Biodiversity, Biology and Conservation of Medicinal Plants of the Thar Desert

CHAPTER · DECEMBER 2009

DOI: 10.1007/978-3-642-02550-1_1

3 AUTHORS:

Jaya Arora
Mohan Lal Sukhadia University

Shaily Goyal

Kishan Gopal Ramawat
Mohan Lal Sukhadia University

Metadata of the chapter that will be visualized online

Series Title	
Chapter Title	Biodiversity, Biology and Conservation of Medicinal Plants of the Thar Desert
Chapter SubTitle	
Copyright Year	2010
Copyright Holder	Springer-Verlag Berlin Heidelberg

Corresponding Author	Family Name	**Ramawat**
	Particle	
	Given Name	**Kishan Gopal**
	Suffix	
	Division	Laboratory of Bio-Molecular Technology, Department of Botany
	Organization	M.L. Sukhadia University
	Address	313001, Udaipur, India
	Email	kg_ramawat@yahoo.com
Author	Family Name	**Arora**
	Particle	
	Given Name	**Jaya**
	Suffix	
	Division	Laboratory of Bio-Molecular Technology, Department of Botany
	Organization	M.L. Sukhadia University
	Address	313001, Udaipur, India
	Email	
Author	Family Name	**Goyal**
	Particle	
	Given Name	**Shaily**
	Suffix	
	Division	Laboratory of Bio-Molecular Technology, Department of Botany
	Organization	M.L. Sukhadia University
	Address	313001, Udaipur, India
	Email	

Abstract	The Great Indian Desert known as the Thar Desert occupies about 60% of the area of Rajasthan – the largest state of India. It is one of the most heavily populated (in terms of both people and cattle) deserts of the world. The animal and human populations exert tremendous pressure on the scant vegetation of the region, making several plants vulnerable to becoming endangered. Inherent biological problems associated with these plants make their survival difficult and have forced adaptation to the harsh environment. The biological activities of these plants range from analgesic, antifungal, antimicrobial, hypolipidemic to hepatoprotective and anticancerous. This chapter reviews the biological problems faced by the medicinal plants of this region, their bioactive molecules, as well as biotechnological approaches aimed at improving and conserving these plants.

Chapter 1
Biodiversity, Biology and Conservation of Medicinal Plants of the Thar Desert

Jaya Arora, Shaily Goyal, and Kishan Gopal Ramawat

Abstract The Great Indian Desert known as the Thar Desert occupies about 60% of the area of Rajasthan – the largest state of India. It is one of the most heavily populated (in terms of both people and cattle) deserts of the world. The animal and human populations exert tremendous pressure on the scant vegetation of the region, making several plants vulnerable to becoming endangered. Inherent biological problems associated with these plants make their survival difficult and have forced adaptation to the harsh environment. The biological activities of these plants range from analgesic, antifungal, antimicrobial, hypolipidemic to hepatoprotective and anticancerous. This chapter reviews the biological problems faced by the medicinal plants of this region, their bioactive molecules, as well as biotechnological approaches aimed at improving and conserving these plants.

1.1 Introduction

Deserts have played a special role in human evolution and adaptation. They appear to be the major terrestrial habitat that channelled early human dispersal, representing barriers at some times, corridors at others (Gamble 1993). Studies of desert societies have also provided some of the most fertile ground for debate regarding human adaptability and how societies cope with marginal – often precarious – environmental circumstances, and about the effects of these environmental conditions on human land use, mobility, and dispersal (Kelly 1995).

J. Arora, S. Goyal, and K.G. Ramawat (✉)
Laboratory of Bio-Molecular Technology, Department of Botany, M.L. Sukhadia University, Udaipur-313001, India
e-mail: kg_ramawat@yahoo.com

K.G. Ramawat (ed.), *Desert Plants*,
DOI 10.1007/978-3-642-02550-1_1,

BookID 186229_Ramawat_ChapID 1_Proof# 1 - 28/8/09

1.2 Deserts of the World

Deserts are large bands of dry lands along the tropics in both the Northern and Southern hemispheres (Mares 1999; Middleton and Thomas 1997). The United Nations Environment Program (UNEP) has prepared a map of the extent of world deserts (Middleton and Thomas 1997). Deserts cover around 25,500,000 km^2, approximately 20% of the land area of the world. The boundaries of these deserts, which are constantly changing due to various climatic and human factors, are likely to drift over the next century as human-induced global warming takes effect. The defining characteristic of world deserts is aridity. The current UNEP definition of desert is a moisture deficit under normal climatic conditions where P/PET <0.20, i.e. where rainfall is less than 20% of potential moisture loss through evaporation (Smith et al. 1995).

1.2.1 The Thar Desert

Rajasthan is the largest state in India, and is located in the northwestern part of the country. The state is rich in floral diversity, with 911 wild species belonging to 780 genera and 154 families growing here (Shetty and Singh 1987–1993; Bhandari 1999). Geographically, Rajasthan lies between 23°3′ to 30°12′ longitude and 69°30′ to 78°17′ latitude. It occupies 342,239 km^2 land area, which is 10.41% of the total land area of India. The desert in northwestern India is known as the Thar Desert, and is one of the most heavily populated deserts in the world. The Thar Desert lies between 24° to 28° N latitude and 68° to 71° E longitude, occupying an area of about 200,000 km^2. Physically the desert stretches as far as Delhi to the east, south to the Run of Kutch and the Arabian Sea, to the arid rocky mountains of Baluchistan in the west, and is bounded in the north by the irrigated plains of Punjab (Fig. 1.1). The Aravalli hills divide the state of Rajasthan into two parts: (1) north-western desert, and (2) south-eastern hilly semi-arid forest. The altitude of the Thar Desert

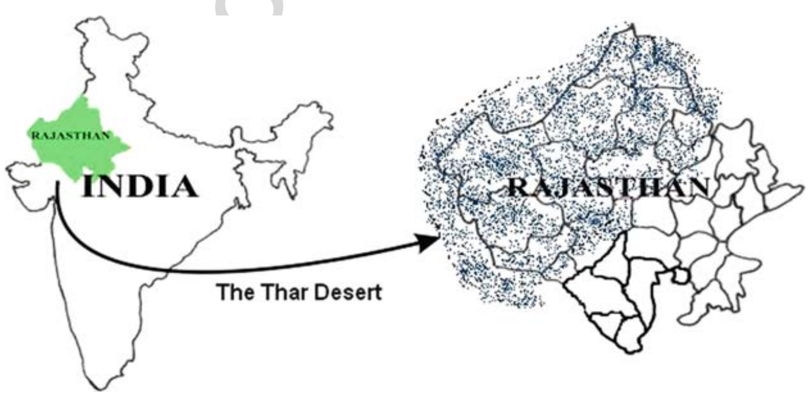

Fig. 1.1 Map of India showing location of the Thar Desert

B/W in Print

ranges from 61 m a.s.l. near Run of Kutch to 457 m in the lower reaches of Aravalli (where the highest peak Guru Shikhar in Mt. Abu is at 1,722 m a.s.l.). These geographical conditions provide extreme habitat for a wide range of flora, including bryophytes, pteridophytes, a lone gymnosperm – *Ephedra foliata* – and angiosperms including hydrophytes, halophytes and xerophytes.

About 720,000 ha desert area is saline and is used for production of table salt through open pits (subsoil) or wells (underground). Due to the high salt conditions, plants in this region have adapted to withstand high salt concentrations. The mechanism of salt tolerance differs in different species (Ramani et al. 2006). Some of the plants commonly found in saline habitats include *Cressa cretica*, *Haloxylon recurvum*, *Haloxylon salicornicum*, *Portulaca oleracea*, *Salsola baryosma*, *Sesuvium sesuvioides*, *Suaeda fruticosa*, *Tamarix aphylla*, *Trianthema triquetra*, *Zaleya redimita*, *and Zygophyllum simplex*.

1.2.2 Climate

Dry hot summers and pleasant dry winters are prominent features of the Thar Desert. The mean daily maximum temperature in summer ranges from 41°C to 46°C, and temperatures can reach up to 53°C in the shade during the hot summer noon. Rainfall is sparse, ranging from 127 mm to 254 mm annually, and is confined mainly to the rainy season (July–September).

1.2.3 Topographical Features

The topography of the Thar Desert is distinctly marked with sand, scattered rocky ridges and steep slopes. Topography and climatic factors play a significant role in determining the type of vegetation. Most regions consist of dry undulating plains of hardened sand, with the rest consisting largely of a rolling plain of loose sand that form shifting sand dunes 2–10 km long and 20–30 m in height.

1.2.4 Phytogeography

Phytogeographically, most of the Thar Desert area lies within the Saharo-Sindhian region. The desert area west of the Aravalli Hills is floristically very poor, comprising 682 species belonging to 351 genera and 87 families of flowering plants (Bhandari 1999), representing only 5% of the flora of India, which has ~17,500 flowering plants (Rao 2006). The flora east of Aravalli harbours about 8% of the flora of India, with 1,378 species belonging to 126 families (Tiagi and Aery 2007). Permanent features of the vegetation of the Thar Desert include trees and shrubs like *Acacia jacquemontii*, *Acacia nilotica*, *Calligonum polygonoides*, *Capparis decidua*, *Commiphora wightii*, *Leptadenia phytotechnica*, *Lycium barbarum*,

BookID 186229_Ramawat_ChapID 1_Proof# 1 - 28/8/09

Prosopis cineraria, *Salvadora oleoides*, *Salvadora persica*, *Tamarix aphylla*, and *Zizyphus nummularia*. Herbs and shrubs like *Aerva persica*, *Blepharis scindica*, *Calotropis procera*, *Crotalaria burhia*, *Cymbopogon javarancusa*, *Euphorbia caducifolia*, *Grewia tenax* and *Tephrosia purpurea*, can generally be observed on the rocks and sandy ridges.

1.3 Ethnobotanical Studies

In India, traditional folklore medicine has a long history and is very deep rooted in rural and tribal populations. It was practiced long before the beginning of the Christian era and perhaps even in the "Pre-vedic" periods of the Mohanjodaro and Harrapan civilisations. Indeed, knowledge of plant species producing medicines, essential oils and insecticides dates back to the beginning of civilisation. The traditional health care practices of indigenous people pertaining to human health is termed ethnomedicine (Ramawat et al. 2009). Several tribes lead a nomadic life in Rajasthan, and movement of such tribes and their cattle causes destruction of vegetation. In addition, several tribes living in East Rajasthan obtain their livelihood from plants, with these minor forest products being purchased by cooperatives. Such produce includes various types of gums (gum arabic from *Acacia senegal*, gum karaya from *Sterculia urens*, dhawda gum from *Anogeissus latifolia*, salai gum from *Boswellia serrata*, oleogum resin of *Commiphora wightii*), catha from *Acacia catechu*, dyes (red colour from *Bixa orellana* and *Mallotus philippensis*), several types of fruits, roots or root tubers from plants like *Chlorophytum borivilianum*, *Curculigo orchioides*, several *Dioscorea* species, leaves for making bidi (a local cigarette containing tobacco) from *Diospyros melanoxylon*, seeds and leaves of *Datura* species, flowers of *Madhuca indica* for making country liquor, and fibre for various usages from plants like *Calotropis procera* and *Crotalaria burhia*, etc. Several works have described the usage of plants by the tribes and local people of Rajasthan in detail (Bhandari 1974; Sebastian and Bhandari 1984a, 1984b; Jain 1991; Joshi 1995; Katewa and Sharma 1998; Katewa et al. 2003; Jain et al. 2005, 2008; Katewa 2009).

1.4 Biology of Desert Plants

The Indian desert is one of the most heavily populated (human and cattle) deserts of the world. The resulting biotic interference exerts tremendous pressure on 84 economically important species, due to which 31 species have become either vulnerable or endangered (Singh 2004). Of these, 17 species and 8 botanical varieties are endemic to The Great Indian Desert. Biological irregularities like poor seed set and production can be caused by reproductive problems, e.g. *Commiphora wightii* (Kumar et al. 2003) and *Anogeissus pendula* (Joshi et al. 1991); low seed viability, e.g. *Anogeissus pendula* (Joshi et al. 1991), *Tecomella undulata* (Arya et al. 1992), and *Azadirachta indica* (Anonymous 1980), or due to flower, fruit and seed infestation by insects, e.g. *Acacia senegal* and *Prosopis cineraria* (Sharma and Ramawat 2005). Xerophytic habit is an adaptation of plants to survive in harsh conditions (high temperature and low water availability) by modifying their requirements. However, several of these plants are affected by insect and termite infestation of stems, and by various fungal pathogens, which affects the growth and wood quality of these species (Anonymous 1980). Infestation of flower, fruit, and seed by insects causes flower abnormalities, poor flower and seed set, and abnormal physiological changes in the plants themselves (Purohit et al. 1979; Ramawat et al. 1979). For example, *Withania coagulans* and *Ephedra foliata* are unable to produce a sufficient quantity of seed because of an imbalance in the ratio of male to female plants / flowers and the predomination of androecious plants/flowers (Singh 2004). *Anogeissus pendula* produces predominantly sterile seeds (Joshi et al. 1991), and *Salvadora* exhibits very poor seed germination. Therefore, efforts to study the reproductive biology and seed physiology of these plants are required in order to be able to select and propagate resistant plants. Since it would be difficult to exploit all the available germplasm immediately, conventional (seed, plantations, pollen) and non-conventional (embryo, callus, shoot tips by cryo-preservation) methods should be used to conserve and preserve the germplasm for future use.

With the exception of a few members of Fabaceae, most of these species, being outbreeders, produce heterozygous progeny, which results in variation in the natural population of these plants, e.g. *Agele marmelos*, *Prosopis* species and *T. undulata*. This variation is expressed in both morphological (fruit size, absence or presence of thorns, crown size, etc) and physiological (sugar, protein and chlorophyll content, isozymes patterns, etc.) characters within the species, e.g. in *Ziziphus mauritiana* (Muchuweti et al. 2005; Pareek 2001). Most of these tree species are grown from seed from a wild population with intraspecific variation. So far, except for a few species like *Z. mauritiana*, no detailed procedures have been adopted to select superior material with the aim of cloning and propagating such species.

1.5 Medicinal and Biological Activities

Traditional medicine is the mainstay of primary health care in virtually all developing countries. The use of herbal medicine in developed countries is also expanding rapidly, with many people turning towards alternative treatments that they hope will be less harmful and have fewer side effects than western medicine. The World Health Organisation (WHO) estimated that $\sim$ 80% of the developing world relies on traditional medicine, and that 85% of this usage relies on plants or their extracts as the active substances. Desert areas harbour a high diversity of medicinal plants. Modern scientific validation methods have confirmed the strong analgesic, anti-arthritic, antifungal, antimicrobial, antiparasitic, hepatoprotective, hypolipidemic, insecticidal and anticancerous activities of several of these species (Table 1.1). Out of 700 species known to occur in extreme desert conditions (Bhandari 1999) about three dozen have potential biological activity. Some of these, such as *Achyranthes*

BookID 186229_Ramawat_ChapID 1_Proof# 1 - 28/8/09

t1.1 **Table 1.1** Medicinal plants of arid regions, plant parts used, their bioactive molecules and biological activities

	Plant species (Family)	Bioactive compounds	Plant part used	Biological activities	References
t1.3	*Abutilon indicum* (Malvaceae)	Abutilin A, (R)-N-(1′ methoxycarbonyl-2′ phenylethyl)-4-hydroxybenzamide, β-sitosterol, eugenol	Whole plant	Mosquito larvicidal	Abdul Rahuman et al. 2008
t1.4				Hepatoprotective	Porchezhian and Ansari 2005
t1.5				Hypoglycemic	Seetharam et al. 2002
t1.6				Analgesic	Ahmed et al. 2000
t1.7	*Acacia nilotica* (Mimosaceae)	Kaempferol (AN-5), D-pinitol, a sex hormone, viz 3 β-acetoxy-17-hydroxy-androst-5-ene	Stem bark, gum, flower, leaves	Antioxidant	Singh et al. 2008
t1.8				Immunosuppressive	Aderbauer et al. 2008
t1.9				Anticancer and antimutagenic	Meena et al. 2006; Arora et al. 2003
t1.10				Antiinflammatory	Chaubal et al. 2003, 2006
t1.11				Antifungal	Hamza et al. 2006
t1.12				Antiplasmodial	Kirira et al. 2006
t1.13				Larvicidal	Chaubal et al. 2005
t1.14				Anti-leishmanial	Fatima et al. 2005
t1.15				Antidiaorrheal	Agunu et al. 2005
t1.16				Moderate antimicrobial activity against multi-drug resistant *Salmonella typhi*	Rani and Khullar 2004
t1.17				Inhibitory effect on hepatitis C virus (HCV) protease	Hussein et al. 2000
t1.18				Antihypertensive and antispasmodic activities	Gilani et al. 1999
t1.19	*Achyranthes aspera* (Amaranthaceae)	Ecdysterone, betaine	Root, leaves	Treatment of leprosy, fistula-in-ano, bronchial asthma	Goyal et al. 2007
t1.20				Post coital antifertility activity	Vasudeva and Sharma 2006
t1.21				Immunity enhancement	Chakrabarti and Vasudeva 2006
t1.22				Anti-inflammatory	Vetrichelvan and Jegadeesan 2003
t1.23				Antiarthritic	Gokhale et al. 2002
t1.24				Cancer chemopreventive	Chakraborty et al. 2002
t1.25				Prothyroidic, antiperoxidative	Tahiliani and Kar 2000
t1.26	*Aerva persica* (Amaranthaceae)	Persinol, persinosides A and B	Whole plant	Antioxidative	Ahmed et al. 2006a

t1.27	*Aristolochia bracteolata* (Asclepiadaceae)	Aristolochic acid	Leaves	Wound healing activity	Shirwaikar et al. 2003
t1.28				Antiplasmodial activity	El-Tahir et al. 1999
t1.29	*Balanites aegyptiaca* (Simaraubaceae)	Balanitin-6 and-7: diosgenyl saponins	Kernel, fruit mesocarp, root, bark	Antitumor activity	Gnoula et al. 2008
t1.30				Larvicidal	Chapagain et al. 2008
t1.31				Antiinflammatory, antinociceptive, antioxidant	Speroni et al. 2005
t1.32				Fasciolicidal	Koko et al. 2000
t1.33	*Barleria prionitis* (Asclepiadaceae)	Iridoid glycoside, barlerin, verbascoside	Whole plant	Hepatoprotective	Singh et al. 2005
t1.34				Significant reduction in spermatogenesis	Verma et al. 2005; Gupta et al. 2000
t1.35				Antiinflammatory and antiarthritic	Singh et al. 2003
t1.36				Potent activity against respiratory syncytial virus	Chen et al. 1998
t1.37	*Boerhaavia diffusa* (Nyctaginaceae)	Nonprenylated rotenoids viz boeravinones G(1), H(2), I(10), J(11), punarnavoside, liriodendrin	Whole plant	Cell-mediated immune response	Manu and Kuttan 2008
t1.38				Breast cancer resistance protein inhibiting activity	Ahmed-Belkacem et al. 2007
t1.39				Radioprotective	Manu et al. 2007
t1.40				Spasmolytic effects	Borrelli et al. 2005, 2006
t1.41				Immunosuppressive	Pandey et al. 2005
t1.42				Antifungal activity	Agrawal et al. 2004
t1.43				Antidiabetic activity with improvement in antioxidant status	Satheesh and Pari 2004
t1.44				Cancer chemopreventive	Bharali et al. 2003
t1.45	*Capparis decidua* (Capparidaceae)	Triacontanol (C1), 2-carboxy-1,1dimethylpyrrolidine (C2)	Stem, flower, fruit	Insecticidal and oviposition inhibitory activity	Upadhyay et al. 2006
t1.46				Hypolipidemic	Purohit and Vyas 2005; Goyal and Grewal 2003
t1.47				Antidiabetic, antioxidative	Yadav et al. 1997
t1.48	*Calotropis procera* (Asclepiadaceae)	Laticifer proteins, calotropagenin, calotropin, rutin	Dried latex, leaves,	Hepatoprotective by acting as antioxidants	Olaleye and Rocha 2008; Padhy et al. 2007

(*continued*)

t1.50 **Table 1.1** (continued)

	Plant species (Family)	Bioactive compounds	Plant part used	Biological activities	References
t1.51					
t1.49			flowers, root, bark	Anticancer and cytotoxic	Soares de Oliveira et al. 2007; Choedon et al. 2006
t1.50				Larvicidal	Singh et al. 2005
t1.51				Anthelmintic activity	Iqbal et al. 2005
t1.52				Spasmolytic effect	Iwalewa et al. 2005
t1.53	*Cassia tora* (Caesalpiniaceae)	Emodin, chrysophanol, chryso-obtusin, obtusifolin, physcoin, cassiaside, aloe-emodin, emodin, torachrysone, toralactone	Seeds, leaves	Improvement of skin viscoelastic properties	Ahshawat et al. 2008
t1.54				Inhibitory activity on protein glycation and aldose reductase	Jang et al. 2007, Lee et al. 2006
t1.55				Oestrogenic and anti-oestrogenic	El-Halawany 2007
t1.56				Hypolipidemic	Cho et al. 2007; Patil et al. 2004
t1.57				Improve serum lipid status in type II diabetic subjects	Cho et al. 2005
t1.58				Antifungal	Kim et al. 2004
t1.59				Used in treatment of plaque and caries	Hebbar et al. 2004
t1.60				Antinociceptive	Chidume et al. 2002
t1.61	*Citrullus colocynthis* (Cucurbitaceae)	Cucurbitacins	Fruit	Low glycemic index food	Robert et al. 2008
t1.62				Larvicidal	Rahuman and Venkatesan 2008
t1.63				Antimicrobial efficiency	Paul 2008
t1.64				Hypolipidemic	Daradka et al. 2007
t1.65	*Commiphora wightii* (Burseraceae)	E- and Z- guggalsterone	Gum resin	Hypolipidemic agent in clinical practice, potential anti-dementia drug	Saxena et al. 2007
t1.66				Inhibits tumour cell proliferation, used traditionally to treat obesity, diabetes, atherosclerosis and osteoarthritis	Shishodia et al. 2007
t1.67	*Ephedra foliata* (Ephedraceae)	Ephedrine, pseudoephedrine	Stem	Neuropharmacological	Caveney et al. 2001
t1.68				Used in anti-asthmatic compound	Rogers et al. 1997

t1.69	*Haloxylon recurvum* (Chenopodiaceae)	Halosterols A and B, Haloxysterols A-D	Whole plant	Chymotrypsin enzyme inhibitory	Hussain et al. 2006
t1.70				Cholinesterase inhibition	Ahmed et al. 2006b
t1.71	*Haloxylon salicornicum* (Chenopodiaceae)	Haloxylines A and B	Whole plant	Antifungal and cholinesterase enzymes inhibitory potentials	Ferheen et al. 2005
t1.72	*Lepidagathis cristata* (Acanthaceae)	Cristatin A, cycloartenol and stigmasta-5,11(12)-diene-3-β-ol	Whole plant	Immunosuppressive	Ravikanth et al. 2001
t1.73	*Malva parvifolia* (Malvaceae)	CW1, CW2	Leaves, roots	Antimicrobial	Tadeg et al. 2005; Wang et al. 2001; Wang and Bunkers 2000
t1.74				Anti-inflammatory	Shale et al. 2005
t1.75				Active against multidrug resistant *Mycobacterium tuberculosis*	Jimenez-Arellanes et al. 2003
t1.76	*Maytenus emarginata* (Celastraceae)	Emarginatine F [1] and emarginatine G [2]	Entire plant	Strong cytotoxicity against several experimental cancer lines	Kuo et al. 1994, 1990
t1.77	*Phyllanthus amarus* (Euphorbeaceae)	Phyllanthin	Leaves, seeds	Hepatoprotective	Faremi et al. 2008; Khatoon et al. 2006
t1.78				Larvicidal	Rahuman et al. 2008
t1.79				Treatment of drug induced nephrotoxicity	Adeneye and Benebo 2008
t1.80				Hypotensive	Amaechina and Omogbai 2007
t1.81				Antimicrobial	Okigbo and Igwe 2007
t1.82				Radioprotective	Harikumar and Kuttan 2007
t1.83				Antinociceptive	Santos et al. 2000
t1.84	*Phyllanthus emblica syn Emblica officinalis* (Euphorbeaceae)	Emblicanin-A, B, gallic acid, ellagic acid, pyrogallol, apigenin 7–0-(6"butyryl-β-glucopyranoside), quercetin, putranjivain A	Fruit	Antimicrobial, virucidal action against HIV-1NL4.3 and HPV infections	Talwar et al. 2008; Srikumar et al. 2007
t1.85				Hepatoprotective	Panchabhai et al. 2008
t1.86				Cancer chemopreventive	Pinmai et al. 2008; Arulkumaran et al. 2007; Sandhya and Mishra 2006; Deep et al. 2005
t1.87				Potent antioxidant in various conditions like prevention of	Saito et al. 2008; Yokozawa et al. 2007; Mythilypriya et al. 2007

(*continued*)

t1.88 **Table 1.1** (continued)

	Plant species (Family)	Bioactive compounds	Plant part used	Biological activities	References
t1.89				age-related renal disease and in arthritis	
t1.88				Memory improvement and reversal of memory deficits	Vasudevan and Parle 2007a, 2007b
t1.89				Preventive role in prefibrogenesis of liver	Mir et al. 2007
t1.90				Healing activity on infected wound in form of TRIPHALA	Kumar et al. 2008
t1.91				Radioprotective effect	Singh et al. 2006
t1.92				Effective for hypercholesterolemia and prevention of atherosclerosis	Kim et al. 2005
t1.93	*Phyllanthus fraternus* (Euphorbeaceae)	E,E-2,4-octadienamide, E,Z-2,4-decadienamide, niruriside, phyllanthin	Whole plant	Hepatoprotective	Sailaja and Setty 2006; Khatoon et al. 2006; Ahmed et al. 2002
t1.94				Antinociceptive	Catapan et al. 2000; Santos et al. 2000
t1.95				Antiplasmodial	Sittie et al. 1998
t1.96	*Salvadora persica* (Salvadoraceae)	Four benzylamides of which N-benzyl-2-phenylacetamide is pharmacologically important	Stem	Caries prevention	Sofrata et al. 2007; Khalessi et al. 2004; Darmani et al. 2006
t1.97				Antiplasmodial	Ali et al. 2002
t1.98				Anticonvulsant and sedative effects	Monforte et al. 2002
t1.99				Antiulcer	Sanogo et al. 1999
t1.100				Hypolipidemic	Galati et al. 1999
t1.101	*Sida cordifolia* (Malvaceae)	Indoloquinoline alkaloid-cryptolepine, 1,2,3,9-tetrahydro-pyrrolo [2,1-β] quinazolin-3-ylamine	Aerial parts, mainly leaves	Antipyretic and antiulcerogenic	Philip et al. 2008
t1.102				Chemotherapeutic agent for treatment of osteorsarcoma	Matsui et al. 2007
t1.103				Antiinflammatory and analgesic	Sutradhar et al. 2007; Franzotti et al. 2000
t1.104				Liver regeneration	Silva et al. 2006
t1.105				Cardiovascular activity, cause hypotension and bradycardia	Medeiros et al. 2006
t1.106				Depressive activity on CNS	Franco et al. 2005

t1.107				Effects in neurodegenerative diseases such as Parkinson's, Alzheimer's, loss of memory	Auddy et al. 2003
t1.108				Hyperglycemic	Kanth and Diwan 1999
t1.109	*Solanum xanthocarpum*	Solasodine, carpesterol, steroidal	Fruits, root	Antifungal	Singh et al. 2007; Dabur et al. 2004
t1.110	(Solanaceae)	glycosides, diosgenin,		Antimalarial	Mohan et al. 2007
t1.111		β-sitosterol		Hypoglycemic	Kar et al. 2006
t1.112				Inhibits growth of Reo virus	Jabbar et al. 2004
t1.113				Potential larvicide	Mohan et al. 2005
t1.114				Used in bronchial asthma	Govindan et al. 2004
t1.115				Antinociceptive activity	Rahman et al. 2003
t1.116				Potential molluscicidal	Wei et al. 2002
t1.117	*Suaeda fruticosa*	Coumarins, histamine	Aerial part	Hypoglycemic effect	Benwahhoud et al. 2001
t1.118	(Chenopodeaceae)			Hypolipidemic activity	Bennani-Kabchi et al. 1999
t1.119	*Tephrosia purpurea* (Fabaceae)	Glabratephrin, (+)-tephrorins A and B, tephrsone	Leaves	Antihyperglycemic and antihyperlipidemic	Pavana et al. 2007
t1.120				Wound healing potential, hepatoprotective, antiulcer, antibacterial	Lodhi et al. 2006
t1.121				Immunomodulatory	Damre et al. 2003
t1.122				Inhibits haemolysis of erythrocytes	Gokhale et al. 2000
t1.123				Cancer chemopreventive	Khan et al. 2001; Saleem et al. 2001; Chang et al. 2000
t1.124	*Tribulus terrestris*	Protodioscin, hecogenin-3-O-β-d-	Fruits, leaves, root	Antimicrobial	Al-Bayati and Al-Mola 2008
t1.125	(Zygophyllaceae)	glucopyranosyl (1→4)- β -D-		Male erectile dysfunction	Gauthaman and Ganesan 2008
t1.126		galactopyranoside, eight steroid saponins TTS-8 to TTS-15,		Attenuates apoptosis in cardiocyte	Sun et al. 2008
t1.127		tribulosin, β-sitosterol-d-		Hypoglycemic and hypolipidemic	El-Tantaway and Hassanin 2007; Li et al. 2002
t1.128		glucoside		Protective role in induced nephrotoxicity	Kavitha and Jagadeesan 2006
t1.129				Analgesic	Heidari et al. 2007

(*continued*)

Table 1.1 (continued)

Plant species (Family)	Bioactive compounds	Plant part used	Biological activities	References
			Increase melanocyte stimulating hormone (MSH) expression	Yang et al. 2006; Deng et al. 2002
			Antifungal	Zhang et al. 2005
			75% inhibition of PPR and Reo virus	Jabbar et al. 2004
			Antihypertensive and vasodilator	Phillips et al. 2006; Sharifi et al. 2003
			Anticancerous	Neychev et al. 2007; Yang et al. 2005; Sun et al. 2004, 2003
			Anthelmintic	Deepak et al. 2002
Tridax procumbens (Fabaceae)	Lupeol, sitosterol	Leaves	Antiinflammatory	Margaret et al. 1998
			Exerts a direct pro-healing effect through release of adrenal steroid	Diwan et al. 1983
Withania coagulans (Solanaceae)	Withaferin, withanolide, withcoagin	Fruits	Hypolipidemic	Hemalata et al. 2006
Withania somnifera (Solanaceae)	Withaferin A, withanolide A, withanoside IV, withanoside VI, sominone, ashwagandhanolide, sterole glycosyltransferases	Root, leaves	Cancer chemopreventive	Stan et al. 2008; Malik et al. 2007; Widodo et al. 2007; Senthil et al. 2007; Subbaraju et al. 2006
			Useful in several neurodegenerative diseases	Srinivasan et al. 2007; Senthilnathan et al. 2006; Ichikawa et al. 2006
			Cardioprotection	Tohda 2008; Kulkarni and Dhir 2008; Kuboyama et al. 2006
			Mood stabliser	Mohanty et al. 2008
			Normalise hyperglycemia in diabetes mellitus type II	Gupta and Rana 2007
			Useful in anxiety and insomnia	Anwer et al. 2008
			Useful in arthritis treatment	Kumar and Kalonia 2007; Khan et al. 2006; Khanna et al. 2007; Rasool and Varalakshmi 2006a; 2007
			Antimalarial	Dikasso et al. 2006
			Prevention of glycation induced pathogenesis in diabetes mellitus and aging	Babu et al. 2007

t1.148				Stress management	Madina et al. 2007
t1.149				Antifungal activity by inhibiting aflatoxin B production	Krishnamurthy and Shashikala 2006; Girish et al. 2006
t1.150				AchE inhibitory	Vinutha et al. 2007
t1.151				Immunomodulatory	Spelman et al. 2006; Rasool and Varalakshmi 2006b
t1.152				Hypocholesteremic and antioxidant	Visavadiya and Narasimhacharya 2007
t1.153				Treatment of osteoporosis	Nagareddy and Lakshmana 2006
t1.154				Antidote	Machiah et al. 2006
t1.155	*Zizyphus mauritiana* (Rhamnaceae)	Betulinic acid	Fruits	Hepatoprotective and immunomodulatory	Adhvaryu et al. 2007
t1.156				Anticacerous activity	Mukherjee et al. 2006

Fig. 1.2 Fruits and leaves of *Phyllanthus emblica*

aspera, *Balanites aegyptiaca*, *Barleria prionitis*, *Boerhaavia diffusa*, *Commiphora wightii*, *Phyllanthus emblica syn. Emblica officinalis*, *Phyllanthus amarus*, *Tribulus terrestris* and *Withania somnifera* are used in the Indian system of traditional medicine (Ramawat and Goyal 2008). Plants like *C. wightii* and *W. somnifera* are used in hundreds of tons, while fruits of *P. emblica* (Fig. 1.2) are used in thousands of tons and rank first in consumption in Indian traditional medicine (Ramawat and Goyal 2008; Anonymous 2001).

The diverse biological activities are due to the presence of a wide array of bioactive molecules (Fig. 1.3), including simple alkaloids, anthraquinones (physcion, emodin, chrysophanol), naphthopyrone glucosides (cassiaside, rubrofusarin-6–0-β-D-gentiobioside), phenolics, rotenoids [boeravinones G (1) and H (2)], saponins, steroids (β-sitosterol, carpesterol, ecdysterone), and terpenes (Table 1.1). Exploration of the chemical constituents of the plants and pharmacological screening may provide the basis for lead compounds in the development of novel agents. Indeed, herbs have already provided us with some of the most important life saving drugs used in modern medicine (Goyal et al. 2008).

1.6 Methods of Propagation

Conventional vegetative propagation methods have been developed mostly in woody plants like *Commiphora wightii*, *Ziziphus mauritiana*, *Prosopis cineraria*, etc. Some of these plants, e.g. *P. cineraria* (Ramawat and Nandwani 1991), are very

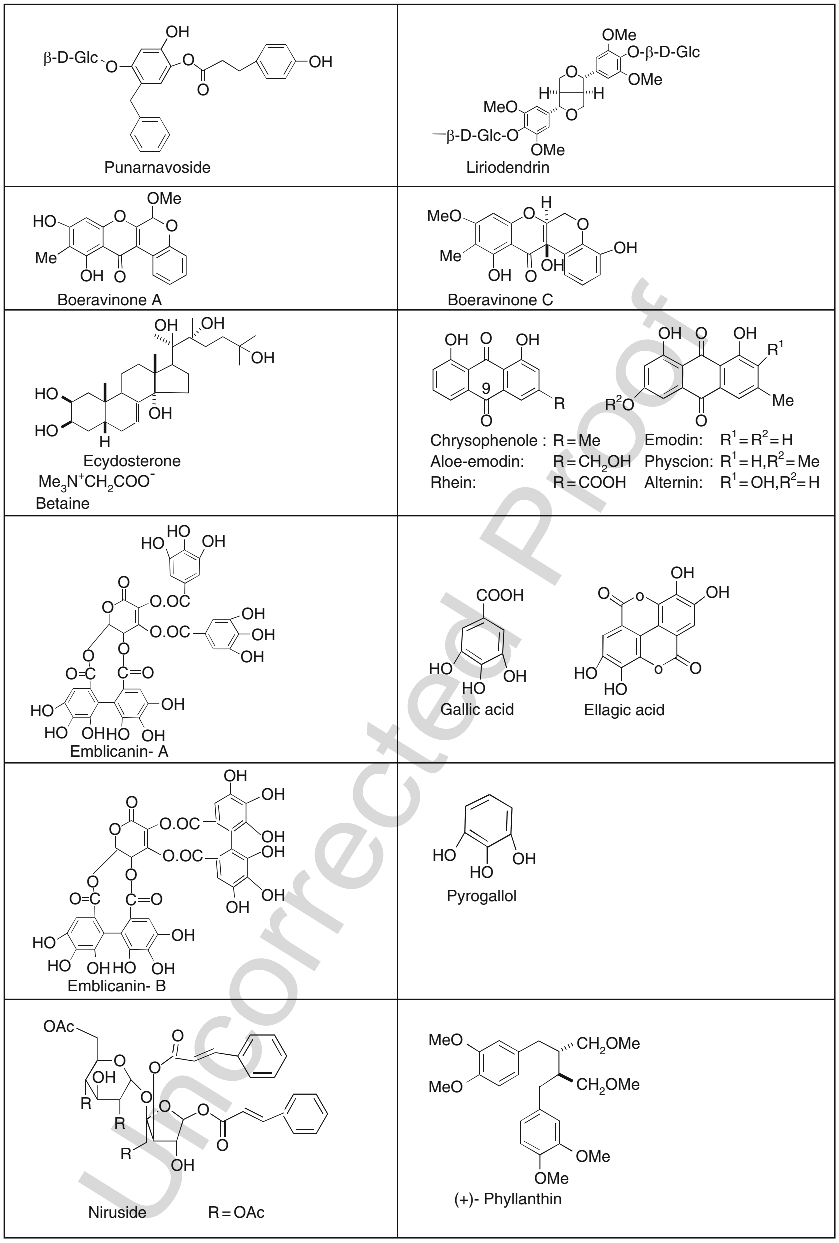

Fig. 1.3 Chemical structures of bioactive molecule of selected medicinal plants

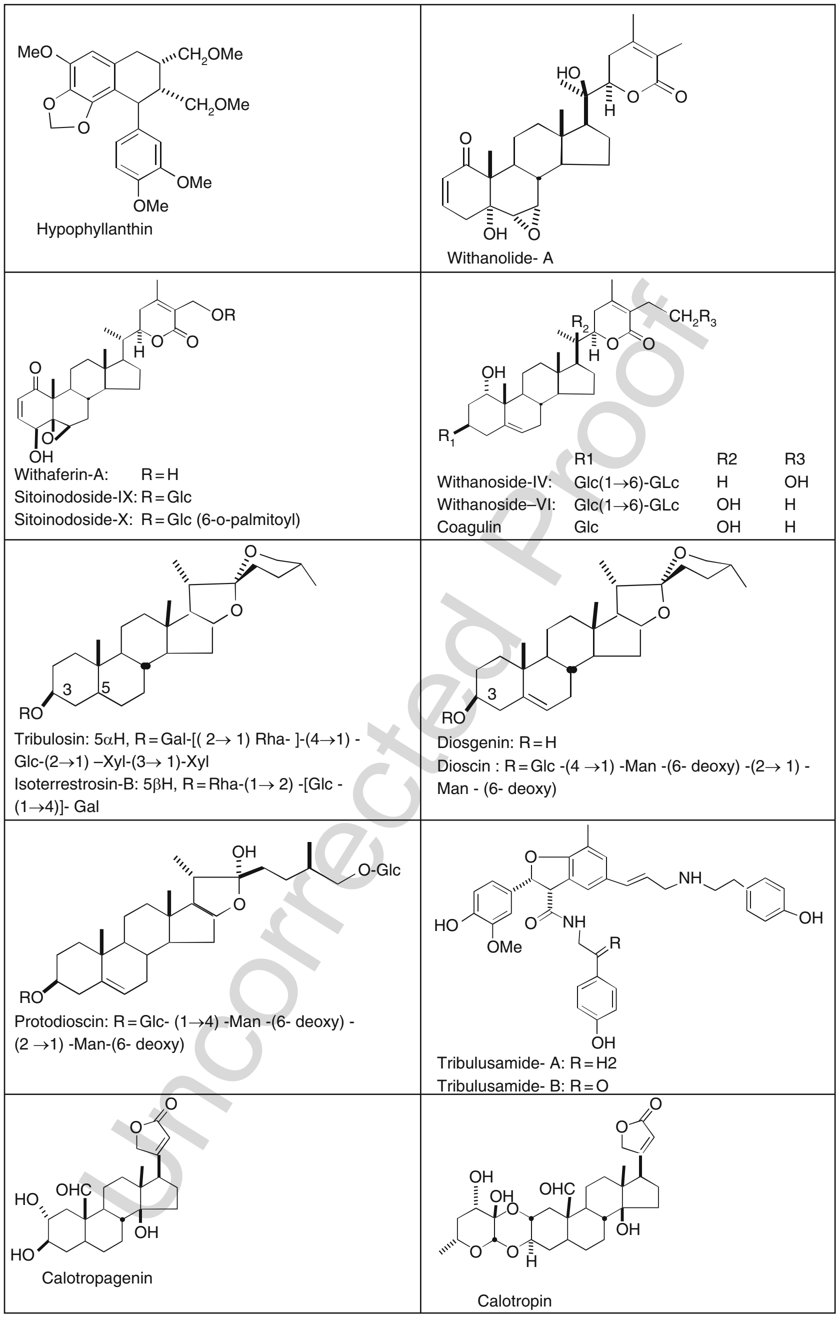

Fig. 1.3 (continued)

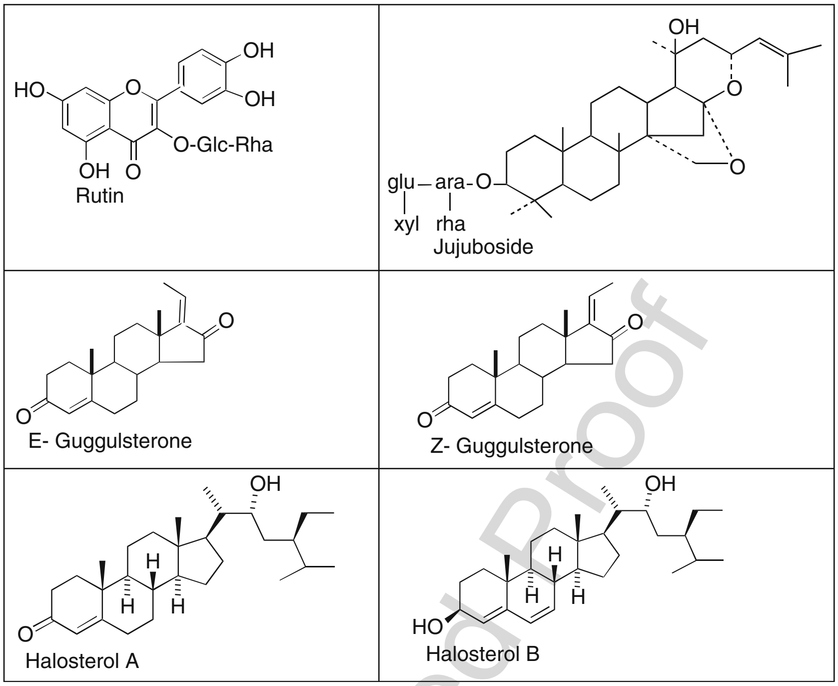

Fig. 1.3 (continued)

difficult to root. In medicinally important plants like *C. wighti*, rooting of up to 70% of stem cuttings can be obtained with the application of auxin and selection of suitable material (Singh et al. 1989). *Z. mauritiana* improved for fruit quality is propagated by grafting (Pareek 2001). Propagation of improved stock is a very difficult and challenging task in arid regions. In the case of *Z. mauritiana*, wild stock with in situ grafting was found to be more successful than nursery grafting and transplanting. The seed-produced plants are not true to the parent stock, and stem cutting of superior selections do not establish properly, leaving grafting on wild stock as the only means of propagating the selected material (Pareek 2001). Other methods, such as air-layering and grafting, are successful with only a few species, and then only on a limited scale. These techniques are adversely affected by variation between and within species, making biotechnological methods an attractive alternative.

1.7 Biotechnological Approaches

Medicinal plant biotechnology offers many novel opportunities and techniques to conserve, propagate, improve and utilise medicinal plants and herbs for the welfare of human beings. Since the emergence of the concept of cellular t2.1 **Table 1.2** Plant species and their in vitro response on different media

	Plant species	Medium	Plant part used	Regeneration	Reference
t2.2					
t2.3	*Achyranthes aspera*	MS + 2,4-D (1.0–2.0 mg/l) + NAA (0.5 mg/l)	Leaf	Callus	Kayani et al. 2008
t2.4	*Aristolochia bracteolata*	MS + BA (4.4–35.5 µM) + kinetin (0.45–9.2 µM) + IAA (0.57–5.8 µM)	Nodes	Shoot regeneration	Rameshree el al. 1994
t2.5		MS + kinetin (0.45–23 µM) + NAA (0.46–9.2 µM) + IAA (0.5–5.7 µM)	Leaves, node	Callus	Rameshree el al. 1994
t2.6	*Boerhaavia diffusa*	MS + BAP (1.5 mg/l) + NAA (0.5 mg/l)	Shoot tip and nodal explants	Multiple shoot regeneration	Roy 2008
t2.7		MS + NAA (1.0 mg/l) + BAP (1.0 mg/l)	Callus	Shooting	Gupta et al. 2004
t2.8	*Balanites aegyptiaca*	MS + BAP (2.5 mg/l) + NAA (0.1 mg/l)	Axillary bud	Shooting	Ndoye et al. 2003
t2.9		MS + IBA (20 mg/l)		Rooting	Ndoye et al. 2003
t2.10		MS + BAP (0.45 µM)	In vitro shoots axillary meristems	Shooting	Rathore et al. 2004
t2.11	*Capparis decidua*	MS + NAA (0.1 mg/l) + BAP (5.0 mg/l) + additives	Node	Multiple shoots	Deora and Shekhawat 1995
t2.12	*Citrullus colocynthis*	MS + BA (25 µM)	Cotyledon	organogenic calli	Dabauza et al. 1997
t2.13		MS + BA (0.5 µM)	Organogenic calli	Shooting	Dabauza et al. 1997
t2.14		MS + IBA (2.5/5.0 µM)	In vitro shoots	Rooting	Dabauza et al. 1997
t2.15	*Cocculus pendulus*	$^{1}/_{4}$ MS + IAA (0.1 mg/l) + kinetin (2.97 mg/l)	Callus	Shoots	Gaur et al. 1995
t2.16	*Commiphora wightii*	MS modified + 2,4,5-T (0.25 mg/l) + kinetin (0.1 mg/l)	Zygotic embryo	Somatic embryogenesis	Kumar et al. 2003
t2.17	*Haloxylon recurvum*	MS + BAP (4.0 µM) + additives	Nodal explant and leaves	Multiple shoots	Dagla and Shekhawat 2005
t2.18		$^{1}/_{2}$ MS + IBA (4.0 µM)+ activated charcoal (100 mg/l)	In vitro shoots	Rooting	Dagla and Shekhawat 2005
t2.19	*Maytenus emarginata*	MS + IAA (0.1 mg/l) + BAP (2.5 mg/l)	Shoot segments	Multiple shoots	Rathore et al. 1992a

BookID 186229_Ramawat_ChapID 1_Proof# 1 - 28/8/09

t2.20		MS + IBA (25 mg/l)	In vitro shoots	Rooting	Rathore et al. 1992a
t2.21	*Phyllanthus amarus*	MS + kinetin (0.1 mg/l) + IAA (0.1 mg/l)	Shoot tips	Direct shoots regeneration	Bhattacharyya and Bhattacharya 2001
t2.22		MS only	Alginate-encapsulated shoot tips	Plant regeneration	Singh et al. 2006
t2.23		$^1/_4$ liquid MS	Leaves	Hairy roots	Bhattacharyya and Bhattacharya 2004
t2.24	*Phyllanthus emblica* syn *Emblica officinalis*	MS + BAP (4.44 µM/l) + IBA (2.46 µM/l)	Nodal explants	Shooting	Goyal and Bhadauria 2008
t2.25		BMS + 2,4-D (1–4 mg/l) + kinetin (0.05 mg/1) and BMS + NAA (1–4 mg/l) + kinetin (0.05 mg/l)	Mature embryo explants	Callus	Tyagi and Govil 1999
t2.26	*Salvadora persica*	MS + BAP (4.0 mg/l) + IAA (0.5 mg/l) + adenine sulphate (40 mg/l) + glutamine (100 mg/l) + thiamine HCl (10 mg/l)	Cotyledonary nodes	Shooting	Mathur et al. 2002
t2.27		$^1/_2$ MS + IBA (3.0 mg/l)	Shoots	Rooting	Mathur et al. 2002
t2.28	*Sida cordifolia*	MS + BAP (2.0 mg/l) + NAA (0.5 mg/l) + adenine sulphate (1.0 mg/l) + 10% (v/v) coconut milk	Nodal explants	Multiple shoots	Sivanesan and Jeong 2007
t2.29		$^1/_2$ MS + IBA (2.0 mg/l)	In vitro regenerated shoots	Rooting	Sivanesan and Jeong 2007
t2.30	*Tephrosia purpurea*	MS + PGR	Root, leaves, stem	Callus	Zafar and Mujeeb 2002
t2.31	*Tribulus terrestris*	MS + NAA (0.2 mg/l) + BAP (0.5 mg/l) + glutamine (0.5 mg/l)	Cotyledonary leaves along with epicotyl segment	Shoots and roots	Ali et al. 1997
t2.32	*Withania somnifera*	MS + 2,4-D (2 mg/l) + kinetin (0.2 mg/l)	Root, cotyledonary leaf segments	Callus	Rania et al. 2003
t2.33		MS + 2,4-D (2 mg/l) + kinetin (0.2 mg/l)	Callus	Shoot regeneration	Rania et al. 2003

(*continued*)

t2.34 **Table 1.2** (continued)

	Plant species	Medium	Plant part used	Regeneration	Reference
t2.35	Plant species	Medium	Plant part used	Regeneration	Reference
t2.36		MS + IBA (2.0 mg/l)	Shoots	Rooting	Rania et al. 2003
t2.37		MS + BA (4.4 M) + 2,4-D (2.3 M)	Shoot tips	Shoot multiplication	Sen and Sharma 1991
t2.38	*Ziziphus mauritiana*	MS + BAP (2.5 mg/l) + IAA (0.1 mg/l) + KNO_3 (3,800 mg/l)	Hypocotyl	15–20 shoots	Mathur et al. 1995
t2.39		$^1/_2$ MS + IBA (0.5 mg/l) + kinetin (0.05 mg/l)	Shoot	Rooting	Goyal and Ayra 1985
t2.40	*Ziziphus nummularia*	MS + kinetin (2.5 mg/l)	Cotyledonary hypocotyls	8–18 adventitious shoot induction	Mathur et al. 1994
t2.41		MS + kinetin (10 mg/l) + IAA (0.1–0.5 mg/l) + KNO_3 (3,800 mg/l)	Hypocotyl	18 shoots	Mathur et al. 1993
t2.42		White's liquid + IBA (25 mg/l) + 48 h pulse then White's HF semi-solid	Regenerated shoots	Rooting	Rathore et al. 1992b

totipotency, contemporary developments in the area of plant tissue culture to devise methods allowing rapid and year-round multiplication of desired genotypes, production of pathogen-free stock, raising uniform clones from highly heterozygous plants, monitoring production of useful natural products in vitro, propagating plants (including genetically transformed plants) with changed/altered genotypes have added new dimensions to this field, pushing this science towards the realm of technological application by providing a basis for modern biotechnology (Ramawat et al. 2004; Ramawat and Goyal 2008). Micropropagation methods have been reported for around 18 species (Table 1.2), while many more have been cultured for various purposes including production of secondary metabolites, e.g. *Commiphora wightii* cell cultures (Mathur and Ramawat 2007), *Pueraria tuberosa* (Goyal and Ramawat 2008a, 2008b) and *Cayratia trifolia* (Roat and Ramawat 2009). Of these, only six are woody trees and the rest are herbs. These methods still need improvement to make them commercially viable programmes.

1.8 Conclusions

It is evident from the account above that the flora of Rajasthan is rich in medicinal plants. The recent surge in publications describing the biological activities of these plants demonstrates the potential for their application in many different areas of human medicine. This is the first compilation of its kind to describe the biological activities of such a large number of desert plants together with biotechnological input. Some of these plants are already well established in the Indian system of medicine, therefore it is desirable to study their reproductive biology and biological activities, and to develop methods for their conservation. Although these plants can be very difficult to work with in terms of propagation and improvement, they possess a gene pool representing some very useful characteristics, such as drought resistance, salinity resistance and the ability to cope with high temperatures. Thus, there is much scope to explore the genetic and molecular biology of these plants to better understand the mechanisms underlying desert plant survival.

Acknowledgements This work was supported by financial assistance from UGC-DRS under the special assistance programme for medicinal plant research and the DST-FIST programme for infrastructure development to K.G.R. J.A. and S.G. thank CSIR, New Delhi for granting of a JRF and RA fellowship, respectively.

References

Abdul Rahuman A, Gopalakrishnan G, Venkatesan P, Geetha K (2008) Isolation and identification of mosquito larvicidal compound from *Abutilon indicum* (Linn.) Sweet. Parasitol Res 102:981–988

Adeneye AA, Benebo AS (2008) Protective effect of the aqueous leaf and seed extract of *Phyllanthus amarus* on gentamicin and acetaminophen-induced nephrotoxic rats. J Ethanopharmacol 23:318–323

Aderbauer B, Clausen PH, Kershaw O, Melzig MF (2008) In vitro and in vivo trypanocidal effect of lipophilic extracts of medicinal plants from Mali and Burkina Faso. J Ethnopharmacol 119:225–231

Adhvaryu MR, Reddy N, Parabia MH (2007) Effects of four Indian medicinal herbs on isoniazid-, rifampicin- and pyrazinamide-induced hepatic injury and immunosuppression in guinea pigs. World J Gastroenterol 13:3199–3205

Agrawal A, Srivastava S, Srivastava MM (2004) Antifungal activity of *Boerhavia diffusa* against some dermatophytic species of *Microsporum*. Hindustan Antibiot Bull 45–46:1–4

Agunu A, Yusuf S, Andrew GO, Zezi AU, Abdurahman EM (2005) Evaluation of five medicinal plants used in diarrhoea treatment in Nigeria. J Ethnopharmacol 101:27–30

Ahmed B, al-Howiriny TA, Mathew R (2002) Antihepatotoxic activity of *Phyllanthus fraternus*. Pharmazie 57:855–856

Ahmed-Belkacem A, Macalou S, Borrelli F, Capasso R, Fattorusso E, Taglialatela-Scafati O, Di Pietro A (2007) Nonprenylated rotenoids, a new class of potent breast cancer resistance protein inhibitors. J Med Chem 50:1933–1938

Ahmed E, Imran M, Malik A, Ashraf M (2006) Antioxidant activity with flavonoidal constituents from *Aerva persica*. Arch Pharm Res 29:343–347

Ahmed E, Nawaz SA, Malik A, Choudhary MI ([illegible]) Isolation and cholinesterase-inhibition studies of sterols from *Haloxylon recurvum*. Bioorg Med Chem Lett 16:573–580

Ahmed M, Amin S, Islam M, Takahashi M, Okuyama E, Hossain CF (2000) Analgesic principle from *Abutilon indicum*. Pharmazie 55:314–316

Ahshawat MS, Saraf S, Saraf S (2008) Preparation and characterization of herbal creams for improvement of skin viscoelastic properties. Int J Cosmet Sci 30:183–193

Al-Bayati FA, Al-Mola HF (2008) Antibacterial and antifungal activities of different parts of *Tribulus terrestris* L. growing in Iraq. J Zhejiang Univ Sci B 9:154–159

Ali G, Mughal MH, Srivastava PS, Iqbal M (1997) Micropropagation of *Tribulus terestris* L., an important medicinal plant. J Plant Biol 40:202–205

Ali H, König GM, Khalid SA, Wright AD, Kaminsky R (2002) Evaluation of selected Sudanese medicinal plants for their in vitro activity against hemoflagellates, selected bacteria, HIV-1-RT and tyrosine kinase inhibitory, and for cytotoxicity. J Ethnopharmacol 83:219–228

Amaechina FC, Omogbai EK (2007) Hypotensive effect of aqueous extract of the leaves of *Phyllanthus amarus* Schum and Thonn (Euphorbiaceae). Acta Pol Pharm 64:547

Anonymous (1980) Firewood crops: shrubs and tree species for energy production. National Academy of Science, Washington DC

Anonymous (2001) Demand study for selected medicinal plants. Centre for Research, Planning and Action, New Delhi, India

Anwer T, Sharma M, Pillai KK, Iqbal M (2008) Effect of *Withania somnifera* on insulin sensitivity in non-insulin-dependent diabetes mellitus rats. Basic Clin Pharmacol Toxicol 102:498–503

Arora S, Kaur K, Kaur S (2003) Indian medicinal plants as a reservoir of protective phytochemicals. Teratog Carcinog Mutagen 1:295–300

Arya S, Toky OP, Harris SM, Harris PJC (1992) *Tecomella undulata* (Rohida) A valuable tree of Thar desert. Int Tree Corps J 7:141–147

Arulkumaran S, Ramprasath VR, Shanthi P, Sachdanandam P (2007) Alteration of DMBA-induced oxidative stress by additive action of a modified indigenous preparation – Kalpaamruthaa. Chem Biol Interact 167:99–106

Auddy B, Ferreira M, Blasina F, Lafon L, Arredondo F, Dajas F, Tripathi PC, Seal T, Mukherjee B (2003) Screening of antioxidant activity of three Indian medicinal plants, traditionally used for the management of neurodegenerative diseases. J Ethnopharmacol 84:131–138

Benwahhoud M, Jouad H, Eddouks M, Lyoussi B (2001) Hypoglycemic effect of *Suaeda fruticosa* in streptozotocin-induced diabetic rats. J Ethnopharmacol 76:35–38

Babu PV, Gokulakrishnan A, Dhandayuthabani R, Ameethkhan D, Kumar CV, Ahamed MI (2007) Protective effect of *Withania somnifera* (Solanaceae) on collagen glycation. Comp Biochem Physiol B Biochem Mol Biol 147:308–313

Bhandari MM (1974) Native resources used as famine foods in Rajasthan. Econ Bot 28:73–81

Bhandari MM (1999) Flora of the Indian desert. MPS Repros, Jodhpur, Rajasthan, India

Bharali R, Azad MR, Tabassum J (2003) Chemopreventive action of *Boerhaavia diffusa* on DMBA-induced skin carcinogenesis in mice. Indian J Physiol Pharmacol 47:459–464

Bhattacharya R, Bhattacharya S (2001) High frequency in vitro propagation of *Phyllanthus amarus* Schum. & Thom. by shoot tip culture. Indian J Exp Biol 39:1184–1187

Bhattacharya R, Bhattacharya S (2004) Development of a potent in vitro source of *Phyllanthus amarus* roots with pronounced activity against surface antigen of hepatitis B virus. In Vitro Cell Dev Biol Plant 40:504–509

Bennani-Kabchi N, El Bouayadi F, Kehel L, Fdhil H, Marquié G (1999) Effect of *Suaeda fruticosa* aqueous extract in the hypercholesterolaemic and insulin-resistant sand rat. Therapie 54:725–730

Borrelli F, Milic N, Ascione V, Capasso R, Izzo AA, Capasso F, Petrucci F, Valente R, Fattorusso E, Taglialatela-Scafati O (2005) Isolation of new rotenoids from *Boerhaavia diffusa* and evaluation of their effect on intestinal motility. Planta Med 71:928–932

Borrelli F, Ascione V, Capasso R, Izzo AA, Fattorusso E, Taglialatela-Scafati O (2006) Spasmolytic effects of nonprenylated rotenoid constituents of *Boerhaavia diffusa* roots. J Nat Prod 69:903–906

Catapan E, Otuki MF, Viana AM, Yunes RA, Bresciani LF, Ferreira J, Santos AR, Calixto JB, Cechinel-Filho V (2000) Pharmacological activity and chemical composition of callus culture extracts from selected species of *Phyllanthus*. Pharmazie 55:945–946

Caveney S, Charlet DA, Freitag H, Maier-Stolte M, Starratt AN (2001) New observations on the secondary chemistry of world *Ephedra* (Epheraceae). Am J Bot 88:1199–1208

Chaubal R, Mujumdar AM, Puranik VG, Deshpande VH, Deshpande NR (2003) Isolation and X-ray study of an anti-inflammatory active androstene steroid from *Acacia nilotica*. Planta Med 69:287–288

Chaubal R, Pawar PV, Hebbalkar GD, Tungikar VB, Puranik VG, Deshpande VH, Deshpande NR (2005) Larvicidal activity of *Acacia nilotica* extracts and isolation of D-pinitol – a bioactive carbohydrate. Chem Biodivers 2:684–688

Chaubal R, Mujumdar AM, Misar A, Deshpande VH, Deshpande NR (2006) Structure–activity relationship study of androstene steroids with respect to local anti-inflammatory activity. Arzneimittelforschung 56:394–398

Chakrabarti R, Vasudeva RY (2006) *Achyranthes aspera* stimulates the immunity and enhances the antigen clearance in *Catla catla*. Int Immunopharmacol 6:782–790

Chakraborty A, Brantner A, Mukainaka T, Nobukuni Y, Kuchide M, Konoshima T, Tokuda H, Nishino H (2002) Cancer chemopreventive activity of *Achyranthes aspera* leaves on Epstein-Barr virus activation and two-stage mouse skin carcinogenesis. Cancer Lett 177:1–5

Chang LC, Chávez D, Song LL, Farnsworth NR, Pezzuto JM, Kinghorn AD (2000) Absolute configuration of novel bioactive flavonoids from *Tephrosia purpurea*. Org Lett 2:515–518

Chapagain BP, Saharan V, Wiesman Z (2008) Larvicidal activity of saponins from *Balanites aegyptiaca* callus against *Aedes aegypti* mosquito. Bioresour Technol 99:1165–1168

Chen JL, Blanc P, Stoddart CA, Bogan M, Rozhon EJ, Parkinson N, Ye Z, Cooper R, Balick M, Nanakorn W, Kernan MR (1998) New iridoids from the medicinal plant *Barleria prionitis* with potent activity against respiratory syncytial virus. J Nat Prod 61:1295–1297

Chidume FC, Kwanashie HO, Adekeye JO, Wambebe C, Gamaniel KS (2002) Antinociceptive and smooth muscle contracting activities of the methanolic extract of *Cassia tora* leaf. J Ethnopharmacol 81:205–209

Cho IJ, Lee C, Ha TY (2007) Hypolipidemic effect of soluble fiber isolated from seeds of *Cassia tora* Linn. in rats fed a high-cholesterol diet. J Agric Food Chem 55:1592–1596

Cho SH, Kim TH, Lee NH, Son HS, Cho IJ, Ha TY (2005) Effects of *Cassia tora* fiber supplement on serum lipids in Korean diabetic patients. J Med Food 8:311–318

Choedon T, Mathan G, Arya S, Kumar VL, Kumar V (2006) Anticancer and cytotoxic properties of the latex of *Calotropis procera* in a transgenic mouse model of hepatocellular carcinoma. World J Gastroenterol 12:2517–2522

Dabur R, Singh H, Chhillar AK, Ali M, Sharma GL (2004) Antifungal potential of Indian medicinal plants. Fitoterapia 75:389–391

Dabauza M, Bordas M, Salvador A, Roig L-A, Moreno V (1997) Plant regeneration and Agrobacterium-mediated transformation of cotyledon explants of *Citrullus colocynthis* (L.) Schrad. Plant Cell Rep 16:888–892

Dagla HR, Shekhawat NS (2005) In vitro multiplication of *Haloxylon recurvum* (Moq.) – a plant for saline soil reclamation. J Plant Biotechnol 3:155–160

Damre AS, Gokhale AB, Phadke AS, Kulkarni KR, Saraf MN (2003) Studies on the immunomodulatory activity of flavonoidal fraction of *Tephrosia purpurea*. Fitoterapia 74:257–261

Daradka A, Almasad MM, Qazan WS, El-Banna NM, Samara OH (2007) Hypolipidaemic effects of *Citrullus colocynthis* L. in rabbits. Pakistan J Biol Sci 10:2768–2771

Darmani H, Nasayr T, AL-Hiyasat AS (2006) Effects of extracts of miswak and derum on proliferation of Balb/C 3T3 fibroblasts and viability of cariogenic bacteria. Int J Dent Hyg 4:62–66

Deep G, Dhiman M, Rao AR, Kale RK (2005) Chemopreventive potential of Triphala (a composite Indian drug) on benzo(a)pyrene induced forestomach tumorigenesis in murine tumor model system. J Exp Clin Cancer Res 24:555–563

Deepak M, Dipankar G, Prashanth D, Asha MK, Amit A, Venkataraman BV (2002) Tribulosin and beta-sitosterol-D-glucoside, the anthelmintic principles of *Tribulus terrestris*. Phytomedicine 9:753–756

Deora NS, Shekhawat NS (1995) Micropropagation of *Capparis decidua* (Forsk.) Edgew. – a tree of arid horticulture. Plant Cell Rep 15:3–4

Deng Y, Yang L, An SL (2002) Effect of *Tribulus terrestris* L. decoction of different concentrations on tyrosinase activity and the proliferation of melanocytes. Di Yi Jun Yi Da Xue Xue Bao 22:1017–1019

Dewan A, Khana N, Gupta SC (1992) In vitro micropropagation of *Acacia nilotica* subsp. indica Brenan via cotyledonary nodes. Plant Cell Rep 12:18–21

Dikasso D, Makonnen E, Debella A, Abebe D, Urga K, Makonnen W, Melaku D, Kassa M, Guta M (2006) Anti-malarial activity of *Withania somnifera* L. Dunal extracts in mice. Ethiop Med J 44:279–285

Diwan PV, Tilloo LD, Kulkarni DR (1983) Steroid depressed wound healing and *Tridax procumbens*. Indian J Physiol Pharmacol 27:32–36

El-Halawany AM (2007) Estrogenic and antiestrogenic activities of *Cassia tora* phenolic constituents. Chem Pharm Bull Tokyo 55:1474–1482

El-Tahir A, Satti GM, Khalid SA (1999) Antiplasmodial activity of selected Sudanese medicinal plants with emphasis on *Acacia nilotica*. Phytother Res 13:474–478

El-Tantawy WH, Hassanin LA (2007) Hypoglycemic and hypolipidemic effects of alcoholic extract of *Tribulus alatus* in streptozotocin-induced diabetic rats: a comparative study with *T. terrestris* (Caltrop). Indian J Exp Biol 45:785–790

Fatima F, Khalid A, Nazar N, Abdalla M, Mohomed H, Toum AM, Magzoub M, Ali MS (2005) In vitro assessment of anti-cutaneous leishmaniasis activity of some Sudanese plants. Turkiye Parazitol Derg 29:3–6

Ferheen S, Ahmed E, Afza N, Malik A, Shah MR, Nawaz SA, Choudhary MI (2005) Haloxylines A and B, antifungal and cholinesterase inhibiting piperidine alkaloids from *Haloxylon salicornicum*. Chem Pharm Bull (Tokyo) 53:570–572

Faremi TY, Suru SM, Fafunso MA, Obioha UE (2008) Hepatoprotective potentials of *Phyllanthus amarus* against ethanol-induced oxidative stress in rats. Food Chem Toxicol 46:2658–2664

Franco CI, Morais LC, Quintans-Júnior LJ, Almeida RN, Antoniolli AR (2005) CNS pharmacological effects of the hydroalcoholic extract of *Sida cordifolia* L. leaves. J Ethnopharmacol 98:275–279

Franzotti EM, Santos CV, Rodrigues HM, Mourão RH, Andrade MR, Antoniolli AR (2000) Anti-inflammatory, analgesic activity and acute toxicity of *Sida cordifolia* L. (Malva-branca). J Ethnopharmacol 72:273–277

Galati EM, Monforte MT, Forestieri AM, Miceli N, Bader A, Trovato A (1999) *Salvadora persica* L.: hypolipidemic activity on experimental hypercholesterolemia in rat. Phytomedicine 6:181–185

Gamble C (1993) Timewalkers: the prehistory of global colonization. Sutton, Phoenix Mill

Gaur A, Singh AK, Suri SS, Ramawat KG (1995) Bud cultures and regeneration of plantlets in *Cocculus pendulus*, a woody medicinal plant. Gartenbau 60:69–72

Gauthaman K, Ganesan AP (2008) The hormonal effects of *Tribulus terrestris* and its role in the management of male erectile dysfunction – an evaluation using primates, rabbit and rat. Phytomedicine 15:44–54

Gilani AH, Shaheen F, Zaman M, Janbaz KH, Shah BH, Akhtar MS (1999) Studies on antihypertensive and antispasmodic activities of methanol extract of *Acacia nilotica* pods. Phytother Res 13:665–669

Girish KS, Machiah KD, Ushanandini S, Harish Kumar K, Nagaraju S, Govindappa M, Vedavathi M, Kemparaju K (2006) Antimicrobial properties of a non-toxic glycoprotein (WSG) from *Withania somnifera* (Ashwagandha). J Basic Microbiol 46:365–374

Gnoula C, Mégalizzi V, De Nève N, Sauvage S, Ribaucour F, Guissou P, Duez P, Dubois J, Ingrassia L, Lefranc F, Kiss R, Mijatovic T (2008) Balanitin-6 and -7: diosgenyl saponins isolated from *Balanites aegyptiaca* Del. display significant anti-tumor activity in vitro and in vivo. Int J Oncol 32:5–15

Gokhale AB, Dikshit VJ, Damre AS, Kulkarni KR, Saraf MN (2000) Influence of ethanolic extract of *Tephrosia purpurea* Linn. on mast cells and erythrocytes membrane integrity. Indian J Exp Biol 38:837–840

Gokhale AB, Damre AS, Kulkami KR, Saraf MN (2002) Preliminary evaluation of anti-inflammatory and anti-arthritic activity of *S. lappa*, *A. speciosa* and *A. aspera*. Phytomedicine 9:433–437

Govindan S, Viswanathan S, Vijayasekaran V, Alagappan R (2004) Further studies on the clinical efficacy of *Solanum xanthocarpum* and *Solanum trilobatum* in bronchial asthma. Phytother Res 18:805–809

Goyal BR, Goyal RK, Mehta AA (2007) Phyto-pharmacology of *Achyranthes aspera*: a review. Pharmacogn Rev 1:143–150

Goyal D, Bhadauria S (2008) In vitro shoot proliferation in *Emblica officinalis* var. Balwant from nodal explants. Ind J Biotechnol 7:394–397

Goyal R, Grewal RB (2003) The influence of teent (*Capparis decidua*) on human plasma triglycerides, total lipids and phospholipids. Nutr Health 17:71–6

Goyal S, Ramawat KG (2008a) Synergistic effect of morphactin on cytokinin-induced production of isoflavonoids in cell cultures of *Pueraria tuberosa* (Roxb. ex. Willd.) DC. Plant Growth Regul 55:175–181

Goyal S, Ramawat KG (2008b) Marked increase in isoflavonoids accumulation by ethrel in cell suspension cultures of *Pueraria tuberosa*. Acta Plant Physiol 30:849–853

Goyal S, Roat C, Ramawat KG (2008) Production of polyphenols through cell cultures: a new class of bioactive molecules. In: Arya ID, Arya S (eds) Utilization of biotechnology in plant sciences, FRI, Dehradun, India, pp 75–94

Goyal Y, Arya HC (1985) Tissue culture of desert trees: II Clonal multiplication of *Ziziphus* in vitro. J Plant Physiol 119:399–404

Girish KS, Machiah KD, Ushanandini S, Harish Kumar K, Nagaraju S, Govindappa M, Vedavathi M, Kemparaju K (2006) Antimicrobial properties of a non-toxic glycoprotein (WSG) from *Withania somnifera* (Ashwagandha). J Basic Microbiol 46:365–374

Gupta GL, Rana AC (2007) Protective effect of *Withania somnifera* dunal root extract against protracted social isolation induced behavior in rats. Indian J Physiol Pharmacol 51:345–353

Gupta RK, Srivastava A, Verma HN (2004) Callus culture and organogenesis in *Boerhaavia diffusa*: a potent antiviral protein containing plant. Physiol Mol Biol Plants 10:263–268

Gupta RS, Kumar P, Dixit VP, Dobhal MP (2000) Antifertility studies of the root extract of the *Barleria prionitis* Linn in male albino rats with special reference to testicular cell population dynamics. J Ethnopharmacol 70:111–117

Hamza OJ, Van den Bout-Van den Beukel CJ, Matee MI, Moshi MJ, Mikx FH, Selemani HO, Mbwambo ZH, Van der Ven AJ, Verweij PE (2006) Antifungal activity of some Tanzanian plants used traditionally for the treatment of fungal infections. J Ethnopharmacol 108:124–132

Harikumar KB, Kuttan R (2007) An extract of *Phyllanthus amarus* protects mouse chromosomes and intestine from radiation induced damages. J Radiat Res (Tokyo) 48:469–476

Hebbar SS, Harsha VH, Shripathi V, Hegde GR (2004) Ethnomedicine of Dharwad district in Karnataka, India-plants used in oral health care. J Ethnopharmacol 94:261–266

Heidari MR, Mehrabani M, Pardakhty A, Khazaeli P, Zahedi MJ, Yakhchali M, Vahedian M (2007) The analgesic effect of *Tribulus terrestris* extract and comparison of gastric ulcerogenicity of the extract with indomethacine in animal experiments. Ann N Y Acad Sci 1095:418–427

Hemalata S, Wahi AK, Singh PN, Chansouria JP (2006) Hypolipidemic activity of aqueous extract of *Withania coagulans* Dunal in albino rats. Phytother Res 20:614–617

Hussein G, Miyashiro H, Nakamura N, Hattori M, Kakiuchi N, Shimotohno K (2000) Inhibitory effects of Sudanese medicinal plant extracts on hepatitis C virus (HCV) protease. Phytother Res 14:510–516

Hussain S, Ahmed E, Malik A, Jabbar A, Ashraf M, Lodhi MA, Choudhary MI (2006) Halosterols A and B, chymotrypsin inhibitory sterols from *Haloxylon recurvum*. Chem Pharm Bull (Tokyo) 4:623–625

Ichikawa H, Takada Y, Shishodia S, Jayaprakasam B, Nair MG, Aggarwal BB (2006) Withanolides potentiate apoptosis, inhibit invasion, and abolish osteoclastogenesis through suppression of nuclear factor-kappaB (NF-kappaB) activation and NF-kappaB-regulated gene expression. Mol Cancer Ther 5:1434–1445

Iqbal Z, Lateef M, Jabbar A, Muhammad G, Khan MN (2005) Anthelmintic activity of *Calotropis procera* (Ait.) Ait. F. flowers in sheep. J Ethnopharmacol 102:256–261

Iwalewa EO, Elujoba AA, Bankole OA (2005) In vitro spasmolytic effect of aqueous extract of *Calotropis procera* on Guinea-pig trachea smooth muscle chain. Fitoterapia 76:250–253

Jabbar S, Khan MT, Choudhuri MS, Sil BK (2004) Bioactivity studies of the individual ingredients of the Dashamularishta. Pak J Pharm Sci 17:9–17

Jain A, Katewa SS, Galav PK, Sharma P (2005) Medicinal plant diversity of Sitamata wildlife sanctuary, Rajasthan, India. J Ethanopharmacol 102:143–157

Jain A, Katewa SS, Galava P, Nag A (2008) Some therapeutic uses of biodiversity among the tribals of Rajasthan. Indian J Tradit Knowl 7:256–262

Jain SK (1991) Dictionary of Indian folk medicine and ethnobotany. Deep, New Delhi

Jang DS, Lee GY, Kim YS, Lee YM, Kim CS, Yoo JL, Kim JS (2007) Anthraquinones from the seeds of *Cassia tora* with inhibitory activity on protein glycation and aldose reductase. Biol Pharm Bull 30:2207–2210

Jimenez-Arellanes A, Meckes M, Ramirez R, Torres J, Luna-Herrera J (2003) Activity against multidrug-resistant *Mycobacterium tuberculosis* in Mexican plants used to treat respiratory diseases. Phytother Res 17:903–908

Joshi P (1995) Ethnobotany of primitive tribes in Rajasthan. Printwell, Jaipur

Joshi R, Shekhawat NS, Rathore TS (1991) Micropropagation of *Anogeissus pendula* Edgew – an arid forest tree. Indian J Exp Biol 29:615–618

Kanth VR, Diwan PV (1999) Analgesic, antiinflammatory and hypoglycaemic activities of *Sida cordifolia*. Phytother Res 13:75–77

Kar DM, Maharana L, Pattnaik S, Dash GK (2006) Studies on hypoglycaemic activity of *Solanum xanthocarpum* Schrad. & Wendl. fruit extract in rats. J Ethnopharmacol 108:251–256

Katewa SS (2009) Indigenous people and forests: perspectives of an ethanobotanical study from Rajasthan (India). In: Ramawat KG (ed) Herbal drugs: ethnomedicine to modern medicine. Springer, Berlin, pp 33–56

Katewa SS, Sharma R (1998) Ethnomedicinal observation from certain watershed areas of Rajasthan. Ethnobotany 10:46–49

Katewa SS, Chaudary BL, Jain A, Galav PK (2003) Traditional uses of plant biodiversity from Aravalli hills of Rajasthan. Indian J Tradit Knowl 2:27–39

Kavitha AV, Jagadeesan G (2006) Role of *Tribulus terrestris* (Linn.) (Zygophyllacea) against mercuric chloride induced nephrotoxicity in mice, *Mus musculus* (Linn.). J Environ Biol 27:397–400

Kayani S, Zia M, Sarwar S, Riaz-ur-Rehman, Chaudhary MF (2008) Callogenic studies of *Achyranthes aspera* leaf explant at different hormonal combinations. Pak J Biol Sci 11:950–952

Kelly RL (1995) The foraging spectrum: diversity in hunter-gatherer lifeways. Smithsonian Institution Press, Washington DC

Khalessi AM, Pack AR, Thomson WM, Tompkins GR (2004) An in vivo study of the plaque control efficacy of Persica: a commercially available herbal mouthwash containing extracts of *Salvadora persica*. Int Dent J 54:279–283

Khan B, Ahmad SF, Bani S, Kaul A, Suri KA, Satti NK, Athar M, Qazi GN (2006) Augmentation and proliferation of T lymphocytes and Th-1 cytokines by *Withania somnifera* in stressed mice. Int Immunopharmacol 6:1394–1403

Khan N, Sharma S, Alam A, Saleem M, Sultana S (2001) *Tephrosia purpurea* ameliorates N-diethylnitrosamine and potassium bromate-mediated renal oxidative stress and toxicity in Wistar rats. Pharmacol Toxicol 88:294–299

Khanna D, Sethi G, Ahn KS, Pandey MK, Kunnumakkara AB, Sung B, Aggarwal A, Aggarwal BB (2007) Natural products as a gold mine for arthritis treatment. Curr Opin Pharmacol 7:344–351

Khatoon S, Rai V, Rawat AK, Mehrotra S (2006) Comparative pharmacognostic studies of three *Phyllanthus* species. J Ethnopharmacol 104:79–86

Kim HJ, Yokozawa T, Kim HY, Tohda C, Rao TP, Juneja LR (2005) Influence of amla (*Emblica officinalis* Gaertn.) on hypercholesterolemia and lipid peroxidation in cholesterol-fed rats. J Nutr Sci Vitaminol (Tokyo) 51:413–418

Kim YM, Lee CH, Kim HG, Lee HS (2004) Anthraquinones isolated from *Cassia tora* (Leguminosae) seed show an antifungal property against phytopathogenic fungi. J Agric Food Chem 52:6096–6100

Kirira PG, Rukunga GM, Wanyonyi AW, Muregi FM, Gathirwa JW, Muthaura CN, Omar SA, Tolo F, Mungai GM, Ndiege IO (2006) Anti-plasmodial activity and toxicity of extracts of plants used in traditional malaria therapy in Meru and Kilifi Districts of Kenya. J Ethnopharmacol 106:403–407

Koko WS, Galal M, Khalid HS (2000) Fasciolicidal efficacy of *Albizia anthelmintica* and *Balanites aegyptiaca* compared with albendazole. J Ethnopharmacol 71:247–252

Krishnamurthy YL, Shashikala J (2006) Inhibition of aflatoxin B production of *Aspergillus flavus*, isolated from soybean seeds by certain natural plant products. Lett Appl Microbiol 43:469–474

Kuboyama T, Tohda C, Komatsu K (2006) Withanoside IV and its active metabolite, sominone, attenuate alpha beta (25–35)-induced neurodegeneration. Eur J Neurosci 23:1417–1426

Kulkarni SK, Dhir A (2008) *Withania somnifera*: an Indian ginseng. Prog Neuropsychopharmacol Biol Psychiatry 32:1093–1105

Kumar A, Kalonia H (2007) Protective effect of *Withania somnifera* Dunal on the behavioral and biochemical alterations in sleep-disturbed mice (grid over water suspended method). Indian J Exp Biol 45:524–528

Kumar MS, Kirubanandan S, Sripriya R, Sehgal PK (2008) Triphala promotes healing of infected full-thickness dermal wound. J Surg Res 144:94–101

Kumar S, Suri SS, Sonie KC, Ramawat KG (2003) Establishment of embryonic cultures and somatic embryogenesis in callus cultures of guggul – *Commiphora wightii* (Arnott.) Bhandari. Indian J Exp Biol 41:69–77

Kuo YH, Chen CH, Kuo LM, King ML, Wu TS, Haruna M, Lee KH (1990) Antitumor agents 112. Emarginatine B, a novel potent cytotoxic sesquiterpene pyridine alkaloid from *Maytenus emarginata*. J Nat Prod 53:422–428

Kuo YH, King ML, Chen CF, Chen HY, Chen CH, Chen K, Lee KH (1994) Two new macrolide sesquiterpene pyridine alkaloids from *Maytenus emarginata:* emarginatine G and the cytotoxic emarginatine F. J Nat Prod 57:263–269

Lee GY, Jang DS, Lee YM, Kim JM, Kim JS (2006) Naphthopyrone glucosides from the seeds of *Cassia tora* with inhibitory activity on advanced glycation end products (AGEs) formation. Arch Pharm Res 29:587–590

Li M, Qu W, Wang Y, Wan H, Tian C (2002) Hypoglycemic effect of saponin from *Tribulus terrestris*. Zhong Yao Cai 25:420–422

Lodhi S, Pawar RS, Jain AP, Singhai AK (2006) Wound healing potential of *Tephrosia purpure* (Linn.) Pers. in rats. J Ethnopharmacol 108:204–210

Machiah DK, Girish KS, Gowda TV (2006) A glycoprotein from a folk medicinal plant, *Withania somnifera*, inhibits hyaluronidase activity of snake venoms. Comp Biochem Physiol C Toxicol Pharmacol 143:158–161

Madina BR, Sharma LK, Chaturvedi P, Sangwan RS, Tuli R (2007) Purification and physico-kinetic characterization of 3beta-hydroxy specific sterol glucosyltransferase from *Withania somnifera* (L) and its stress response. Biochim Biophys Acta 1774:392–402

Malik F, Kumar A, Bhushan S, Khan S, Bhatia A, Suri KA, Qazi GN, Singh J (2007) Reactive oxygen species generation and mitochondrial dysfunction in the apoptotic cell death of human myeloid leukemia HL-60 cells by a dietary compound withaferin A with concomitant protection by N-acetyl cysteine. Apoptosis 12:2115–2133

Manu KA, Kuttan G (2008) *Boerhaavia diffusa* stimulates cell-mediated immune response by upregulating IL-2 and downregulating the pro-inflammatory cytokines and GM-CSF in B16F-10 metastatic melanoma bearing mice. J Exp Ther Oncol 7:17–29

Manu KA, Leyon PV, Kuttan G (2007) Studies on the protective effects of *Boerhaavia diffusa* L. against gamma radiation induced damage in mice. Integr Cancer Ther 6:381–388

Mares MA (1999) Encyclopedia of deserts. University of Oklahoma Press, Norman, OK

Margaret I, Reddy P, Srinivasa JK (1998) Antiinflammatory profile of *Tridax procumbens* in animal and fibroblast cell models. Phytother Res 12:285–287

Mathur M, Ramawat KG (2007) Guggulsterone production in cell suspension cultures of *Commiphora wightii* grown in shake flasks and bioreactors. Biotechnol Lett 29:979–982

Mathur N, Ramawat KG, Sonie KC (1993) In vitro propagation of *Ziziphus numularia*. Ann Arid Zones 32:219–222

Mathur N, Ramawat KG, Sonie KC (1994) Plant regeneration from seedling explants of *Ziziphus* and silver nitrate and nutrient requirement for callus morphogenesis. Gartenbau 58:255–260

Mathur N, Ramawat KG, Nandawani D (1995) Rapid in vitro multiplication of Jujube through mature stem explant. Plant Cell Tissue Organ Cult 43:75–77

Mathur S, Shekhawat GS, Batra A (2002) Micropropagation of *Salvadora persica* Linn. via cotyledonary nodes. Indian J Biotechnol 1:197–200

Matsui TA, Sowa Y, Murata H, Takagi K, Nakanishi R, Aoki S, Yoshikawa M, Kobayashi M, Sakabe T, Kubo T, Sakai T (2007) The plant alkaloid cryptolepine induces p21WAF1/CIP1 and cell cycle arrest in a human osteosarcoma cell line. Int J Oncol 31:915–922

Medeiros IA, Santos MR, Nascimento NM, Duarte JC (2006) Cardiovascular effects of *Sida cordifolia* leaves extract in rats. Fitoterapia 77:19–27

Meena PD, Kaushik P, Shukla S, Soni AK, Kumar M, Kumar A (2006) Anticancer and antimutagenic properties of *Acacia nilotica* (Linn.) on 7,12-dimethylbenz(a)anthracene-induced skin papillomagenesis in Swiss albino mice. Asian Pac J Cancer Prev 7:627–632

Middleton N, Thomas D (1997) World atlas of desertification (2nd edn). Arnold, London

Mir AI, Kumar B, Tasduq SA, Gupta DK, Bhardwaj S, Johri RK (2007) Reversal of hepatotoxin-induced pre-fibrogenic events by *Emblica officinalis* – a histological study. Indian J Exp Biol 45:626–629

Mohan L, Sharma P, Srivastava CN (2005) Evaluation of *Solanum xanthocarpum* extracts as mosquito larvicides. J Environ Biol 26:399–401

Mohan L, Sharma P, Srivastava CN (2007) Comparative efficacy of *Solanum xanthocarpum* extracts alone and in combination with a synthetic pyrethroid, cypermethrin, against malaria vector, *Anopheles stephensi*. Southeast Asian J Trop Med Public Health 38:256–260

Mohanty IR, Arya DS, Gupta SK (2008) *Withania somnifera* provides cardioprotection and attenuates ischemia-reperfusion induced apoptosis. Clin Nutr 27:635–642

Monforte MT, Trovato A, Rossitto A, Forestieri AM, D'Aquino A, Miceili N, Galati EM (2002) Anticonvulsant and sedative effects of *Salvadora persica* L. stem extracts. Phytother Res 16:395–397

Muchuweti M, Zenda G, Nadhlala AR, Kasiyamahuru A (2005) Sugars, organic acid and phenolic compounds of *Ziziphus mauritiana* fruit. Eur Food Res Technol 221:570–574

Mukherjee R, Khattar D, Jaggi M, Singh AT, Kumar M, Bala H (2006) Method for treating cancer using betulinic acid rich herbal extract. USPTO Application 20060159783

Mythilypriya R, Shanthi P, Sachdanandam P (2007) Restorative and synergistic efficacy of Kalpaamruthaa, a modified Siddha preparation, on an altered antioxidant status in adjuvant induced arthritic rat model. Chem Biol Interact 168:193–202

Nagareddy PR, Lakshmana M (2006) *Withania somnifera* improves bone calcification in calcium-deficient ovariectomized rats. J Pharm Pharmacol 58:513–519

Ndoye M, Diallo I, Gassama-Dia YK (2003) In vitro multiplication of the semi-arid forest tree, *Balanites aegyptiaca* (L.) Del. Afr J Biotechnol 2:421–424

Neychev VK, Nikolova E, Zhelev N, Mitev VI (2007) Saponins from *Tribulus terrestris* L are less toxic for normal human fibroblasts than for many cancer lines: influence on apoptosis and proliferation. Exp Biol Med 232:126–133

Okigbo RN, Igwe DI (2007) Antimicrobial effects of *Piper guineense* 'Uziza' and *Phyllantus amarus* 'Ebe-benizo' on *Candida albicans* and *Streptococcus faecalis*. Acta Microbiol Immunol Hung 54:353–366

Olaleye MT, Rocha BT (2008) Acetaminophen-induced liver damage in mice: effects of some medicinal plants on the oxidative defense system. Exp Toxicol Pathol 59:319–327

Padhy BM, Srivastava A, Kumar VL (2007) *Calotropis procera* latex affords protection against carbon tetrachloride induced hepatotoxicity in rats. J Ethnopharmacol 113:498–502

Panchabhai TS, Ambarkhane SV, Joshi AS, Samant BD, Rege NN (2008) Protective effect of *Tinospora cordifolia, Phyllanthus emblica* and their combination against antitubercular drugs induced hepatic damage: an experimental study. Phytother Res 22:646–650

Pandey R, Maurya R, Singh G, Sathiamoorthy B, Naik S (2005) Immunosuppressive properties of flavonoids isolated from *Boerhaavia diffusa* Linn. Int Immunopharmacol 5:541–553

Pareek OP (2001) Fruits of future-2 Ber. International Center for Underutilized Crops, Southampton, UK

Patil UK, Saraf S, Dixit VK (2004) Hypolipidemic activity of seeds of *Cassia tora* Linn. J Ethnopharmacol 90:249–252

Paul JP (2008) Studies on antimicrobial efficiency of *Citrullus colocynthis* (L.) Schrad: a medicinal plant. Ethnobot Leafl 12:944–947

Pavana P, Manoharan S, Renju GL, Sethupathy S (2007) Antihyperglycemic and antihyperlipidemic effects of *Tephrosia purpurea* leaf extract in streptozotocin induced diabetic rats. J Environ Biol 28:833–837

Philip BK, Muralidharan A, Natarajan B, Varadamurthy S, Venkataraman S (2008) Preliminary evaluation of anti-pyretic and anti-ulcerogenic activities of *Sida cordifolia* methanolic extract. Fitoterapia 79:229–231

Phillips OA, Mathew KT, Oriowo MA (2006) Antihypertensive and vasodilator effects of methanolic and aqueous extracts of *Tribulus terrestris* in rats. J Ethnopharmacol 104:351–355

Pinmai K, Chunlaratthanabhorn S, Ngamkitidechakul C, Soonthornchareon N, Hahnvajanawong C (2008) Synergistic growth inhibitory effects of *Phyllanthus emblica* and *Terminalia bellerica* extracts with conventional cytotoxic agents: doxorubicin and cisplatin against human hepatocellular carcinoma and lung cancer cells. World J Gastroenterol 14:1491–1497

Porchezhian E, Ansari SH (2005) Hepatoprotective activity of *Abutilon indicum* on experimental liver damage in rats. Phytomedicine 12:62–64

Purohit A, Vyas KB (2005) Hypolipidaemic efficacy of *Capparis decidua* fruit and shoot extracts in cholesterol fed rabbits. Indian J Exp Biol 43:863–866

Purohit SD, Ramawat KG, Arya HC (1979) Phenolics peroxidase and phenolase as related to gall formation in some arid zone plants. Curr Sci 48:714–716

Rahman MT, Ahmed M, Alimuzzaman M, Shilpi JA (2003) Antinociceptive activity of the aerial parts of *Solanum xanthocarpum*. Fitoterapia 74:119–121

Rahuman AA, Venkatesan P (2008) Larvicidal efficacy of five cucurbitaceous plant leaf extracts against mosquito species. Parasitol Res 103:133–139

Rahuman AA, Gopalakrishnan G, Venkatesan P, Geetha K (2008) Larvicidal activity of some Euphorbiaceae plant extracts against *Aedes aegypti* and *Culex quinquefasciatus* (Diptera: Culicidae). Parasitol Res 102:867–873

Ramani B, Reeck T, Debez A, Stelzer R, Huchzermeyer B, Schmidt A, Papenbrock J (2006) *Aster tripolium* L. and *Sesuvium portulacastrum* L.: two halophytes, two strategies to survive in saline habitats. Plant Physiol Biochem 44:395–408

Ramawat KG, Goyal ~~Y~~ (2008) The Indian herbal drugs scenario in global perspectives. In: Ramawat KG, Merillon JM (eds) Bioactive molecules and medicinal plants, Springer, Berlin, pp 325–343

Ramawat KG, Nandwani D (1991) Regeneration in *Prosopis* species: problems, perseverance and prospects. Ann Arid Zone 30:247–258

Ramawat KG, Purohit SD, Arya HC (1979) Altered states of oxidizing enzymes and phenolic in Copdia gall. ISDT and UCDS (Jodhpur) 5:38–41

Ramawat KG, Sonie KC, Sharma MC (2004) Therapeutic potential of medicinal plants. In: Ramawat KG (ed) Biotechnology of medicinal plants: vitalizer and therapeutic. Science, Enfield, pp 1–18

Ramawat KG, Dass S, Mathur M (2009) The chemical diversity of bioactive molecules and therapeutic potential of medicinal plants. In: Ramawat KG (ed) Herbal drugs: ethanomedicine to modern medicine, Springer, Berlin, pp 7–32

Rameshree AB, Hariharan M, Unnikrishnan K (1994) Micropropagation and callus induction of *Aristolochia bracteolata* Lam. – a medicinal plant. Phytomorphology 44:247–252

Rani P, Khullar N (2004) Antimicrobial evaluation of some medicinal plants for their anti-enteric potential against multi-drug resistant *Salmonella typhi*. Phytother Res 18:670–673

Rania G, Virka GS, Avinash NB (2003) Callus induction and plantlet regeneration in *Withania somnifera*. In Vitro Cell Dev Biol Plant 39:468–474

Rao RR (2006) Conservation and bioprospection of the floristic diversity in India: prospects, constraints and urgent tasks ahead. In: Proceedings of the 29th All India Botany Conference, 9–11 October, Department of Botany, ML Sukhadia University, Udaipur, India, pp 1–5

Rasool M, Varalakshmi P (2006a) Suppressive effect of *Withania somnifera* root powder on experimental gouty arthritis: an in vivo and in vitro study. Chem Biol Interact 164:174–180

Rasool M, Varalakshmi P (2006b) Immunomodulatory role of *Withania somnifera* root powder on experimental induced inflammation: an in vivo and in vitro study. Vascul Pharmacol 44:406–410

Rasool M, Varalakshmi P (2007) Protective effect of *Withania somnifera* root powder in relation to lipid peroxidation, antioxidant status, glycoproteins and bone collagen on adjuvant-induced arthritis in rats. Fundam Clin Pharmacol 21:157–164

Rathore TS, Singh RP, Deora NS, Shekhawat NS (1992a) Cloning of *Maytenus emarginata* (Willd.) Ding Hon – a tree of the Indian Desert – through tissue culture. Plant Cell Rep 11:449–451

Rathore TS, Singh RP, Deora NS, Shekhawat NS (1992b) Clonal propagation of *Ziziphus* species through tissue culture. Sci Hortic 51:165–168

Rathore JS, Rathor V, Shekhawat NS, Singh RP, Liler G, Phulwaria M, Dagla HR (2004) Micropropagation of woody plants. In: Srivastva PS, Narula A, Srivastva S (eds) Plant biotechnology and molecular markers. Kluwer, Dordrecht, pp 195–205

Ravikanth V, Reddy NVL, Ramesh P, Rao PT, Diwan PV, Khar A, Venkateswarlu Y (2001) An immunosuppressive tryptophan-derived alkaloid from *Lepidagathis cristata*. Phytochemistry 58:1263–1266

Roat C, Ramawat KG (2009) Morphactin and 2iP markedly enhance accumulation of stilbenes in cell cultures of *Cayratia trifolia* (L.) Domin. Acta Physiol 31:411–414

Robert SD, Ismail AA, Winn T, Wolever TM (2008) Glycemic index of common Malaysian fruits. Asia Pac J Clin Nutr 17:35–39

Rogers PL, Shin HS, Wang B (1997) Biotransformation for Lephedrine production. Adv Biochem Eng Biotechnol 56:33–59

Roy PK (2008) Rapid multiplication of *Boerhaavia diffusa* L. through in vitro culture of shoot tip and nodal explants. Plant Tissue Cult Biotechnol 18:49–56

Sailaja R, Setty OH (2006) Protective effect of *Phyllanthus fraternus* against allyl alcohol-induced oxidative stress in liver mitochondria. J Ethnopharmacol 105:201–209

Saito K, Kohno M, Yoshizaki F, Niwano Y (2008) Extensive screening for edible herbal extracts with potent scavenging activity against superoxide anions. Plant Foods Hum Nutr 63:65–70

Saleem M, Ahmed Su, Alam A, Sultana S (2001) *Tephrosia purpurea* alleviates phorbol ester-induced tumor promotion response in murine skin. Pharmacol Res 43:135–144

Sandhya T, Mishra KP (2006) Cytotoxic response of breast cancer cell lines, MCF 7 and T 47 D to triphala and its modification by antioxidants. Cancer Lett 238:304–313

Sanogo R, Monforte MT, Daquino A, Rossitto A, Maur DD, Galati EM (1999) Antiulcer activity of *Salvadora persica* L.: structural modifications. Phytomedicine 6:363–366

Santos AR, De Campos RO, Miguel OG, Filho VC, Siani AC, Yunes RA, Calixto JB (2000) Antinociceptive properties of extracts of new species of plants of the genus *Phyllanthus* (Euphorbiaceae). J Ethnopharmacol 72:229–238

Satheesh MA, Pari L (2004) Antioxidant effect of *Boerhavia diffusa* L. in tissues of alloxan induced diabetic rats. Indian J Exp Biol 42:989–992

Saxena G, Singh SP, Pal R, Singh S, Pratap R, Nath C (2007) Gugulipid, an extract of *Commiphora wightii* with lipid-lowering properties, has protective effects against streptozotocin-induced memory deficits in mice. Pharmacol Biochem Behav 86:797–805

Sebastian MK, Bhandari MM (1984a) Medico-ethnobotany of Mt. Abu, Rajasthan. Indian J Ethnopharmacol 12:223–230

Sebastian MK, Bhandari MM (1984b) Medicinal plant lore of Udaipur district, Rajasthan. Bull Medico-Ethnobot Res 5:133–134

Seetharam YN, Chalageri G, Setty SR, Bheemachar (2002) Hypoglycemic activity of *Abutilon indicum* leaf extracts in rats. Fitoterapia 73:156–159

Sen J, Sharma AK (1991) Micropropagation of *Withania somnifera* from germinating seeds and shoot tips. Plant Cell Tissue Organ Cult 26:71–73

Senthil V, Ramadevi S, Venkatakrishnan V, Giridharan P, Lakshmi BS, Vishwakarma RA, Balakrishnan A (2007) Withanolide induces apoptosis in HL-60 leukemia cells via mitochondria mediated cytochrome *c* release and caspase activation. Chem Biol Interact 167:19–30

Senthilnathan P, Padmavathi R, Magesh V, Sakthisekaran D (2006) Stabilization of membrane bound enzyme profiles and lipid peroxidation by *Withania somnifera* along with paclitaxel on benzo(a)pyrene induced experimental lung cancer. Mol Cell Biochem 292:13–17

Shale TL, Stirk WA, van Staden J (2005) Variation in antibacterial and anti-inflammatory activity of different growth forms of *Malva parviflora* and evidence for synergism of the anti-inflammatory compounds. J Ethnopharmacol 96:325–330

Sharifi AM, Darabi R, Akbarloo N (2003) Study of antihypertensive mechanism of *Tribulus terrestris* in 2K1C hypertensive rats: role of tissue ACE activity. Life Sci 73:2963–2971

Sharma R, Ramawat KG (2005) Regeneration of woody plants of arid zones with special reference to *Prosopis*: problems, perseverance and prospects. In: Trivedi PC (ed) Plant biotechnology: recent advances. Panima Pub Crop, New Delhi, pp 325–349

Shetty BV, Singh V (1987–1993) Flora of Rajasthan. BSI, Calcutta, India

Shirwaikar A, Somashekar AP, Udupa AL, Udupa SL, Somashekar S (2003) Wound healing studies of *Aristolochia bracteolata* Lam. with supportive action of antioxidant enzymes. Phytomedicine 10:558–562

Shishodia S, Sethi G, Ahn KS, Aggarwal BB (2007) Guggulsterone inhibits tumor cell proliferation, induces S-phase arrest, and promotes apoptosis through activation of c-Jun N-terminal kinase, suppression of Akt pathway, and downregulation of antiapoptotic gene products. Biochem Pharmacol 74:118–130

Silva RL, Melo GB, Melo VA, Antoniolli AR, Michellone PR, Zucoloto S, Picinato MA, Franco CF, Mota Gde A, Silva Ode C (2006) Effect of the aqueous extract of *Sida cordifolia* on liver regeneration after partial hepatectomy. Acta Cir Bras 21:37–39

Singh AK (2004) Endangered economic species of Indian desert. Genet Res Crop Evolut 51:371–380

Singh AK, Sharma M, Varshney R, Agarwal SS, Bansal KC (2006) Plant regeneration from aliginate-encapsulated shoot tips of *Phyllanthus amarus* Schum and Thonn, a medicinally important plant species. In Vitro Cell Dev Biol Plant 42:109–113

Singh B, Bani S, Gupta DK, Chandan BK, Kaul A (2003) Anti-inflammatory activity of ‘TAF’ an active fraction from the plant *Barleria prionitis* Linn. J Ethnopharmacol 85:187–193

Singh B, Chandan BK, Prabhakar A, Taneja SC, Singh J, Qazi GN (2005) Chemistry and hepatoprotective activity of an active fraction from *Barleria prionitis* Linn. in experimental animals. Phytother Res 19:391–404

Singh I, Soyal D, Goyal PK (2006) *Emblica officinalis* (Linn.) fruit extract provides protection against radiation-induced hematological and biochemical alterations in mice. J Environ Pathol Toxicol Oncol 25:643–654

Singh OM, Subharani K, Singh NI, Devi NB, Nevidita L (2007) Isolation of steroidal glycosides from *Solanum xanthocarpum* and studies on their antifungal activities. Nat Prod Res 21:585–590

Singh P, Sharma ML, Mukherjee S (1989) Effect of indole butyric on sprouting in plant cuttings of *Commiphora wightii* (Arnott) Bhandari. Indian Drugs 26:515–516

Singh R, Singh B, Singh S, Kumar N, Kumar S, Arora S (2008) Anti-free radical activities of kaempferol isolated from *Acacia nilotica* (L.) Willd. Ex. Del. Toxicol In Vitro 22:1965–1970

Singh RK, Mittal PK, Dhiman RC (2005) Laboratory study on larvicidal properties of leaf extract of *Calotropis procera* (Family-Asclepiadaceae) against mosquito larvae. J Commun Dis 37:109–113

Sittie AA, Lemmich E, Olsen CE, Hviid L, Christensen SB (1998) Alkamides from *Phyllanthus fraternus*. Planta Med 64:192–193

Sivanesan I, Jeong BR (2007) Direct shoot regeneration from nodal explants of *Sida cordifolia* Linn. In Vitro Cell Dev Biol Plant 43:436–441

Smith MA, Vellen L, Pask J (1995) Vegetation history from archaelogical charcoals in central Australia: the late quaternary record from Puritjarra rock shelter. In: Bittman F (ed) Vegetation history and archaeobotany, Springer, Berlin, pp 171–177

Soares de Oliveira J, Pereira Bezerra D, Teixeira de Freitas CD, Delano Barreto Marinho Filho J, Odorico de Moraes M, Pessoa C, Costa-Lotufo LV, Ramos MV (2007) In vitro cytotoxicity against different human cancer cell lines of laticifer proteins of *Calotropis procera* (Ait.) R. Br. Toxicol In Vitro 21:1563–1573

Sofrata A, Lingström P, Baljoon M, Gustafsson A (2007) The effect of miswak extract on plaque pH, an in vivo study. Caries Res 41:451–454

Spelman K, Burns J, Nichols D, Winters N, Ottersberg S, Tenborg M (2006) Modulation of cytokine expression by traditional medicines: a review of herbal immunomodulators. Altern Med Rev 11:128–150

Speroni E, Cervellati R, Innocenti G, Costa S, Guerra MC, Dall’ Acqua S, Govoni P (2005) Anti-inflammatory, anti-nociceptive and antioxidant activities of *Balanites aegyptiaca* (L.) Delile. J Ethnopharmacol 98:117–125

Srikumar R, Parthasarathy NJ, Shankar EM, Manikandan S, Vijayakumar R, Thangaraj R, Vijayananth K, Sheeladevi R, Rao UA (2007) Evaluation of the growth inhibitory activities of Triphala against common bacterial isolates from HIV infected patients. Phytother Res 21:476–480

Srinivasan S, Ranga RS, Burikhanov R, Han SS, Chendil D (2007) Par-4-dependent apoptosis by the dietary compound withaferin A in prostate cancer cells. Cancer Res 67:246–253

Stan SD, Hahm ER, Warin R, Singh SV (2008) Withaferin A causes FOXO3a- and Bim-dependent apoptosis and inhibits growth of human breast cancer cells in vivo. Cancer Res 68:7661–7669

Subbaraju GV, Vanisree M, Rao CV, Sivaramakrishna C, Sridhar P, Jayaprakasam B, Nair MG (2006) Ashwagandhanolide, a bioactive dimeric thiowithanolide isolated from the roots of *Withania somnifera*. J Nat Prod 69:1790–1792

Sun B, Qu W, Bai Z (2003) The inhibitory effect of saponins from *Tribulus terrestris* on Bcap-37 breast cancer cell line in vitro. Zhong Yao Cai 26:104–106

Sun B, Qu WJ, Zhang XL, Yang HJ, Zhuang XY, Zhang P (2004) Investigation on inhibitory and apoptosis-inducing effects of saponins from *Tribulus terrestris* on hepatoma cell line BEL-7402. Zhongguo Zhong Yao Za Zhi 29:681–684

Sun W, Li H, Yang SJ (2008) A triterpene saponin from *Tribulus terrestris* attenuates apoptosis in cardiocyte via activating PKC signalling transduction pathway. J Asian Nat Prod Res 10:39–48

Sutradhar RK, Rahman AM, Ahmad M, Bachar SC, Saha A, Roy TG (2007) Anti-inflammatory and analgesic alkaloid from *Sida cordifolia* linn. Pak J Pharm Sci 20:185–188

Tadeg H, Mohammed E, Asres K, Gebre-Mariam T (2005) Antimicrobial activities of some selected traditional Ethiopian medicinal plants used in the treatment of skin disorders. J Ethnopharmacol 100:168–175

Tahiliani P, Kar A (2000) *Achyranthes aspera* elevates thyroid hormone levels and decreases hepatic lipid peroxidation in male rats. J Ethnopharmacol 71:527–532

Talwar GP, Dar SA, Rai MK, Reddy KV, Mitra D, Kulkarni SV, Doncel GF, Buck CB, Schiller JT, Muralidhar S, Bala M, Agrawal SS, Bansal K, Verma JK (2008) A novel polyherbal microbicide with inhibitory effect on bacterial, fungal and viral genital pathogens. Int J Antimicrob Agents 32:180–185

Tiagi YD, Aery NC (2007) Flora of Rajasthan (South and South-East Region). Himanshu, Udaipur-New Delhi, India

Tohda C (2008) Overcoming several neurodegenerative diseases by traditional medicines: the development of therapeutic medicines and unraveling pathophysiological mechanisms. Yakugaku Zasshi 128:1159–1167

Tyagi S, Govil CM (1999) Somatic embryogenesis and micro-propagation in *Emblica officinalis* gaertn. J Indian Bot Soc 78:363–365

Upadhyay RK, Rohatgi L, Chaubey MK, Jain SC (2006) Ovipositional responses of the pulse beetle, *Bruchus chinensis* (Coleoptera: Bruchidae) to extracts and compounds of *Capparis decidua*. J Agric Food Chem 54:9747–9751

Vasudeva N, Sharma SK (2006) Post-coital antifertility activity of *Achyranthes aspera* Linn. root. J Ethnopharmacol 107:179–81

Vasudevan M, Parle M (2007a) Effect of Anwala churna (*Emblica officinalis* GAERTN.): an ayurvedic preparation on memory deficit rats. Yakugaku Zasshi 127:1701–1707

Vasudevan M, Parle M (2007b) Memory enhancing activity of Anwala churna (*Emblica officinalis* Gaertn.): an Ayurvedic preparation. Physiol Behav 91:46–54

Verma PK, Sharma A, Joshi SC, Gupta RS, Dixit VP (2005) Effect of isolated fractions of *Barleria prionitis* root methanolic extract on reproductive function of male rats: preliminary study. Fitoterapia 76:428–432

Vetrichelvan T, Jegadeesan M (2003) Effect of alcohol extract of *Achyranthes aspera* Linn. on acute and subacute inflammation. Phytother Res 17:77–79

Vinutha B, Prashanth D, Salma K, Sreeja SL, Pratiti D, Padmaja R, Radhika S, Amit A, Venkateshwarlu K, Deepak M (2007) Screening of selected Indian medicinal plants for acetylcholinesterase inhibitory activity. J Ethnopharmacol 109:359–363

Visavadiya NP, Narasimhacharya AV (2007) Hypocholesteremic and antioxidant effects of *Withania somnifera* (Dunal) in hypercholesteremic rats. Phytomedicine 14:136–142

Wang X, Bunkers GJ (2000) Potent heterologous antifungal proteins from cheeseweed (*Malva parviflora*). Biochem Biophys Res Commun 279:669–673

Wang X, Bunkers GJ, Walters MR, Thoma RS (2001) Purification and characterization of three antifungal proteins from cheeseweed (*Malva parviflora*). Biochem Biophys Res Commun 282:1224–1228

Wei FH, Xu XJ, Liu JB, Dai YH, Dussart G, Trigwell J (2002) Toxicology of a potential molluscicide derived from the plant *Solanum xanthocarpum*: a preliminary study. Ann Trop Med Parasitol 96:325–331

Widodo N, Kaur K, Shrestha BG, Takagi Y, Ishii T, Wadhwa R, Kaul SC (2007) Selective killing of cancer cells by leaf extract of Ashwagandha: identification of a tumor-inhibitory factor and the first molecular insights to its effect. Clin Cancer Res 13:2298–2306

Yadav P, Sarkar S, Bhatnagar D (1997) Action of *Capparis decidua* against alloxan-induced oxidative stress and diabetes in rat tissues. Pharmacol Res 36:221–228

Yang HJ, Qu WJ, Sun B (2005) Experimental study of saponins from *Tribulus terrestris* on renal carcinoma cell line. Zhongguo Zhong Yao Za Zhi 30:1271–1274

Yang L, Lu JW, An J, Jiang X (2006) Effect of *Tribulus terrestris* extract on melanocyte-stimulating hormone expression in mouse hair follicles. Nan Fang Yi Ke Da Xue Xue Bao 26:1777–1779

Yokozawa T, Kim HY, Kim HJ, Tanaka T, Sugino H, Okubo T, Chu DC, Juneja LR (2007) Amla (*Emblica officinalis* Gaertn.) attenuates age-related renal dysfunction by oxidative stress. J Agric Food Chem 55:7744–7752

Zafar R, Mujeeb M (2002) Rotenoids and rutin in callus culture of *Tephrosia pupurea* (L) Pers. seeds. Indian J Pharm Sci 64:217–221

Zhang JD, Cao YB, Xu Z, Sun HH, An MM, Yan L, Chen HS, Gao PH, Wang Y, Jia XM, Jiang YY (2005) In vitro and in vivo antifungal activities of the eight steroid saponins from *Tribulus terrestris* L. with potent activity against fluconazole-resistant fungal pathogens. Biol Pharm Bull 28:2211–2215