abyssinica* (root bark) against *E. coli* and other clinical pathogens. Only extracts of *S. birrea* showed inhibitory activity against *E. coli*. Antibacterial activity of crude methanolic root extracts of *Asparagus racemosus* against *E. coli* and various other gastrointestinal pathogens was observed (Mandal *et al.*, 2000). Pichai *et al.* (2000) investigated antibacterial effectiveness of *n*-hexane, chloroform and aqueous leaf extracts of *Tabebuia rosea* against *E. coli* and other pathogens. Among three different extracts *n*-hexane and chloroform extract was proved to be more effective against *E. coli* detected by agar dilution method. In another study, Pitchai and Saraswathy (2000) documented antibacterial potency of *n*-hexane and chloroform extract of *Dichrostachys cinerea* against *E. coli* and *n*-hexane extract was proved to be more effective against tested organism where as moderate activity was observed in chloroform extract of same plant. Stojanovic *et al.* (2000) reported antibacterial activity of essential oil and Co$_2$ leaf extract of semi-oriental tobacco against *E. coli*. The major constituents observed from tobacco leaf essential oils were neophytadiene and solanine. Taddei and Rosas-Romero (2000) investigated antibacterial activity of *n*-hexane flower extract of *Tridax procumbens* against *E. coli*.

Ahmed *et al.* (2001) reported antibacterial effectiveness of alcoholic extracts of *Emblica offcinalis*, *Terminalia chebula*, *T. belerica*, *Plumbago zeylanica* and *Holorrhena*
antidysentrica against E. coli and other enteric/non-enteric pathogens. In addition in vitro synergistic interaction between various alcoholic extracts of five different plants was observed on E. coli and other clinical pathogens.

Britto and Senthikumar (2001) investigated antibacterial activity of aqueous methanolic extract of Solanum incannum against various E. coli strains. Ebi (2001) documented antimicrobial effectiveness of methanolic leaf, stem and root extracts of Alchornea cordifolia against E. coli. Olila et al. (2001) observed antibacterial activity of aqueous seed extract of Warburgia ugandensis against E. coli and proved its effective usage for treatment of E. coli associated infections in both human and veterinary animals. Rojas et al. (2001) documented antibacterial activity of hexane, chloroform and methanolic extracts of six different plants against E. coli and other pathogens. The plants showed maximum effectiveness against E. coli were Ghapholium oxyphyllum, G. americanum and Crescentia alata.

Iscan et al. (2002) studied antibacterial activity of bioactive compounds of Mentha piperita essential oils against E. coli ATCC 25922 using microdilution technique. 80% of ethanolic extract of aerial and rhizome of Sanguisorba officinalis of Family Rosaceae was reported to be having growth limiting activity against E. coli ATCC 25922 (Janovska et al., 2003). Rhayour et al. (2003) recorded antimicrobial activity of oregano (Origanum compactum) and clove essential oils against E. coli. The two polyphenolic compounds detected from both plants were thymol and eugenol.

Shukla (2003) reported antibacterial activity of root extract of Oenothera biennis against E. coli and other clinical pathogens. The major compounds detected from root extract was olenolic acid, maslinic acid, sitosterol, gallic acid, 2-7, 8- tri methyl ellagic acid, tetra methyl ellagic acid, 2-methyl-7-oxo-tritetraconat-1, 5-diene-21-ol, 18- hydroxypentacos-21-en-1-oic acid, 5-methyl-27-oxo-triacont-4-en-24-ol and 3,5-dihydroxy-4-pent-4noyl-1’-oxymethylbenzoic acid.

Srinivas et al. (2003) reported significant antibacterial effectiveness of chloroform and ethyl acetate husk extracts of Cocos nucifera against E. coli. Tamizhamani et al. (2003) investigated antibacterial effectiveness of ethanolic rhizome extract of Nelumbo nucifera against E. coli by disc diffusion method. Antibacterial activity of petroleum ether,
chloroform, ethyl acetate and methanolic leaf extracts of *Alstonia scholaris* was investigated against *E. coli* and other enteric pathogens (Versha *et al.*, 2003).

Minimum Inhibitory Concentration (MIC) of acetone and aqueous extract of *Quercus infectoria* was studied against *E. coli NCTC 12079 O157:H7* and various other disease cause standard strains by broth microdilution technique using 96-well microtiter plates (Basri and Fan, 2005). Trivedi and Hotchandani (2004) reported antibacterial activity of oils of eucalyptus against *E. coli*. Voravuthikunchai *et al.* (2004) analyzed MIC of ethanolic and aqueous extracts of *Quercus infectoria* and *Punica grantum* against *E. coli O157: H7* and other non-O157 VT + *E.coli* strains like O26:H11, O111: NM, O22 and *E. coli ATCC 25922* by broth microdilution technique.

Antibacterial activity of three different spices of family Zingiberaceae was reported to be having strongest inhibitory activity against clinical isolated strain of *E. coli*. The spices investigated including *Zingeber officnale Rosc.*, *Curcuma longa* L. and *C. amada Rosc.* The solvents which are used in order to evaluate antibacterial properties including 1, 4 Dioxan and DMF (Di-methyl furan). In addition, antibacterial activity was studied from methanolic, hot and cold aqueous extracts of three different rhizome extracts of spices. Both heated and non heated aqueous rhizome extracts of *Z. officnale*, *C. longa* and *C. amada* showed effective growth inhibitory response against *E. coli*. The study of antibacterial activity of underground parts (rhizome) of three different spices of same family using different solvent extracts was carried out by well-diffusion and disc diffusion method. Heated and non-heated 1,4 Dioxan extracts of *Z. officnale*, *C. longa* and *C. amada* showed inhibitory activity but DMF extract failed to exhibit growth inhibitory response against tested organism (Chandarana *et al.*, 2005).

Elizabeth (2005) documented antibacterial effectiveness of crude aqueous and methanolic fruit extracts of *Terminalia bellerica* against enteropathogenic *E. coli* and uropathogenic *E. coli* with MIC of 500 μg/ml for uro pathogenic *E. coli* and 2000 μg/ml for enteropathogenic *E. coli*. Proestos *et al.* (2005) showed effective antibacterial activity of ferulic acid, caffeic acid (Phenolic compounds), catecine and quercetine (Flavonoidal compounds) derived from *Menta pulegium* and *Thymus vulgaris* against *E. coli*.

Antibacterial activity of three different varieties of Mangrove was investigated to control hospital associated infections. The plants investigated for the research purpose were
Avicennia marina, A. officinalies and Bruguiera serangula. Ethyl acetate and ethanolic mature leaf extracts of A. marina was found to be having effective to control clinical isolated E. coli growth. Petroleum ether and chloroform extracts of A. marine failed to exhibit inhibition against same tested organism. Ethanolic bark extract of A. officinalies showed much effective response to control E. coli growth. Combination of various extracts was performed to study their additive/ antagonistic activity against tested organism. Most of the extracts in combination showed antagonistic results where as individual of same extract were found to be much effective (Abheysinghe et al., 2006).

Gur et al. (2006) observed antibacterial effect of 18% oleic acid isolated from ginger roots against E. coli ATCC 25921 by well diffusion method. Kuete et al. (2006) reported antibacterial effect of saponin rich MeOH fraction obtained from bark extract of Tridesmostemon omphalocarpoide effective against E. coli. Naz et al. (2006) detected antibacterial activity of 4-hydroxy-3-methoxy cinnamic acid (Ferulic acid) and 4-hydroxy-3-methoxy benzoic acid (Vanillic acid) against E. coli isolated from ethanolic extract of the root bark of Onosma hispidum. Ngemenya et al. (2006) observed antibacterial effectiveness of 17 different plant extracts against E. coli among them the strongest inhibitory result was observed from whole plant extract of Ageratum conyzoides.

Antibacterial activity of aqueous, methanol and local solvents like palm wine and gin leaf extracts of Bryophyllum pinnatum and Kalanchoe crenata was investigated against clinical and ATCC 25922 strains of E. coli by Akinsulire et al. (2007). In addition squeezed leaves of both plants were studied against tested organism. Methanolic extract, squeezed leaves and local gin extracts of Bryophyllum pinnatum showed strongest inhibitory response whereas, aqueous extract and palm wine extract failed to show any inhibition against two different strains of E. coli. Methanolic, squeezed leaf juice, aqueous, palm wine and local gin extract of Kalanchoe crenata showed effective inhibitory response against tested organisms.

Ogueke et al. (2007) documented antibacterial effectiveness of ethanolic leaf extract of Euphorbia hirta against E. coli. In other studies antibacterial activity of polar and non polar solvent extracts of Nyctenthes arbor-tristis and Vicoa indica was investigated against E. coli (Priya and Ganjewala, 2007; Srinivasan et al., 2007).

Akhtar et al. (2008) studied antibacterial effectiveness of petroleum ether, acetone, 50% methanolic and aqueous fruit extracts of Pimpinella anisum against E. coli ATCC 723
and other pathogenic standard strains. The effectiveness was observed only in 50% methanolic and aqueous extract whereas petroleum ether and acetone showed no inhibitory response against tested organisms.

Doss et al. (2008) observed antibacterial potency of five different solvent extracts of *Sphaeranthus indicus* of Family Asteraceae against clinical isolated *E. coli* strain. Benzene, chloroform, ethylacetate, petroleum ether and methanolic extracts of whole part of *S. indicus* showed effective inhibition against *E. coli* whereas petroleum ether and aqueous extract of same plant showed negative results against tested organism. Kaushik and Chauhan (2008) investigated MIC of hexane, ethyl acetate, dichloromethane and methanolic extract of *Spirulina platensis* against *E. coli* and other gram negative organisms using broth microdilution technique.

Khan et al. (2008 a) isolated an active compound 3, 5 diacetyltambulin from *Amorphophallus campanulatus* Blume ex. Decne effective against *E. coli* and other gram negative enteric pathogens. In another finding, Amblyone obtained from crude extracts of *Amorphophallus campanulatus* exhibited inhibitory activity against *E. coli* (Khan et al., 2008 b). Ogbonnia et al. (2008) observed growth inhibitory activity of 70% ethanolic bark extracts of *Treculia africana* against clinical isolated diarrheagenic strains of *E. coli*.

Okigbo and Mmeka (2008) documented successful bactericidal activity of ethanolic, cold and hot aqueous extracts of *Cymbopogon citratus* (lemongrass), *Vernonia amygdalina* (bitter leaf) and *Garcinia kola* (bitter kola) against clinical isolated strain of *E. coli*. Ethanolic seed extract of *G. kola* and both ethanolic and aqueous extracts of *C. citratus* showed strongest inhibitory response against tested clinical pathogen.

In another study, effective antidiarrheal activity of two plants of Family Mimoceaceae was reported against Enteropathogenic strains of *E. coli*. Four different solvent extracts (aqueous, methanol, chloroform and petroleum ether) of *Acacia catechue* and *A. nilotica* were studied against EPEC. Among them methanolic and chloroform extracts of plants showed strongest growth limiting response against EPEC performed by well-diffusion method. Aqueous and petroleum ether extract of *A. catechue* showed no activity against tested organism. However, results obtained from plate count technique showed different results of better inhibition against organism from aqueous and petroleum ether extracts of *A. catechue* (Patel et al., 2008).
Ratnam and Raju (2008) reported antibacterial effectiveness of petroleum ether and methanolic fruit extracts of *Syzygium alternifolium* and *S. samarangensis*. Sultana *et al.* (2008) documented effectiveness of three different compounds glycerol-1-docosanoate, zaluzanic-C and perydiscadic acid obtained from *Arctotis arctotoides* extracts which shows growth inhibitory results against *E. coli* and various other gram positive and gram negative bacteria.

Studies on antibacterial activity of aqueous and chloroform extracts of *Carica papaya, Cynodon dactylon, Euphorbia hirta, Melia azedarach L.* and *Psidium guajava* against *E. coli* MTCC strains was reported. Aqueous extracts of *Cynodon dactylon* was reported to be inactive. However, aqueous extracts of other plants showed effective inhibitory response. Chloroform extract of *Carica papaya* was found to be ineffective against *E. coli* whereas chloroform extracts of other plants was found to be having bacteriostatic effect against tested organism performed by agar diffusion method (Suresh *et al.*, 2008). Vijaya and Mani (2008) documented antibacterial effectiveness of hexane, chloroform and methanolic extract of whole plant of *Ocimum americanum* against *E. coli* and methanolic extract was found to be more effective over chloroform and hexane extract.

Ekwenye and Elegalam (2005); Gupta and Ravishankar (2005); Indu *et al.* (2006); Yusha’u *et al.* (2008); Adeshina *et al.* (2011) studied antibacterial properties of polar solvents extracts as well as fresh juices of *Zingiber officinale* and *Allium sativum* against various *E. coli* strains isolated from clinical, environmental samples including *E. coli* strains associated with respiratory tract infections as well as diarrhea causing enterotoxigenic *E. coli* O8, O88 and enterohemorrhagic *E. coli* O157:H7 strains. Al-Bayati (2009) observed inhibitory effects of menthol against *E. coli* isolated from *Mentha longifolia*. Al-Zubayadi *et al.* (2009) observed antibacterial effects of cold and hot ethanolic stem extract of *Aloe vera* against *E. coli* ATCC 25922.

Awe and Omojasola (2009) reported effective antidiarrheal activity of *Piliostigma reticulatum* (DL). Hochst of Family Leguminosae against various bacteria associated with gastrointestinal infections. Studies revealed that ethanolic bark extract of *Piliostigma reticulatum* showed effective growth limiting response against *E. coli* in comparison to hot and cold aqueous bark extracts of plants. Begum *et al.* (2009) recorded strongest inhibitory activity of chloroform soluble fraction of leaf extract of *Lawsonia inermis* against *E. coli* and
other human pathogens. Chougale et al. (2009) studied antibacterial activity of hexane, dichloromethane, acetone and methanolic extracts of *Tinospora cordifolia* against *E. coli* and other pathogens and highest inhibitory activity was observed from acetone extract against all tested microorganism. Habib et al. (2009) documented antibacterial activity of ethyl acetate stem bark extract of *Amoora rohituka* (Family: Meliaceae) against *E. coli* and other enteric/non enteric pathogens. Hammami et al. (2009) reported antibacterial effectiveness of acetone fraction of aqueous seed extracts of *Juniperus phoenicea, Pistacia altantica* and *Dudneya africana* against *E. coli* ATCC 25922 and other pathogens. Chloroform root extract of *Polygonum hydropiper* of Family Polygonaceae demonstrated strongest inhibitory activity against *E. coli* as well as various other gram positive and gram negative bacteria (Hasan et al., 2009). Mohammed and Al-Bayati (2009) isolated caffeine (3, 7-dihydro-1, 3, 7- tri methyl-1H purine 2, 6 dione) from *Coffea arabica* and *Camellia sinensis* as an effective antibacterial agent against *E. coli*. Determination of MIC of isolated caffeine was performed by broth microdilution method using 96 multi-well microtiter plates.

Singh and Pandey (2009) documented antibacterial activity of methanolic stem, leaves and seed extracts of *Hyoscyamus niger* against *E. coli* and other pathogens and strongest growth limiting response was recorded from methanolic extract. Uma et al. (2009 b) noticed antibacterial activity of methanolic, aqueous and chloroform bark extract of *Ficus religiosa* and *F. benghalensis* against two different clinical isolated ETEC strains and observed presence of carbohydrates, flavonoids, aminoacids, steroids, saponins and tannins. In another study, Uma et al. (2009 a) observed antibacterial effectiveness of crude aqueous, methanolic and chloroform flower extracts of *Clitoria ternatea* Linn. by agar disc diffusion and broth macrodilution method against Enteropathogenic and Enterotoxigenic *E. coli* strains. MIC of aqueous extract was of 10 mg/ml, methanolic extract of 2.5 mg/ml and chloroform extract of 5 mg/ml.

Igbinosa et al. (2009); Anandarajagopal et al. (2011) reported antibacterial activity of polar solvent (methanol, ethanol, distilled water) stem bark extracts of *Jatropha curcas* and *Bombax ceiba* Linn. against *E. coli* and other pathogens by well diffusion and broth dilution method. Ahirrao et al. (2010) reported antibacterial activity of aqueous extract of whole plant of *Biophytum sensitivum* against *E. coli* and other clinical pathogens. Ajayi and Akintola (2010) observed effective *in vitro* control results of autoclaved and tryndalized aqueous leaf extracts of *Croton zambensis* against diarrheagenic *E. coli* strains.
Ali et al. (2010) documented antibacterial activity of essential oil from leaves of *Stachys yemenensis* against *E. coli* ATCC 35218 and other standard pathogens. The major components observed from essential oils were alpha-phellandrene, beta-phellandrene, elemol, spathulenol, beta-eudesmol, alpha-eudesmol and squalene. Bussmann et al. (2010) made a comprehensive study on antibacterial activity of ethanolic extracts of 51 plant species against *E. coli* and other clinical pathogens. Among them *Hyperium laricifolium, Hura crepitans, Caesalpinia paipai, Cassia fistula, Hyptis sidifolia, Salvia sp., Banisteriopsis caapi, Miconia salicifolia* and *Polygonum hydropiperoids* showed lowest MIC values detected on the basis of deep-well broth microdilution method.

Acetone and petroleum ether pod extract of *Cassia fistula* (Family: Fabaceae) was reported to be having strongest inhibitory activity against *E. coli* ATCC 25922 (Chavan et al., 2010). Dugler et al. (2010) observed strongest inhibitory results from ethanolic extracts of whole plant of *Ballota nigra* against *E. coli* ATCC 10538 and other standard strains by disk diffusion and microdilution method. Frey and Meyers (2010) observed strongest antibacterial efficacy of aqueous leaf extracts of *Ipomoea pandurata* as well as leaf and flower extracts of *Rosa multiflora* against *E. coli*. Hassan et al. (2010) documented antibacterial activity of saponin present in 100% MeOH (methanol) fractions of *Cyamopsis tetragonoloba* L. bean extract against *E. coli* by microdilution method.

Hemashenpagam and Selvary (2010) reported antimicrobial activity of aqueous and solvent (benzene, acetone, methanol and ethanol) extracts of root, stem, leaves and fruits of *Solanum xanthocarpum* (Family: Solaneaceae) against *E. coli* and other clinical pathogens. Among them aqueous extract failed to show any inhibitory results against any tested organism. Idowu et al. (2010) investigated antibacterial activity of epicatechin and quercetine-3-O-alpha L-rhamnopyranoside isolated from ethyl acetate fraction of methanolic leaf extract of *Ixora coccinea* against *E. coli*. Kalaichelvi and Rajeswari (2010) documented antibacterial activity of aqueous and ethanolic extracts of various plant parts of *Eclipta alba* and *Phyllanthus niruri* against *E. coli* and other clinical pathogens.

Kamba and Hassan (2010) noticed antibacterial activity of ethanolic leaf, stem and root extracts of *Euphorbia balasmifera* and MIC ranged from 5.0 to 6.0 mg/ml is all three parts to inhibit *E. coli* strains and other clinical pathogens. Khan, A. et al. (2010) observed antibacterial efficacy of glycoside Patuloside A obtained from crude extract of *Peperomia*
pellucida (Linn) of family Piperaceae against *E. coli*. Kowti *et al.* (2010) observed antibacterial effectiveness of ethanolic leaf and flower extracts of *Spathodea campanulata* against *E. coli* and other enteric pathogens.

Negi and Dave (2010); Lakshmi *et al.*, (2011) studied antibacterial properties of methanolic leaf and ethanolic stem bark extracts of *Acacia catechue* against *E. coli* by broth macrodilution method. Merkl *et al.* (2010) investigated antibacterial activity of 3, 4 dihydroxphenolic acids, protocatechuic acid and caffeic acid against *E. coli* DMF 7503 by broth microdilution technique. In another study antibacterial activity of crude as well as purified fractions of *Commiphora glandulari* was reported against *E. coli* NCTC 9002 (Motlhanka *et al.*, 2010). Nisha *et al.* (2010) observed antibacterial effectiveness of chloroform, acetone, methanolic and ethanolic root extracts of *Glycyrrhiza glabra* against *E. coli* and other clinical pathogens. Policegoudra *et al.* (2010) studied antibacterial property of amadaldehyde against *E. coli* using broth microdilution technique with MIC of 180 ppm. Santhi and Annapoorani (2010) recorded antibacterial effectiveness of chloroform, ethanolic and aqueous leaf extract of *Clerodendron inerme* against *E. coli* and other clinical pathogens. Strongest inhibitory activity was noticed from ethanolic leaf extract against tested strain. Satish *et al.* (2010) documented antibacterial effectiveness of petroleum ether, chloroform, methanolic and aqueous leaf extracts of *Cocculus hirsutus* and *Hyptis suaveolens* against *E. coli* and other pathogenic organism. Sharma and Sharma (2010) reported antibacterial effectiveness of both polar and non polar solvent extracts of *Mimosa pudica* Linn. and *Tridax procumbens* against *E. coli* by well diffusion method.

Sibandze *et al.* (2010) detected antibacterial activity of dichloromethane: methanol (1:1) bark extract of *Ozoroa sphaerocarpa*, *Breonadia salicina* and *Syzygium cordatum* against diarrheagenic *E. coli*. In addition strongest in vitro synergistic interaction between extracts of *Syzygium cordatum* and *Breonadia salicina* was observed to inhibit the tested organism. Rest other extracts in combination showed antagonism.

Srividya *et al.* (2010) documented antibacterial activity of hot and cold macerated and methanolic extracts of *Alpinia officinarum* (Family: Zingiberaceae) against *E. coli* and other clinical pathogens. Usha *et al.* (2010) studied antibacterial activity of ethanolic, aqueous, petroleum ether and ethyl acetate extracts of *Morinda citrifolia* against *E. coli*. Results revealed that cold ethanolic and aqueous leaf extract of the plant showed effective inhibition
against standard MTCC E. coli strain but no inhibitory activity was noticed in petroleum ether and ethyl acetate extract of the same plant.

Abiramasundari et al. (2011) studied antibacterial effectiveness of petroleum ether, chloroform, benzene, acetone, methanolic and aqueous extracts of leaf, stem and root of Cocculus hirsutus against E. coli and other clinical enteric and non-enteric pathogens by well diffusion and broth dilution method. Antibacterial effectiveness was observed to be maximum in petroleum ether leaf extract of C. hirsutus on the basis of diameter of zone of inhibition whereas highest inhibitory zones were observed in acetone stem and root extracts of same plant on E. coli strain. Ajitha rani et al. (2011) analyzed antibacterial effectiveness of n-hexane, ethyl acetate, chloroform, methanolic, ethanolic and aqueous extracts of various plant parts of Desmodium triflorum (Family: Polypodiaceae) against E. coli. Preliminary phytochemical analysis of crude extracts of D. triflorum showed presence of alkaloids, steroids, tannins, flavonoids and saponins. Hydro alcoholic and chloroform root extract of Cassia fistula L. showed effective inhibitory response against E. coli (Bhalodia, 2011).

Gopalkrishnan and Vadivel (2011) observed antibacterial effectiveness of benzene, chloroform, ethanolic and aqueous bark extract of Bauhinia tomentosa against E. coli and other clinical pathogens. Among all extracts strongest inhibitory activity was observed in ethanolic extract. He et al. (2011) reported antibacterial activity of fumaric acid isolated from acetoacetate fraction of Aloe vera against avine pathogenic E. coli. Indhumathi et al. (2011) observed inhibitory activity of aqueous and ethanolic seed extracts of Spermacoce hispida against E. coli and other clinical pathogens. Jahan et al. (2011) reported significant antibacterial potential of crude methanolic, acetone, ethyl acetate, water and gmmomodified extracts of two different medicinal plants: Terminalia arjuna and Euphorbia tirucalli against E. coli. Among all extracts highest antibacterial effect was observed from gmmomodified extracts of both plants with zone of inhibition of 27.7 mm from T. arjuna and 26 mm from E. tirucalli.

Kiran et al. (2011) reported antibacterial effectiveness of aqueous and solvent leaf extracts of Tribulus terrestris and observed more antibacterial effectiveness of methanolic leaf extracts over petroleum ether and chloroform extract with zone of inhibition of 31 mm from methanolic extract where as from petroleum ether and chloroform extracts zone of inhibition was found to be of 25 mm and 17 mm respectively. Koona and Budida (2011)
studied antibacterial effectiveness of hexane, chloroform and methanolic leaf extracts of *Azadirachta indica* against *E. coli* ATCC B9637 and other standard strains by agar well diffusion method. Maximum antibacterial effectiveness was observed in methanolic leaf extracts of *Azadirachta indica* against all tested organisms in comparison to hexane and chloroform extract.


Pirbalouti *et al.* (2011) isolated two different antibacterial agents thymol and carvacrol from ethanolic leaf and flower extracts of *Thymus daenensis* and observed its MIC of 0.019 mg/g against *E. coli* O157: H7 associated with diarrheal infections in animals. Salman *et al.* (2011) observed antibacterial efficacy of methanolic seed extract of *Nigella sativa* against *E. coli* and other clinical pathogens. Singh (2011) recorded antibacterial activity of hot ethanolic leaf and root as well as callus extracts of both parts of *Premna serratifolia* against *E. coli* and other human pathogens and observed more effectiveness from root callus extract. Srivastava and Bhargava (2011) documented antibacterial activity of crude chloroform and methanolic leaf extracts of two varieties of *Brassica oleracea* eg; *botrytis* and *capitata* against *E. coli*. Growth limiting response was found to be more in *Brassica oleracea* botrytis.

Yukub and Mukhtar (2011) recognized antimicrobial activities of aqueous and ethanolic extracts of various plant parts (flower, leaves, stem and whole plant) of *Euphorbia pulcherima* against *E. coli* O157: H7. Zubayr *et al.* (2011) investigated antibacterial potency of methanolic leaf extract and fractions of *Solanum nigrum* against *E. coli* and observed more
effective inhibitory response from fractions in comparison to crude extracts examined on the basis of diameter of zone of inhibition as well as by broth micro dilution method.

Kalayou et al. (2012) observed effective antibacterial activity of hydroalcoholic extracts of various plant parts of Achyranthes aspera L., Ficus caria, Malvi parviflora and Solanum hastifolium against E. coli associated with gastrointestinal infections in animals. Kasim et al. (2012) studied antibacterial efficacy of 70% aqueous-ethanolic leaf extracts of six Nigerian medicinal plants Acalypha fimbriata, Glaphe brevis, Vernonia amygdalina, Struchium sparganophora, Celosia argentea and Amaranthus spinosus against diarrheagenic E. coli and other clinical pathogens. Antibacterial effectiveness was observed in A. fimbriata, C. argentea, A. spinosus and S. sparganophora whereas G. brevis and V. amygdalina failed to exhibit inhibitory response on E. coli.

Menghani and Soni (2012) observed effective inhibitory results from petroleum ether, chloroform, benzene, ethyl acetate, methanolic and aqueous extracts of Alpinia galangal and Embelia ribes against E. coli and other clinical pathogens. Nithya et al. (2012) documented antibacterial effectiveness of ethanolic and aqueous extract of Vallarai chooranam against E. coli.

Patel and Rao (2012) studied antibacterial activity of diethyl ether, ethyl acetate, acetone, methanolic and aqueous fruit extracts of Physalis minima L. against E. coli MTCC 109 by both agar diffusion and broth dilution method. MIC of methanolic extract was of 4 mg/ml against E. coli whereas, no inhibitory response was observed from rest other extracts to inhibit E. coli strain. Sarnthima and Khammung (2012) studied antibacterial activity of partially purified bioactive fractions of Solanum stamonifolium against E. coli and other clinical isolates by disc diffusion method. Thulasi and Amsaveni (2012) studied antibacterial activity of leaf and flower of Cassia auriculata against extended spectrum beta lactamase uropathogenic E. coli strains. Ethyl acetate extract of leaf and flower of C. auriculata showed maximum inhibitory response against all E. coli strains in comparison to methanolic extracts whereas no inhibitory results were observed from ethanolic, chloroform, hexane and aqueous extracts of C. auriculata.
Synergistic interactions between herbal extracts and antibiotics

Combined administration of extracts and antibiotics is quite benificial to cure infections more effectively and are recently practiced by most microbiologists world wide for better therapy. Synergistic activity of extracts of *Senna obtusifolia* with Ofloxacin and Coltrimaxole was studied against *E. coli* (EC 002 MBFTY) which shows interaction of extract with Ofloxacin and failed to exhibit any results with Coltrimaxole (Doughari *et al.*, 2008).

Kumar *et al.* (2009) analyzed *in vitro* synergistic response between crude methanolic flower extract of *Thespesia populnea* with Oxytetracycline against *E. coli* ATCC 11775 by well diffusion method. Chatterjee *et al.* (2009) noticed *in vitro* positive interaction between ethanolic leaf extract of *Vangueria spinosa* Roxb. (Rubiaceae) with Doxycycline and Ofloxacin to inhibit *E. coli*. Hot aqueous clove extract individually as well as in combination with Ofloxacin and Amikacin showed strongest synergistic interaction to inhibit *E. coli* and other enteric pathogens (Ghaly *et al.*, 2009). Ampicillin and Streptomycin was reported to produce antagonistic effect on combination with ethanolic leaf extract of *Ocimum gratissimum* L. against *E. coli* ATCC 11755 whereas clinical isolated *E. coli* strain showed additive interaction with Ciprofloxacin, antagonistic with Streptomycin and synergistic with Ampicillin and Septrin (Nweze and Eze, 2009). Tetracycline was reported to perform synergistic interaction with clove extract against four different clinical isolated UTI causing *E. coli* strains followed by Chloramphenicol, Gentamycin, Evofloxacin, Amikin and Norfloxicin (Al-Jiffri *et al.*, 2011).

Complete antagonistic activity was observed on combined administration of raw extract of *A. sativum* and *G. latifolium* with Ciprofloxacin and Ampicillin against *E. coli* (Eja *et al.*, 2011). Elbashiti *et al.* (2011) observed strongest synergistic interaction between ethanolic root, shoot and seed extract of *Cakile maritima* and *Mesembrayanthemum crystallinum* with Amikacin, Tetracycline, Kanamycin and Tobramycin to inhibit *E. coli* strain. Hussin and El-Sayed (2011) reported synergistic interaction between dichloromethane/methanol extracts from *Punica granatum, Thymus vulgaris, Commiphora molmol* and *Achillea fragrantissima* (AF) with Tetracycline against *E. coli* ATCC 25922.

Stefanovic and Comic (2012) reported synergistic interaction between aqueous and ethanolic leaf extracts of *Melissa officinalis* with Rifamycin to inhibit drug resistant clinical isolated *E. coli* performed by disc-diffusion method.