

BIOPROSPECTING ANTICARCINOGENIC POTENTIAL OF PLANTS IN RAJASTHAN, INDIA

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Abstract: Purpose of this communication is to report on the present status of anticarcinogenic plants of Rajasthan based on folk lores, ethnobotanical, pharmacological and biochemical studies meant for more fruitful and directed future studies and projects. An up to date account of antioxidants, antimutagens, detoxicants anti-inflammatory, antiproliferative, antimetastasis and antiangiogenic plants has been given.

Keywords: Bioprospecting, Anticarcinogenic, Antioxidant plants, Rajasthan

INTRODUCTION

Uncontrolled growth of body's own tissues and organs due to genotoxic and epigenetic carcinogens is called cancer, a leading cause of mortality worldwide. In India, every year about 65,00,000 new cancer cases are diagnosed resulting in about 58,00,000 cancer related death of which, oral and lung cancer in men and breast and cervical cancer in women predominate. These are basically caused by oxidative stresses caused by modifiable and unmodifiable factors. Dominant carcinogens are nitroso foods, contaminated aflatoxinogenic foods, infections, occupational pollutants, poor diet, obesity, tobacco chewing and smoking, alcoholism, radiation exposure and drugs (Singh *et al.*, 2009).

A variety of synthetic and natural anticancer agents with various degree of chemopreventive values have been identified to combat cancer but treatment of cancer by synthetic drugs is generally not preferred because of their high cost, range of side effects, toxicity, drug resistance and large number of consequent dropouts. Hence, bioprospecting novel anticancer agents from traditional medicinal and dietary plants and their products is the oldest and most effective strategies that date back to Chinese and Indian Ayurvedic medicines (Sharma & Kumar, 2000)

Recently, there have been exponential increases in the quantum of studies investigating cancer chemoprevention by plants especially in poor countries. These anticarcinogenic investigations use several complementary and overlapping mechanisms, such as, inhibition of activation of procarcinogens, enhancement of detoxification pathways, antioxidants, antimutagens and alteration of cellular signal pathways (Singh & Pracheta, 2012). In Rajasthan, majority of studies concern antioxidant plants apart from Ethnobotanical studies showing such activities. Antioxidant system tends to reduce free radical formation, balances oxidative stress implicated in tumour initiation, cell proliferation and differentiation besides apoptotic induction by diverse stimuli (Goyal & Sharma, 2009) hence are justified for bioprospecting anticancer herbal drugs.

Ethnic tribes, Ethnomedical and Ayurvedic studies in Rajasthan having anticarcinogenic potential:

Asurs, Bhils, Bhungi, Cherkas, Garos, Gonds, Hoes, Jaintians, Karses, Khases, Konds, Lodhas, Mahles, Mudras, Marias, Mishrees, Rotha, Soras, Lohars, Santals and Shopners are main tribes of Rajasthan and are distributed in Dausa, Jhalwar, Udaipur, Chittod, Jodhpur, Jaipur, Banswara, Ajmer, Mount Abu and Alwar areas. Because of dwindling ethnicity and likely folk lores and traditional knowledge, several investigators have, therefore, explored Ethnobotanical/Ethnomedicinal wealth of Rajasthan used by Bhopas to treat various ailments including tumours. Sood *et al.* (2005) have prepared a compendium on Ethnic plants of India used in cancer cure. Garg *et al.* (1980) made survey for alkaloids in Rajasthan desert plants. Ethnobotanical studies on fern allies of Rajasthan were undertaken by Sharma and Vyas (1985) who found several species of *Selaginella*, *Equisetum*, *Marsilia*, *Adiantum*, *Pteris*, *Angiopteris* and *Blechnum* to possess anticancer properties. Dhanukar *et al.* (2000) reported on the pharmacology of medicinal plants and natural products but did not cover much of the anticarcinogenic plants. However, anti-inflammatory plants like *Azadirachta indica*, *Butea monosperma*, *Calotropis procera*, *Gymnema sylvestre*, *Gmelina asiatica*, *Ocimum sanctum* and *Pongamia pinnata* were reported by them. This was followed by an overview on medicinal Pteridophytes by Dixit and Singh (2004). Antitumour properties in Pteridophytes have also been described by Singh and Pracheta (2012). Sharma and Kumar (2001) searched for anticancer drugs in traditional medicines. Chaudhary and Swarnkar (2001) reported on antioxidant activity of phenolic and flavonoid compounds in some medicinal plants of India. Anti-inflammatory and antitumour properties were reported in ethnomedical plants like *Bombax ceiba*, *Citrus medica*, *Cleome gynandra*, *Commiphora wightii*, *Ipomoea muricata*, *Lomonia acidissima* and *Salvadora oleoides*, medicoethnobotany of Dausa District was explored by Sharma and Trivedi (2004) who reported several antioxidantive plants, such as *Aegle marmelos*, *Achyranthes aspera*, *Aloe vera*, *Azadirachta indica*,

Bacopa monnieri, *Barleria prionitis*, *Butea monosperma*, *Cassia angustifolia*, *Cassia fistula*, *Calotropis procera*, *Compimphora wightii*, *Curcuma longa*, *Gymnema sylvestre*, *Picorrhiza kurroa*, *Tinospora cordifolia*, *Withania somnifera*, *Euphorbia hirta*, *E. neriifolia*, *Lawsonia inermis*, *Moringa oleifera*, *Pterocarpus sp.*, *Tamirindus indica*, *Vitax negundo*, *Acacia nilotica*, *A. catechu*, *Dalbergia sissoo* *Phyllanthus emblica* and *Tecomella undulata* but local herbalists were unaware of anticarcinogenic potential in them albeit searching for anticancer drugs in traditional medicines was undertaken by Sharma and Ashwani Kumar (2001). Sharma (2004) studied ethnomedic-oreligious plants of Hadoti plateau of Rajasthan and reported *Acacia nilotica*, *Aegle marmelos*, *Azadirachta indica*, *Butea monosperma*, *Calotropis gigantia*, *Calotropis procera*, *Ficus religiosa*, *Gloriosa superba*, *Solanum surattense*, *Syzium cumini* etc. Chaudhary, Singh and Pillai (2008) also made ethnobotanical survey of Banswara District of Rajasthan and reported anticancer properties in *Leea macrophylla* and *Sauromatus venosum*. Suresh Kumari *et al.* (2008) also investigated antioxidant activity in some selected Indian medicinal plants. Besides reporting on anticancer *Albizia amores*, *Achyranthes aspera*, *Cassia fistula*, *Curcuma longa* and *Gloriosa superba.*, Jain, Jain and Singh (2009) made ethnobotanical survey of medicinal plants of Sariska and Siliserh region from Alwar District of Rajasthan including *Coccinia cordifolia*, *Catharenes roseus*, *Sida rhombifolia*, *Salvadora oleoides*, *Aegle marmelos*, *Achyranthes aspera*, *Asparagus racemosus*, *Barleria prionitis*, *Boerhaavia diffusa*, *Corchorus aestuans* *Grewia tenax*, *Emblia officinalis*, and *Terminalia arjuna* which are now known to be anticarcinogenic.

Anticarcinogenic studies: Recently, there has been exponential increase in the number of studies investigating cancer chemoprevention in plants. These cancer preventing anticarcinogenic studies use several overlapping and complementary mechanisms including 1. initiation of activation of procarcinogens 2. antimutagens 3. stimulation of detoxification 4. antioxidants 5. alteration of cellular signal pathways. as antioxidant system tends to reduce free radical formation, balances oxidative stress implicated in tumour initiation, proliferation, differentiation as well as apoptosis induction by diverse stimuli (Goyal and Sharma, 2009), hence present attempt of bioprospecting antioxidant plants of Rajasthan in anticarcinogenesis is justified: Singlu, Jain & Jain (2009) observed antioxidant activity of some medicinally important Arid zone plants, such as, *Aerva tomentosa*, *Helitropium sp.*, *lepidagathes trinervis*, *Mimosa hamata*, *Mollugo nudicaulis*, *Trianthema decandra*, *Tribulus terrestris*, *Verbesina encelioides*, *polycarpaea corymbosa*, *Portulaca pilosa* and *Gisekia plannaceioides*. Mandal *et al.* (2009) and Panchawat *et al.* (2010) reviewed our

information on herbal antioxidants. Chaudhary, Saroha and Swarnkar (2011) observed antioxidant activity in *Acacia nilotica*, *Dalbergia sissoo*, *Delonix regia*, *Catharenes roseus*, *Mentha arvensis*, *Ocimum basilicum*, and *Tinospora cordifolia* etc while Kumar *et al.* (2011) compared Antioxidant activity in hepatoprotective plants. An overview on potent herbal antioxidant drugs was presented by Rajwar *et al.* (2011).

Documented antioxidant plants of Rajasthan: Due to the presence of polysaccharides, phenolics, alkaloids, flavonoids, glucosides and caronotoids and plants are known to possess antioxidative properties, Many such plants have been reported from Rajasthan as mentioned below: 1. *Aerva tomentosa* (Sethi & Sharma, 2011) 2. *Asparagus racemosus* (Patro & Bhatnagar, 2005; Viral, 2005) 3. *Acacia nilotica* (Meena *et al.*, 2006) 4. *A. arabica* (Gupta & Bokadia, 1975) 5. *Azadirachta indica* (Koul *et al.*, 2006) 6. *Amaranthus paniculata* (Bhatia & Jain, 2002) 7. *A. gangeticus* (Verma, Sisodia and Bhatia, 2002) 8. *Andrographis paniculata* (Handa & Sharma, 1990; Tanwer *et al.*, 2010) 9. *Achyranthes aspera* (Srivastava *et al.*, 2011) 10. *Alstonia scholaris* (Swafiya *et al.*, 2010) 11. *Acacia catechu* (Syed & Asad, 2009; Karwani, *et al.*, 2011) 12. *Aegle marmelos* (Rajan *et al.*, 2011) 13. *Aloe vera* (Panche, Kumar & Kumar, 1998; Saritha *et al.*, 2010) 14. *Boerhaavia diffusa* (Chakraborti & Handa, 1989) 15. *Bougainvillea glabra* (Gupta & Rathore, 2011) 16. *Barleria prionitis* (Singh *et al.*, 2005) 17. *Balanitis roxbughii* (Singh *et al.*, 2009) 19. *B. aegyptica* (Vijay & Vijayvergis, 2010) 20. *Bauhinea variegata* & *Leucas aspera* (Bhatia *et al.*, 2011; Gupta, Bhattacharya, Sharma & Nareg, 2010; Gupta *et al.*, 2011) 21. *Butea monosperma* (Sharma & Deshwal, 2011) 22. *Cissus quadrangulaenes* (Vijay *et al.*, 2010) 23. *Corchorus aestuans* (Patel, 2011) 24. *Chlorophytum borivillianum* (Kumar *et al.*, 2010) 25. *Cyperus rotundus* (Yazdenparst and Ardestam, 2008) 26. *Cleome viscosa* (Gupta & Dixit, 2009) 27. *Euphorbia neriifolia* (Sharma, Pracheta & Singh, 2011; Sharma, Pracheta, Paliwal, Singh, & Sharma, 2011) 27. *Garuga pinnata* (Kathod *et al.*, 2010) 28. *Glycosmis pentaphylla* (Gupta *et al.*, 2011) 29. *Grewia asiatica* (Ahaskar *et al.*, 2007) 30. *Gisekia plannaceioides* (Singh, Jain & Jain, 2009) 31. *Moringa oleifera* (Sharma *et al.*, 2011) 32. *Momordica charantia* (Chaudhary *et al.*, 2009) 33. *Peltophorum pterocarpus* (Jain *et al.*, 2011) 34. *Prosopis cinerariae* (Sharma *et al.*, 2010; Dharni *et al.*, 2011) 35. *Portulaca oleracea/pilosa* (Sanja *et al.*, 2009; Dejas *et al.*, 2002) 36. *Polycarpa corymbosa* (Hukkeri and Kenganora, 2007) 37. *Phyllanthus niruri*, *P. emblica* etc. (Harish & Shivandappa, 2005; Kumaran & Karuna Kumar, 2007) 38. *Rubus ellipticus* (Sharma & Kumar, 2011) 39. *Pongamia pinnata* (Sangwan *et al.*, 2011) 40. *Mentha piperita* (Samarath, Goyal & Kumar, 2001) 41. *Terminalia arjuna* (Singh *et al.*, 2011) 42. *Tecomella undulata*

(Singh & Gupta, 2011) 43. *Tinospora cordifolia* (Sharma *et al.*, 2011) 44. *Triumfetta pilosa* (Ramakrishna *et al.*, 2011) 44. *Tribulus terrestris* (Pandey, Bhavani & Saini, 2007) 45. *Thuja occidentalis* (Dubey & Batre, 2009) 46. *Symplocos racemosa* (Vimal, 2010) 47. *Cassia sophera* (Nagore *et al.*, 2010) 48. *Panax ginseng* (Verma, Jahan, Kim & Goyal, 2011) 49. *Bacopa monnieri*, *Terminalia chebulae* & *Picrorrhiza kurroa* (Kumar, Singh & Singh, 2008) 50. *Withania somnifera* (Devi, 1996; Sharma *et al.*, 2011) 51. *Calotropis procera*/*Calotropis gigantia* (Suresh & Chauhan, 1992; Joshi *et al.*, 2010) 52. *Salvadora oleroides* (Yadav *et al.*, 2008; Jain, Jain & Singh, 2009) 53. *Spinacea oleracea* (Bhati & Jain, 2004) 54. *Glycyrrhiza glabra* (Dayanan *et al.*, 2010). A delving back in ethnomedical literature reveals antioxidant plants, such as, *Leea macrophylla*, *Sauromantusa venosum*, *Bombax ceiba* (Gandhare *et al.*, 2010), *Cassia fistula*, *Curcuma longa*, *Calotropis procera*, *Dalbergia sissoo*, *Delonix regia*, *Cyperus rotundus* (Yazdenparst and Ardestam, 2008), *Rosmarinus officinalis*, *Nerium indicum*, *Murraya koinighii*, *Ocimum basilicum*, *Tamarindus indica*, *Solanum surattense*, *Trigonella foenum graceum*, *Sygium cumini* and *Zizyphus mauritiana* are also found in Rajasthan. (Chaudhary, Singh & Pillai, 2008; Jain, Jain & Singh, 2009; Chaudhary, Saroha & Swarnkar, 2011). Singh, Jain & Jain (2009) also reported *Heliotropium marifolium*, *Lepidagathes trinervis*, *Mollugo nudicaulis*, *triantherma decandra*, *Verbesiana enchiides*, and *Portulaca pilosa* from Rajasthan.

Bioactive phytoconstituents of some antioxidative plants: Plants contain such as, *Acacia nilotica* contains tannins, ellagic acid, stearic acid, carotene, ascorbic acid and selenium; *Acacia catechu*-catechin, tannic acid, quercetin; *Asparagus racemosus*-saponin, flavonoid; *Aloe vera*-emodin, barbalein, bradykininose, anthraquinones; *Alstonia scholaris*-alkaloids, saponin, triterpene, xanthine oxidase, SOD; *Azadirachta indica*-azadirachtin, gedernin; *Amaranthus paniculata*-carotenoids and vitamin C; *Achyranthes aspera*-achyranthane, emblicin; *Andrographis paniculata*- andrographides; *Boerhaavia diffusa*- alkaloids, sterols, isofuroxanthone; *Chlorophytum borivilianum*-flavonoids, tannins, phenolic compounds; *Calotropis procera*- flavonoids glucoside alkaloids; *Curcuma longa*- curcumin; *Glycyrrhiza glabra*-glycyrrhizin; *Corchorus aestuaris*/*Corchorus olitorius*-phenolics, glucisnoids; *Glycosmis pentaphylla*-flavonoids, alkaloids like naphthaquinin, acridone, avicenol; *Heliotropium indica*-indicene N-oxide; *Coriandrum sativum*-anethol; *Mentha arvensis*-L menthol, *Moringa oleifera*- saponin, glycosides, flavonoids, proanthocyanidins, beta sterol; *Phyllanthus*-quercetin, flavonoids, ascorbic acid; *Spinacea oleracea*- ascorbic acid, beta carotene, lutein, zeaxanthin; *Euphorbia nerifolia*-saponin,

triterpene, sterol; *Ocimum sanctum*-orientin, vicinin; *Sygium cumini*-ellagic acid; *Solanum surratense*-trans-squalene-9, 12, 15-octade calrieoic acid; *Salvadora*-anthraquinone; *Tecomella undulata*-beta sterol, COX enzymes; *Leucas aspera*- leucasin; *Triumfetta pilosa*-iridoid alkaloids, coumarins, flavonoids, leucoanthocyanin; *Withania somnifera*-withanolids.

Antitumour anticarcinogenic plants and mechanisms:

Hepatoprotective antioxidants: These include *Bacopa monnieri*, *Picrorrhiza kurroa*, *Glycyrrhiza glabra*, *Azadirachta indica*, *Tephrosia purpurea*, *Terminalia arjuna*, *Tinospora cordifolia*, *Swertia chirata*, *Phyllanthus amarus*, *Justicia gendarussa* *Aloe vera* (Kumar *et al.*, 2011). Bhatia and Jain (2004) have reviewed information on this topic.

Antimutagenic plants: *Acacia nilotica*, *Coriandrum sativum*, *Chlorophytum* sp. etc

Radioprotective plants: *Panax ginseng* (Pande *et al.*, 1980) *Aloe vera* (Pande *et al.*, 1998) *Amaranthus gangeticum* (Verma, Sisodia and Bhatia, 2002) *Mentha piperita*, *Ocimum sanctum*, *Amaranthus paniculata*, *Spinacea oleracea* etc. (Saxena, 1997; Jain, 2002) Bhatia and Jain, (2004) and Herbal preparations like Liv 52 (Constituents- *Capparis spinosa*, *Cichorium intybus*, *Solanum nigrum*, *Cassia occidentalis*, *Terminalia arjuna*, *Achilla millefolium*, *Tamarix gallica*). Goyal (2004) has reviewed the subject adequately.

Anti-inflammatory plants: *Achyranthes aspera*, *Barleria prionitis*, *Azadirachta indica*, *Boerhaavia diffusa*, *Semecarpus anacardium*, *Aloe vera*, *Curcuma longa*, *Aegle marmelos*, *Tinospora cordifolia*, *Euphorbia nerii folia*, *Cassia sophera*, *Sygium cumini* and *Corchorus aestuans*.

Antiproliferative plants: *Andrographis paniculata*, *Panax ginseng*, *Garcinea* sp. *Gymnostemma pentaphylla*, *Coriandrum sativum*, *Butea monosperma* (Pathak *et al.*, 2011).

Plants with antimetastasis activity: eg. *Trigonella foenum graceum*.

Plants with antimigration activity: e.g, *Euphorbia nerifolia*.

Antiangiogenic plants; *Bombax ceiba*, *Delonix regia*, *Calotropis procera*

Plants with cytotoxic activity: *Glycyrrhiza glabra*, *Euphorbia nerifolia*, *Cyperus rotundus*, *Glycosmis pentaphylla*.

Plants that are immunomodulatory: *Acacia catechu*, *Euphorbia* spp.

Plants that cause apoptosis induction: *Tribulus terrestris*, *Cyperus rotundus*

Plant-derived anticancer drugs: 1. bengaptin (*Balanitis aegyptica*) 2. vincristine, vinblastin (*Catheranthes roseus*)

Most extensively investigated anticarcinogenic plants of Rajasthan: These are *Euphorbia nerifolia*, *Moringa oleifera* and *Withania somnifera* and are discussed below:

***Euphorbia nerifolia*:** Rao and Prasad (1995) purified and partially characterized a lectin from the latex of this plant. Rasik et al (1996) observed wound healing properties in the latex. Phytopharmacological review of *E. nerifolia* was undertaken by Bigoniya and Rana (2005; 2008;2010). They observed Radioprotective, Hepatotoxic, Antitumour and cytotoxic properties due to saponin (2009). Gaur et al (2009) observed anti-inflammatory and antianalgesic activity. Pal, Sahu and Patnaik (2009), Sharma, Janmeda and Singh (2011) and Ahmad *et al.* (2011) observed hepatoprotective and anticarcinogenic antioxidant activity of alcohol extract of aerial parts of *E. nerifolia*. Preliminary phytochemical screening and in vitro antioxidant potential of hydroalcoholic extract of this plant was also carried out by Pracheta *et al.* (2011) and found alkaloids, flavonoids and terpenoids as important constituents. In the same year, Pracheta, Sharma, Paliwal and Sharma reported on in vitro free radical scavenging and antioxidant potential of ethanolic extract of *E.neriifolia*. Pracheta *et al.* (2011) observed chemopreventive effect of hydroethanolic extract of the plant leaves against DENA- induced Renal carcinogenesis. Sharma, Pracheta, Paliwal, Singh and Sharma (2011) investigated anticarcinogenic potential of *E. nerifolia* leaves against N-Nitrosodiethylamine induced nephrotoxicity in mice. Pracheta *et al.* (2011) also observed chemopreventive activity of hydroalcoholic extract of *E. nerifolia* leaves against DENA-induced Liver carcinogenesis. antitumour, antistimulatory and immunomodulatory properties of *E. nerifolia* appear due to sapogenin, lectin polysaccharide ingenase. anticarcinogenic potential in other species of *Euphorbia*, such as, *E. kansui*, *E. tirucalli*, *E.hirta*, *E. fischeriana*, *E. pephes*, *E. drumondii*, *E. petiollta*, *E. hebecurpa*, *E. microciardi* has also been reported elsewhere (Chen, 2000;Patil and Magdum,2011)

***Moringa oleifera*:** Horse Radish tree, *Moringa oleifera* has also extensively been studied with respect to its importance. A review on the commercial importance of this multipurpose tree was written by Paliwal, Sharma and Pracheta (2011). With respect to anticarcinogenic antioxidant activities, the chemomodulatory effect of *M. oleifera* leaves on hepatic carcinogen metabolizing enzymes, antioxidant parameters and skin papillanagenesis in mice was undertaken by Bharati, Tabassam and Azad (2003). Sharma, Paliwal, Pracheta and Sharma (2011) investigated phytochemical and antioxidant activities of the ethanolic extract of the pods of the plant in question. Paliwal, sharma and Pracheta (2011) free radical scavenging activity of aqueous and hydroethanolic extract of *Moringa oleifera* pods. In the same year, Paliwal, Sharma, Pracheta and Sharma (2011) reported on hepatoprotective and antioxidant potential of pods of this plant against DMBA-induced hepatocarcinogenesis in male mice.

Paliwal *et al.* (2011) also investigated anti-nephrotoxic effect of administration of *Moringa oleifera* in amelioration of DMBA-induced carcinogenesis in Swiss Albino mice.

***Withania somnifera*:** Bhattacharya, Satyan, Kalkunta and Shibnath (1997) observed antioxidant activity of glycowithanolides of this plant after Umadevi (1996) suggested that Ashwagandha may be a potential plant source of a promising drug for cancer chemotherapy and radiosensitisation. Prakash, Gupta and Dinda (2002) observed that withania somnifera root extract protected DMBA-induced Squamous cell carcinoma of skin in Albino mice. Sharma, Sharma, Pracheta and Paliwal (2011) reported that *Withania somnifera* is a rejuvenating Ayurvedic medicinal herb that is useful in the treatment of many human ailments. Sharma, Sharma, Pracheta, Paliwal and Sharma (2011) in particular observed therapeutic efficiency of *W. somnifera* root extract in the regulation of Lead nitrate Nephrotoxicity in Albino mice. Sharma, Sharma, Pracheta and Sharma (2011) also reported that ethanolic root extract of the plant affects Neurological parameters in mice subjected to lead nitrate. Earlier, Patro and Bhatnagar (2005) reported antioxidant effects of Ashwagandha.

Some other anticarcinogenic plants of the State: 1. *Rosmarinus officinalis*:- Radioprotective (Sancheti and Goyal,) 2.*Bombax ceiba*: antioxidantive, hepatoprotective, and antiangiogenic (Gandhare et al,2010) 3. *Butea monosperma*:- Anti-inflammatory, Hepatoprotective, radical scavenging and Chemopreventive (Sharma and Deshwal,2011) 4.*Prosopis cineraria*:- Bark is Antioxidant,Lepidemic (Sharma et al,2010) 5.*Glycosmis pentaphylla*:-Antioxidative and Cytotoxic (Gupta *et al.*, 2011) 6. *Triumfetta pilosa*:-anti-inflammatory, immunomodulatory and anticancer 7.*Aloe vera*:- anti-inflammatory, antitumorigenic, antileukemic, radioprotective, cytotoxic, antitussive and anticarcinogenic 8. *Polycarpae corymbosa*:-Antioxidative 9. *Cyperus rotundus*:-Antioxidative, Cytotoxic and Apoptotic 10 *Calotropis gigantea*:- antioxidative (Joshi *et al.*, 2010) 11.*Cleome Vesica*:- hepatoprotective.

Important dissertations and undergoing projects : A Saxena (1997) got his Ph.D. on (Enterohepatic response against the combined effect of mercury and radiation in mice and its modification by Liv52; K Marda (1999) was awarded Ph.D. on Investigation on the possible radioprotective effect of beta carotene on mice testis while M Jain (2002) got his degree on evaluation of antioxidant efficacy of certain plants extract: A study on mice liver. These works were carried out at Rajasthan University,Jaipur.

Projects: 1. Dr. Sreemoylee Chatterjee of International College for Girls, Jaipur is working on study of antimutagenic activity of fennel and Ajwain against sodium azide induced mutagenesis 2.Dr. Hemant Lal Jadhav of Jodhpur is working on antioxidant profile of some medicinal plants of

Rajasthan 3. Dr. Prachi Tyagi of BITS, Pilani is working on studies of antioxidant activity of different spices and herbs.

Himalaya International is setting up functional food project at Keshwana, near Behnor, Jaipur. Liv-52, Triphala and Amalika are important herbal products of Rajasthan (Bhatia and Jain; Verma *et al.*, 2011).

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