FUTURE CROPS

— *Volume 2* —

Editor
Professor K.V. Peter

2014
Daya Publishing House®
A Division of
Astral International Pvt. Ltd.
New Delhi – 110 002

Cataloging in Publication Data—DK
Courtesy: D.K. Agencies (P) Ltd. <docinfo@dkagencies.com>
Future crops / editor, K.V. Peter.
v. 2 cm.
Contributed articles.
Includes bibliographical references and index.
ISBN 9788170357537 (Series)
ISBN 9789351301226 (Series) (International Edition)
ISBN 9789351242680 (Vol. 2) (Hardbound)
ISBN 9789351301219 (Vol. 2) (International Edition)
1. Horticultural crops—India. I. Peter, K. V.
DDC 635.0954 23

Published by : **Daya Publishing House®**
A Division of
Astral International Pvt. Ltd.
– ISO 9001:2008 Certified Company –
81, Darya Ganj, Near Hindi Park,
Delhi Medical Association Road,
New Delhi - 110 002
Phone: 011-4354 9197, 2327 8134
Fax: +91-11-2324 3060
E-mail: info@astralint.com
Website: www.astralint.com

Laser Typesetting : **Classic Computer Services**, Delhi - 110 035
Printed at : **Salasar Imaging Systems**, Delhi - 110 035

PRINTED IN INDIA

2014, Future Crops Vol. 2 *Pages* 237–256
Editor: Professor K.V. Peter
Published by: DAYA PUBLISHING HOUSE, NEW DELHI

Chapter 12

Propagation and Cultivation Techniques of *Embelia ribes* (Vidanga)

A. Patwardhan[1,2]*, M. Mhaskar[1,2], A. Joglekar[1,2], M. Tadwalkar[1,2], R. Wagh[1,2] and R. Vasudeva[3]

[1]Department of Biodiversity, Abasaheb Garware College, Deccan Gymkhana, Karve Road, Pune – 411 004, Maharashtra
[2]Research and Action in Natural Wealth Administration (RANWA), 16, Swastishree Society, Ganesh Nagar, Kothrud, Pune – 411 052, Maharashtra
[3]Department of Forest Biology and Tree Improvement, College of Forestry, University of Agricultural Sciences, Dharwad, Sirsi Campus – 581 401, Karnataka
**E-mail: ankurpatwardhan@gmail.com*

Biological resources are now viewed as 'resource capital' of a nation. Medicinal plants are among the most valued resources of a country. The current volume of markets dealing with medicinal plants at international level is reported US $ 100 billion. India ranks 2nd in terms of the volume and value of medicinal plants exported (32000 tones – US$ 265 million), after China. India with its rich repository of medicinal plant species (1/4th of the world) meets health care needs of more than 80 per cent of the population of this country (Ravikumar and Ved, 2000). In the past a few decades, many species of plants all over the world are gaining international importance because of the medicinally or economically important biomolecules they possess. Out of these plants, 25 per cent are found in Western Ghats of India, a mega biodiversity hot-spot (Myers *et al.*, 2000) being an important site of wild collection of medicinal plants. Recently Ved and Goraya (2008) reported that about 960 plant species from India are traded for their medicinal properties and of them about 178 species are consumed in volumes exceeding 100 metric tons. Their consolidated consumption accounts for about 80 per cent of the total industrial demand of all botanicals in the country. *E. ribes* (Vavding or Vidanga) is one such species high in demand for its various uses in Ayurveda and modern medicine alike.

Unfortunately despite its huge importance, the entire demand for the species is met by wild collections alone. This has lead to its indiscriminate harvest from the wild and hence the very existence of this species is under severe threat. Virtually there are no efforts to develop and standardize the

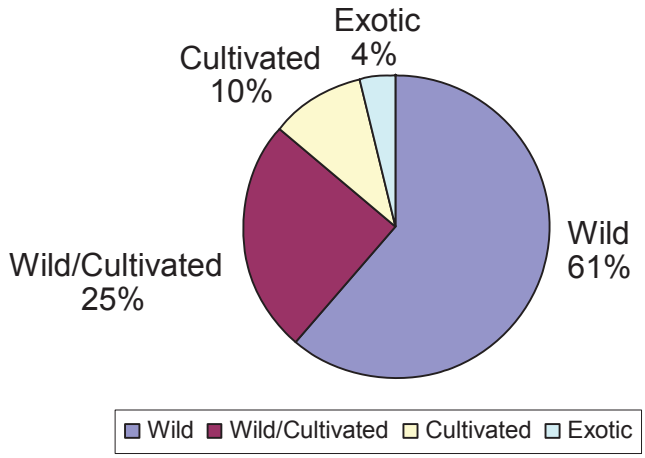


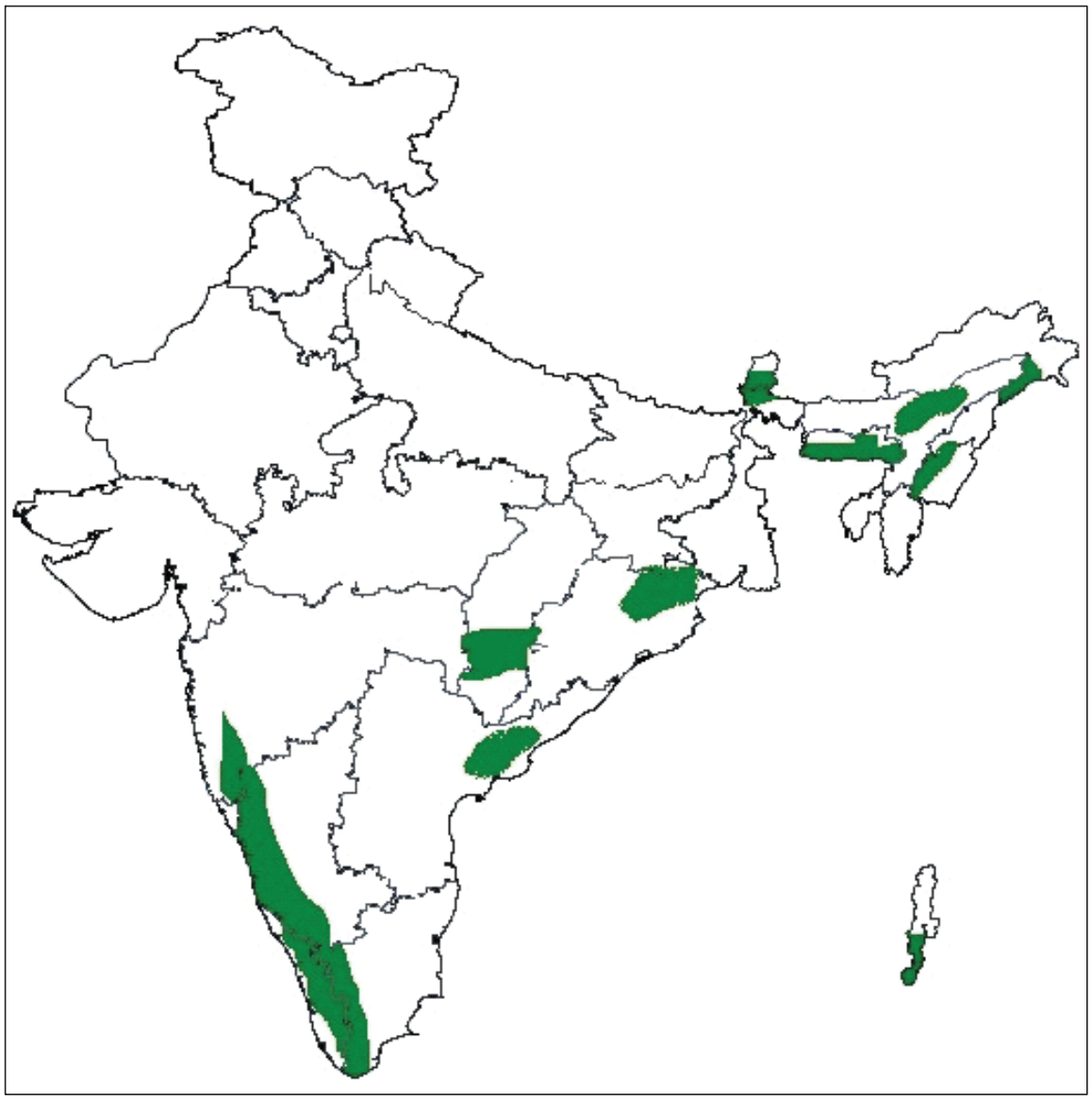
Figure 12.1: Share of wild collected and cultivated origin of MAPs in trade.

nursery and planting techniques attempted in this country. The present chapter takes an overview of status of *E. ribes* in general, and focuses on various aspects of standardization of propagation techniques and development of mass multiplication protocols. Comparative account of *E. ribes* with *E. basaal* (syn. *E. tsjerium-cottam, E. robusta*) is also presented as the later is also used and traded as *Vidanga*. Cultivation and domestication will help tackle problems inherent to medicinal plant industry/herbal medicines like unavailability of Quality Planting Material (QPM: seeds and seedling), misidentification, instability in the supply of material, and contaminants.

Distribution and Taxonomy

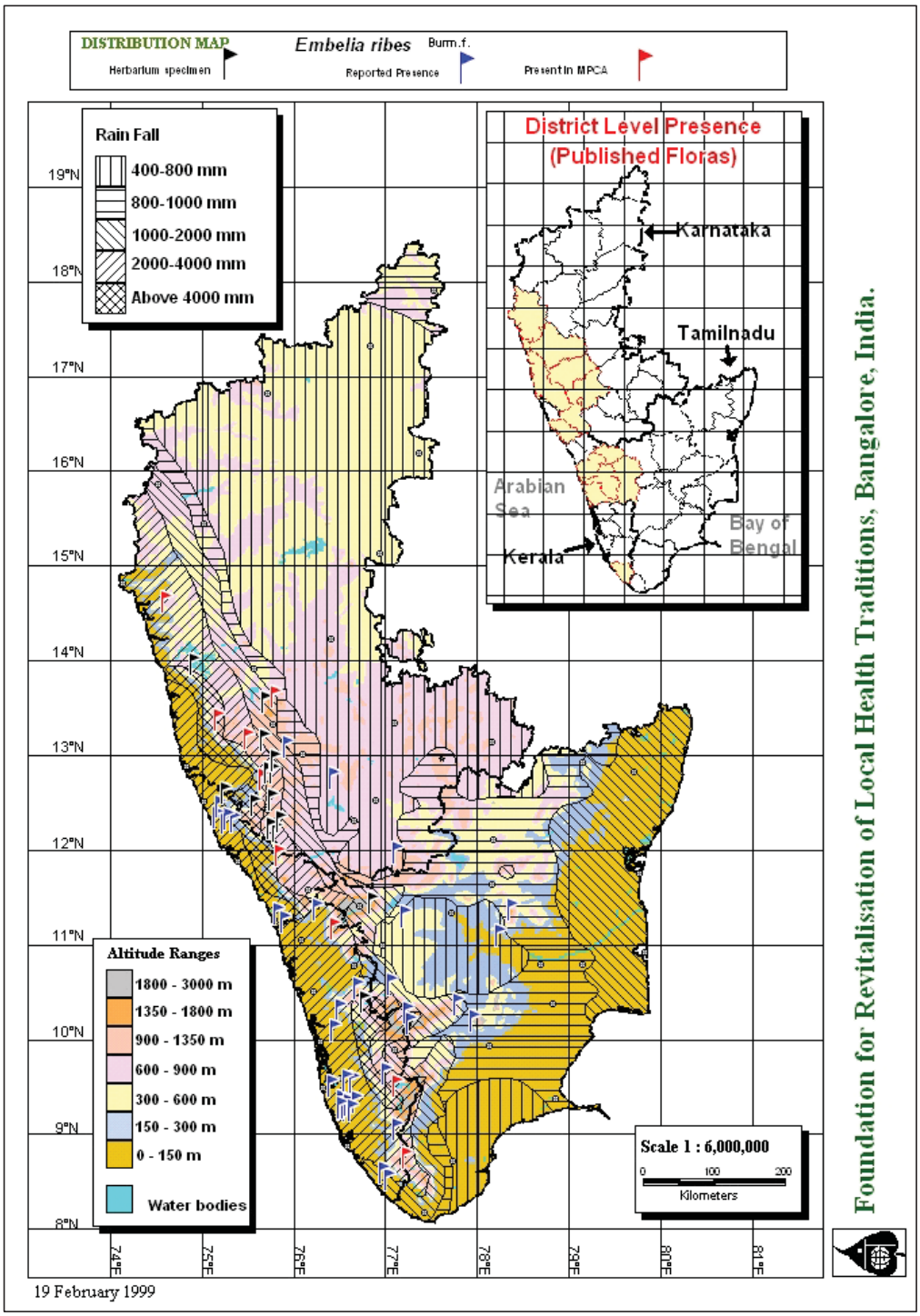
The genus *Embelia* belongs to family Myrsinaceae (order Ericales) which is one of the 'primuloid' families (Ma and Saunders, 2003). It is mainly distributed in warmer regions of northern and southern hemisphere. Most of the genera and species are tropical. Genus *Embelia*, represented by more than 100 species, is distributed in Tropical Asia, Africa and Australia and Pacific islands. Species of *Embelia* like *E. ribes* and *E. basaal a*re known for their medicinal use since thousands of years in parts of Southeast Asia. *E. ribes* is an Indo Malayan species, distributed in India, Sri Lanka, Singapore, Malaysia and S. China. It is sparsely distributed in the evergreen to moist deciduous forests of Arunachal Pradesh, Assam, Maharashtra, Andhra Pradesh, Karnataka, Kerala and Tamil Nadu and is now confined to the informally protected '*sacred groves' and restricted* to a few remnant forest pockets and MPCAs (Medicinal Plant Conservation Areas) that Forest Department has established (Figure 12.2). Within India, it is found throughout up to an altitude of 1750 m amsl in these regions. It is 'Vulnerable-VU' in Karnataka and Tamil Nadu, 'Near Threatened – NT' in Arunachal Pradesh and Kerala and 'Data Deficient -DD' in Assam, Meghalaya, Sikkim and Maharashtra (CAMP, 2001). In Karnataka, *E. ribes* is distributed in evergreen forests. In northern parts of Western Ghats, *E. ribes* is distributed on edges of disturbed evergreen and semi evergreen forests (Mhaskar *et al.,* 2011). Recently Hareesh *et al.* (2009) reported that in humid tropics of the central Western Ghats, only 8 individuals out of 24 identified in a 1 km transect bear fruits. Although size class distribution of lianas suggested a near 'reserve J' pattern, the regeneration was restricted to mildly disturbed spots. Further there was lack of regeneration of Class-IV seedlings indicating poor regeneration in its type habitat.

Figure 12.2: Distribution map of *E. ribes.*
Source: FRLHT-IAIM Database 1991-2011.



Contd...

Figure 12.2–*Contd...*



Embelia ribes Burm. f.

Common Name

False pepper

Vernacular Name

Vidanga, Vavding, Karkanni, Murudvel, Vaivarang, Baibidanga

It is a dioecious woody climber with lenticellular bark. Leaves are entire, elliptic, lanceolate, thinly coriaceous and gland dotted beneath. Base is rounded and apex acute. The whole surface is covered with scattered minute sunken glands. Flowers are in terminal, pubescent, paniculate racemes and greenish yellow in colour. Pentamerous flowers have hairy sepals; calyx is connate at the base and petals are papillose. Stamens 5 slightly exerted. Ovary is ribbed. Fruits are globose, smooth succulent, tipped with persistent style. The drupes are green when young and black when ripe with usually one seed; seeds globose (Figure 12.3).

Flowering and Fruiting period

February – July

Drooping habit

Lenticellular bark

Branch

Sunken glands near midrib

Male

Flower

Bisexual Flower Fruits

Figure 12.3: *Embelia ribes.*

Comparative Account of *E. ribes* with *E. basaal*

There are at least 3-4 botanical species, currently traded as Vidanga, one of them is *E. basaal*. Comparison of *E. ribes* with its 'substitute' and 'adulterant' species was critically discussed by Mhaskar *et al.* (2011). If an NTFP (Non Timber Forest Produce) is coming from two closely related plant species, correct identification forms the first and foremost criteria for sustainable utilization of the resource. *E. basaal* is one such species where it is very often mistaken with *E. ribes*. This becomes more serious when one species is threatened and possesses high conservation significance. Figure 12.4 gives various features of *E. basaal* and will help clearing confusion in identification of these two *Embelia* species that may arise because of misidentification.

Figure 12.4: *Embelia basaal.*

Use of *E. ribes* in Traditional and Modern Medicine

Embelia, especially *E. ribes* and *E. basaal* possess deworming activity in humans and are utilized since ages in traditional medicine. It is employed in India, since ancient times, as anthelmintic and administered as powder, usually with milk, followed by a purgative. It is effective in the treatment of ascariasis (Anonymus, 1952). *E. ribes* is also used in Unani medicine as an antihelminthic and has

antifertility action. The root of *E. ribes* is boiled in water and the decoction is effective against chest pains. Besides, paste of powdered leaves, mixed with honey is consumed to treat ulcers of mouth (Sharma 1997). Roots are ground with lime juice and taken orally with honey against cough (Rajakumar and Shivanna, 2010).

It is used in about 75 formulations. Fruits are used in Ayurvedic preparations like Abhayarishtam, Ayaskrithi, Pippallyasavam, Anuthailam and Kachuradithailam (lyer, 1983). Ayurvedic products like Vidangadi Churna, Vidanga lauha, Vidanga Taila and Vidangarishta are also available. The fruits are acrid, astringent, anthelmintic, depurative, digestive, diuretic, carminative and contraceptive (Shah and Khanna, 1961; Warrier *et al.,* 1994). The paste is locally applied against ringworm and other skin infections. Seed powder is used to cure headache. The roots and leaves are astringent, thermogenic and stomachic (Warrier *et al.,* 1994). Powder from dried bark of the root is a reputed remedy for toothache. The plant is used as an anti-inflammatory drug to relieve rheumatism and fever (Khan *et al.,* 2010b). The fruit cures tumors, ascites, bronchitis, jaundice and mental disorders.

Major Phyto-constituents

The phytochemical characterization of *E. ribes* has predominantly focused on the composition of fruits and/or seeds. It yields embelin and other high valued secondary metabolites which have a wide range of clinical applications. Reported constituents include fatty acids glycerides (linoleic acid and palmitic acid), gallic acid and simple carbohydrates (glucose, fructose), quercitol and glycerol (Kuichi *et al.,* 1998; Lakshmanan *et al.,* 1990; Mitra, 1995). Kuichi *et al.* (1998) reported the Embelin content of *E. ribes* fruit as 2.4-4 per cent w/w (isolated yield) using cold ether extraction. From water extracts of *E. ribes* fruit, gallic acid (~1 per cent w/w/fruit), glucose, fructose and glycerol were isolated (Kuichi *et al.,* 1998).

Table 12.1 gives details of various phyto-constituents extracted from different parts of *E. ribes*. Details on pharmacological activity are presented in Table 12.2.

Table 12.1: Chemical constituents and activities reported from *E. ribes.*

Plant Part Used	*Phyto-constituents*	*Activity*
Fruits	Embelin, embolic acid, rapanone (Fieser and Chamberlin, 1948)	Anti-helminthic, against tumour, bronchitis, mental disorders, jaundice (Kirtikar and Basu, 1987), Anti-fertility (Seth *et al.,* 1982), analgesic (Atal *et al.,* 1984), antibacterial(Narang *et al.,* 1961), anti-inflammatory(Ahn *et al.,* 2007), antioxidant (Bhandari *et al.,* 2007)
	Embelin	Against diabetes (Bhandari *et al.,* 2002), Cardio protective activity (Bhandari *et al.,* 2002), (Bhandari *et al.,* 2008a) Contraceptive (Chaudhury *et al.,* 2001)
	Sitosterol and daucosterol (Haq *et al.,* 2005), embelinol, embeliaribyl ester, embeliol (Haq *et al.,* 2005), (Latha, 2007), vilangin (Rao *et al.,* 1965), christenbine (Chopra *et al.,* 1956)	–
Whole plant	Embelin	Anti-inflammatory (Kapoor *et al.,* 1983)
Roots	Embelin	Influenza epidemic (Menon, 1999)
Seeds	Embelin	Antibiotic, Anti-tuberculosis (Guhabakshi *et al.,* 2001)
Leaves	Embelin	Skin diseases and Leprosy (Sharma *et al.,* 2002)

Table 12.2: Pharmacological activities reported from *E. ribes.*

Sl.No.	Constituents	Pharmacological Activity	Activity Studied against	References
1.	Ethanolic extract of *E. ribes*	Hepatoprotective activity	Mice	Tabassum *et al.,* 2003
		α-amylase inhibitor activity	–	Prashanth *et al.*, 2001
		Anti-diabetic activity	Rats	Bhandari *et al.,* 2008b Bhandari *et al.*, 2007
		Methionine-induced hyperhomocysteinemia and oxidative stress	Rats	Ansari *et al.,* 2008
		Antihyperglycemic activity, antioxidant property	Rats	Bhandari *et al.,* 2002
2.	Ethanol extract of leaves of *Embelia ribes* Burm.	Wound healing property	Swiss Albino Rats	Kumara Swamy *et al.,* 2007
3.	Aqueous extract of *Embelia ribes*	Cardio-protective effect	Wistar albino rats	Bhandari *et al.,* 2008a
		Antihyperhomocysteinemic property	Rats	Bhandari *et al.,* 2008c
		Methionine-induced hyperhomocysteinemia and oxidative stress	Rats	Bhandari *et al.,* 2008c
4.	Aqueous, 80 per cent ethanolic and hexane extracts of leaves of *E. ribes*	No antimicrobial activity	–	Jiapiyasakul *et al.,* 2007
5.	Aqueous and ethanol extracts of *Embelia ribes*	Antibacterial activity	Gram positive strains	Khan *et al.,* 2010a
6.	Embelin	Antioxidant activity	Rats	Singh *et al.,* 2009
		Anticonvulsant activity	–	Mahendran *et al.,* 2010
		Decrease in testicular weight and variable degrees of spermatogenic arrest	Oral treatment in male dogs	Dixit *et al.,* 1983
7.	Embelin from *E. ribes*	Antioxidant property	–	Joshi *et al.,* 2007
		Effect on reproductive system	Male albino rats	Satyavati *et al.,* 1984; Anderson 1986; Arora *et al.,* 1971; Krishnaswamy *et al.,* 1980a, b; Purandare *et al.,* 1979; Shah 1971; Chaudhary *et al.,* 2001; Sharma *et al.,* 2001; Agarwal *et al.,* 1986; Mathur 1986; Gupta *et al.,* 1989

Contd...

Table 12.2–*Contd...*

Sl.No.	Constituents	Pharmacological Activity	Activity Studied against	References
		Anti-cancer property	Wistar rats	Sreepriya and Bali, 2005; Retuer *et al.,* 2010; Ahn *et al.,* 2007; Chitra *et al.,* 1995
		Anti., oxidant activity	–	Jain *et al.,* 2007
8.	Fruits of *E. ribes*	Anti., nematodal activity	Goats	Javed *et al.,* 1990
		Mollusicidal activity	*Lymnaea acuminata*	Rao *et al.,* 2001; Singh *et al.,* 2001
9.	Methanolic extract of *E. ribes* and Embelin	Anti-bacterial activity	–	Gajjar *et al.,* 2009; Tambekar *et al.,* 2009; Chitra *et al.,* 2003
10.	Dichloromethane extract of dried fruits of *Ardisia colorata* Roxb	Ant-itoxic, high inhibitory effect	Cancer cells	Prasertsang *et al.,* 2003
11.	Diethyl ether, petroleum ether, methanol extracts of *E. ribes* and embelin	Anti-fungal activity	–	Suthar *et al.,* 2009
12.	Benzene extract of *P. longum* and methanol extract of *E. ribes* berries	Pregnancy inhibition	Animals	Kholkute *et al.,* 1979
13.	Petroleum ether, solvent ether, methanol and water extract of *E. ribes*	Anti-fungal activity	–	Rathi *et al.,* 2010
14.	Seed oils of *Embelia ribes*	Anti-helminthic and antibacterial activity	*Pheritima posthuma*	Jalalpure *et al.,* 2007; Tambekar *et al.,* 2009
15.	Hexane extract of fruits of *E. ribes*	Anti-proloferative activity	Human cells	Joy and Lakshmi, 2010
16.	Ayurvedic formulation of Embelin and Embelin-borax complex	Anti-fertility activity	–	Singh *et al.,* 2007
17.	Formulation of Diarex containing Embelin	Anti-diarrhoeal	Humans	Srivastava *et al.,* 1988
18.	Zycox, containing *H. antidysentrica, B. aristata, E. ribes* and *A. calamus*	Anti-cocidal activity	–	Tipu *et al.,* 2006
19.	Powdered seeds of *E. ribes*, fruit of *P. longum* L. and borax powder	Ayurvedic contraceptive	–	Chaudhary *et al.,* 2001
20.	Potassium embelate	Analgesic activity	Rats and mice	Atal *et al.,* 1984; Zutshi *et al.,* 1989

Contd...

Table 12.2–*Contd...*

Sl.No.	*Constituents*	*Pharmacological Activity*	*Activity Studied against*	*References*
21.	–	Trypsin inhibition	–	Med. Arom Plant Abstr, 1995
22.	–	Adaptogenic property	–	Handa *et al.,* 1986; Paranjape and Kulkarni, 1995; Med Arom Plant Abrstr, 1995
23.	–	Antihyperlipidemic activity	–	Bhandari *et al.,* 2002

Trade

Vidanga is one of the most traded plants in volume with demand of > 100 metric tones/annum. The commercial importance of this plant drug is also confirmed by the study conducted by CERPA, New Delhi, under the aegis of Dept. of ISM and H (Indian System of Medicine and Homoeopathy) in 2000-2001. This study estimated the domestic consumption of *Vidanga* to be about 400 tons, valued approximately at Rs. 40 million, for 1999-2000 and is one of the top 50 traded plant drugs in India. Demand for vidanga seeds saw a steep increase in this period, as its export market, especially to Middle Eastern countries, increased tremendously and rates went up to Rs. 200/kg. Table 12.3 gives details of trade of *Embelia* species in leading markets in India in 2000-01. A study by FRLHT estimated the annual growth rate of about 23 per cent and projected the demand to touch 1000 tones by 2004-2005. But, for last a few years, a decline in demand was seen in the market. Studies indicated that Embelia ribes to be the authentic species. Trade data pointed out that > 95 per cent of the traded species are *E. tsjeriam-cottam*. This is because being a large shrub, maximum fruit bearing capacity and throughout distribution, coupled with non-availability of genuine *E. ribes*, market of *E. basaal* has increased. *E. basal* and *Myrsine africana* L. are used as substitutes as they possess embelin, while Maesa indica Roxb. is used as an 'adulterant' of *E. ribes* owing to its similarity with fruits. The local community in Maharastra identify M. indica also as Vavding (Mhaskar *et al.,* 2011). Curiously, Talbot (1911) mentioned that dried fruits of this species were earlier employed by the local communities of Uttara Kannada district of Karnataka as an adulterant with black pepper because of its morphological similarity.

Table 12.3: Trade of *Embelia ribes* and *E. basaal* in leading markets of India in 2000-01.

Sl.No.	Plant Name	Trade Name	Plant Part	Estimated Consumption (Tones)	Price Rs/kg	Market
1.	*E. ribes*	Baibidang, black, Vai-vidang	(Fr.-B), (Fruit)	4-5	150-160	Hyderabad
2.	*E. ribes*	Vai-Vidang	Fruit	>10	135-160	Delhi
3.	*E. basaal, E. ribes*	Vaividang (Red), Vavding (Kala), Vavding (Lal-Kala)	Fruit	>100	60-120 60-250, 110-160	Mumbai
4.	*E. basaal, E. ribes*	Bai-Bidang,	Fruit	10-80	110-160	Kolkata
5.	*E. ribes*	Vai - Vidang	Fruit	100 - 500	85	Dhamtari, Chattisgarh
6.	*E. ribes*	Vai - Vidang (black)	Fruit	100 - 500	70	Jagdalpur
7.	*E. ribes*	Vai - Vidang (black)	Fruit	100 - 500	70	Keshkal, Odisa
8.	*E. ribes*	Vai - Vidang (black)	Fruit	100 – 500	80	Raipur, (Chattisgarh)
	E. basaal	Vai - Vidang (red)	Fruit	100 – 500	95	Raipur
9.	*E. ribes*	Vai - Vidang (black)	Fruit	<100	65	Bagdihi (Odisa)

Propagation Techniques and Cultivation

The ideal time for seed collection is from June to August. Mature seeds of *E. ribes* are purple to black unlike red colored seeds of *E. basaal*. Propagation can be achieved through seed germination and through stem cuttings.

By Seeds (Figure 12.5)

Matured and ripened fruits are packed in polythene covers and placed under the artificial light source for 8 h per day. The cycle is continued for a period of 4-5 days. Pre sowing treatment of (10 per cent) H_2SO_4 for 10 min + GA_3 (4000 ppm) is the best treatment for *Embelia ribes*. By this method,40 per cent seed germination can be achieved successfully. Sand media are sufficient to achieve the seed germination. Sand bed with at least 9 cm thickness prepared in large tray is sufficient for raising seedlings under nursery conditions. Seeds are sown in a row inside the handmade furrows. Uniform and thin layer of sand should be spread over the seeds. Immediate watering should be done. The trays thus prepared should be placed inside the poly

Figure 12.5: Various steps in germination of *E. ribes* through seeds.

tunnel. Watering should be done regularly or as and when required. Weeding should be done if required. Compost/Vermi compost and organic manure are preferred. Seed germination starts after 50 days of sowing with 40 per cent germination.

Through Stem Cuttings (Figure 12.6)

Pencil sized stem cuttings of 1.0-1.5 cm thickness bearing 3 nodes are planted 3 cm deep in polybags and kept in shade. Cuttings are treated with two types of root regulators such as Indole Butyric Acid (IBA) (200ppm) and commercial quick root solution before planting. Post-Monsoon season is the best time for collection of stem cuttings. Pre treated stem cuttings are placed in root

trainers and transferred to poly chambers. Rooting media is prepared from sand, coir pith and perlite. Microclimate with ambient condition is created inside the micro-poly chambers. By this method nearly 10 per cent of the stem cuttings sprout immediately. The rooting commences only after 35-40 days and within 3 weeks one or two axillary buds above the leaf scars develop and grow into branches. After the formation of healthy root system, it is ready for transplanting.

Figure 12.6: Various steps in vegetative propagation of *E. ribes* through stem cuttings.

Seedling Growth and Nutrient Management

Once the plants attain considerable growth, it should be transferred to polythene bags of bigger size. Periodical watering and weeding should be done. Additional boosting nutrients are necessary. The plants are also resistant to diseases and pests and hence protective sprays are not necessary. Seedling should be nurtured under the nursery conditions until they are transferred to fields. About 50 kg seeds are required for preparing 10,000 plants.

Development in the Nursery

After thirty days seedlings should be transferred to polythene covers as soon as the radical growth begins. Polythene bags of 12 x18cm size are ideal for transplanting. A potting mixture made out of sand, soil and Farm yard manure in a ratio of 1: 1: 0.5 acts as good rooting media. SeedlingS should be protected from scorching sunlight by using shade nets. Watering, weeding and shifting should be done as and when required. Capton (0.05 per cent) is sprayed over the seedlings to protect plants from fungal infection.

Embelia can be cultivated in all types of soils, the well drained light cotton soils or sandy loam soils are the best suited for cultivation.

Transplanting to the Fields

The seedlings raised in polythene bags under nursery conditions can be transferred to natural conditions immediately. Area with partial shade is preferred for this species. June and July are ideal for planting. Since it is a woody climber supporting tree is required. Saplings should be planted next to tree species as it requires shade in the initial stages. Saplings of one year and above can be easily transferred to the fields. Pits of 15 to 30 cm size should be made and filled with farm yard manure, sand and forest soil (1: 1: 0.5). Soil should be tightened properly. The pit size should be always 2-3 times wider than the root balls. Saplings can be planted at a spacing of 2-5 m distance. Saucers should be made around the planting place so that water supplied or obtained naturally will trickle down into the hole and helps in growth of saplings. The plantation can be irrigated usually at an interval of 15 days. Harvesting is done after two years. The fruits are collected, dried in shade and stored in clean porous Jute-bags. The fruits are collected manually and the plant is allowed to grow further. Weeding and thinning of plants may be done as and when required usually after 15- 30 days for better growth of plants.

Tissue Culture of *E. ribes*

Direct shoot organogenesis from leaf explants of *E. ribes* was reported by Raghu *et al.* (2006). The *in vitro* procedure involved three steps that included induction of shoot initials from leaf tissue, regeneration and elongation of shoots from shoot initials, and rooting of shoots. The induction of shoot initials was achieved on Murashige and Skoog (MS) solid medium supplemented with different concentrations of thidiazuron (TDZ). The best medium for shoot induction was MS with 0.272µM TDZ. Numerous shoot primordia were observed within 2–3 weeks on leaf margin as well as on the midrib region, without any callus phase. In second step, the shoot clumps are seperated from the leaf explant on transfer to MS basal medium, resulting in differentiation of 90 per cent of the shoot initials into well-developed shoots. The 2 to 3cm long shoots rooted on half-strength MS basal medium supplemented with 4.90µM indole-3-butyric acid (IBA) and 3 per cent (w/v) sucrose in the third stage. The rooted plants could be established in soil with 70 per cent success. This protocol could be utilized for *in vitro* propagation and conservation of this important threatened medicinal plant.

Discussion

E. ribes is listed in the 'Priority Species List' for cultivation by the National Medicinal Plant Board and the Maharashtra State Horticultural and Medicinal Plant Board. The population of this species has declined > 50 per cent in last decade because of immature and over harvest of fruits, narrow genetic base, dioecious breeding system and extrinsic factors like habitat loss, fragmentation, and degradation. Reducing harvest pressure on wild population and promoting viable commercial cultivation with the community and government participation are huge challenges. Efforts are on to develop suitable agronomy practices so that the pressure on wild populations will decrease. Once the 'package of practices' (POP) is developed, the species can be further inducted to suitable agro-forestry systems. Participatory cultivation through 'Contractual Farming Schemes' of National Horticulture and Medicinal Plant Board can be explored. Cultivation and domestication will also help tackle problems, inherent to herbal medicines like misidentification, instability in supply of material and adulterants.

Acknowledgements

We thank Rufford Small Grant Programme, UK for their support. We also thank the Principle Chief Conservator of Forests (Territorial and Wild Life wing of Maharashtra), CF (WL) Kolhapur and other forest department staff. We are also thankful to Dr. Ved and Mr. Vijay Barve of FRLHT who kindly shared the distribution map of *E. ribes*. Thanks are also due to Dr. B. S. Janagoudar, Dean, College of Forestry, Sirsi for support and encouragement.

References

Agarwal S, Chauhan S and Mathur R. 1986. Antifertility Effects of Embelin in Male Rats. Andrologia 18(2): 125-32.

Ahn KS, Sethi G and Aggarwal BB. 2007. Embelin, an inhibitor of X chromosome-linked inhibitor-of-apoptosis protein, blocks nuclear factor-kappaB (NF-kappaB) signaling pathway leading to suppression of NF-kappaB-regulated antiapoptotic and metastatic gene products. Mol. Pharmacol 71(1): 209-219.

Anderson EF. 1986. Ethnobotany of Hill tribes of Northern Thailand. II, Lahu medicinal plants. Econ Bot 40(4): 442-450.

Anonymous. 1952. The Wealth of India: a Dictionary of Indian Raw Materials and Industrial Products, Vol. III, CSIR, New Delhi, 167.

Ansari M N and Bhandari U. 2008. Protective effect of *Embelia ribes* Burm on methionine-induced hyperhomocysteinemia and oxidative stress in rat brain. Indian Journal of Experimental Biology 46: 521-527.

Arora RB, Ghatak N and Gupta SP. 1971. Antifertility effects of *Embelia ribes*. J. Res. Indian Med 6: 107.

Atal CK, Sidique MA, Zutshi U, Amla V, Johri RK, Rao PG and Kour AS. 1984. Non acrotic, orally effective, centrally acting analgesic from an Ayurvedic drug. J. Ethnopharmacol 11(3): 309–318.

Bhandari U, Ansari MN and Islam F. 2008a. Cardioprotective effect of aqueous extract of *Embelia ribes* Burm fruits against isoproterenol- induced myocardial infarction in albino rats. Indian J Exp Biol 46: 35-40.

Bhandari U, Ansari MN, Islam F and Tripathi CD. 2008c. The effect of aqueous extract of *Embelia ribes* Burm on serum homocysteine, lipids and oxidative enzymes in methionine induced hyperhomocysteinemia. *Indian J Pharmacol* 40(4): 152-157.

Bhandari U, Jain N and Pillai KK. 2007. Further studies on antioxidant potential and protection of pancreatic β-cells by *Embelia ribes* in Experimental diabetes. Exp Diabetes Res Article ID 15803, 1-6.

Bhandari U, Jain N, Ansari MN and Pillai KK. 2008b. Beneficial effect of *Embelia ribes* ethanolic extract on blood pressure and glycosylated hemoglobin in streptozotocin-induced diabetes in rats. Fitoterapia 79: 351-355.

Bhandari U, Kanojia R and Pillai KK. 2002. Effect of Ethanolic Extract of *Embelia ribes* on Dyslipidemia in Diabetic Rats. Intl. J. Experimental Diab. Res 3: 159–162.

Chaudhury MR, Chandrasekaran R and Mishra S. 2001. Embrotoxicity and teratogenecity studies of an Ayurvedic contraceptive: Pippaliyadi vati. J. Ethnopharmacol 74(2): 189–193.

Chitra M, Shyamala Devi CS and Sukumar E. 2003. Antibacterial activity of embelin Fitoterapia 74: 401-403.

Chitra M, Sukumar E and Devi CS. 1995. [^{3}H]-Thymidine Uptake and Lipid Peroxidation by Tumor Cells on Embelin Treatment: An *in vitro* Study. Oncology 52(1): 66-68.

Chopra RN, Nayar SL and Chopra IC. 1956. Glossary of Indian Medicinal Plants, CSIR, New Delhi Vol 10.

Dixit VP and Bhargava SK. 1983. Reversible contraception like activity of embelin in male dogs (*Canis indicus* Linn). Andrologia 15(5): 486-94.

Fieser LF and Chamberlin EM. 1948. Synthesis of embelin, rapanone and related quinones by peroxide alkylation. J. Am. Chem. Soc 70: 71–75.

Gajjar UH, Khambolja KM and Patel RK. 2009. International Journal of Pharm Tech Research 1(4): 1594-1597.

Guhabakshi DN, Sensarma P and Pal DC. 2001. A Lexicon Medicinal Plants of India, Naya Prakashan, 135–136.

Gupta S, Sanyal SN and Kanwar U. 1989. Antispermatogenic effect of embelin, a plant benzoquinone, on male albino rats *in vivo* and *in vitro.* Contraception 39(3): 307-320.

Handa SS, Sharma A and Chakraborti KK. 1986. Natural products and plants as liver protecting drugs. Fitoterapia 57: 307-45.

Haq K, Ali M and Siddiqui AW. 2005. New compounds from the seeds of *Embelia ribes* Burm. Pharmazie 60: 69–71.

Hareesh TS, Hegde VD, Gunaga S, Gunaga RP and Vasudeva R. 2009. Occurrence and regeneration status of *Embelia ribes* Burm. F.: an endangered and medicinally important liana of central western ghats. Journal of Non- Timber Forest Products 16(1): 5-10.

Iyer SR. 1983. Ayurveda Yogasamgraham, Vaidyaratnam P. S. *Varier's Arya Vaidya Sala*, Kottakkal.

Jain SC, Menghani E and Jain R. 2007. Biomarkers as a Tool for Validation of Herbs and Spices. Journal of Food Safety 9: 1-6.

Jalalpure SS, Alagawadi KR, Mahajanshetti CS, Shah BN, Salahuddin, Singh V and Patil JK. 2007. *In vitro* Anthelmintic Property of Various Seed Oils Against *Pheritima posthuma*. Indian Journal of Pharmaceutical Sciences 69(1): 158-160.

Javed I and Akhtar MS. 1990. Screening of *Veronia anthelmintica* seed and *Embelia ribes* fruit mixed in equal parts against gastrointestinal nematodes. Pakistan Journal of Pharmaceutical sciences 3(2): 69-74.

Jiapiyasakul P and Areekul V. 2007. Antimicrobial Activity in Some Indigenous Plant Extracts. Food Innovation Asia 2007. The 9th Agro-industrial Conference. Bitec Conventional Center, Bangkok. 14-15.

Joshi R, Kamat JP and Mukherjee T. 2007. Free radical scavenging reactions and antioxidant activity of embelin: Biochemical and pulse radiolytic studies. Chemical Biology Interact 167(2): 125-134.

Joy B and Lakshmi S. 2010. Antiproliferative Properties of *Embelia Ribes*. The Open Process Chemistry Journal 3: 17-22.

Kapoor VK, Chawla AS, Kumar M and Kumar P. 1983. Search for anti-inflammatory agent in Indian laboratories. Indian Drugs 30: 481–488.

Khan MA, Naidu MA and Akbar Z. 2010a. *In-vitro* Antimicrobial Activity of Fruits Extract of *Embelia ribes* Burm. International Journal of Pharmaceutical and Biological Archives 1(3): 267-270.

Khan MI, Ahmed A, Akram M, Mohiuddin E, Usmanghani K and Shah SM. 2010b. Monograph of *Embelia ribes* Burm. f. Plant Science 4: 503-505.

Kholkute SD, Kekare MB and Munshi SR. 1979. Antifertility effects of the fruits of *Piper longum* in female rats. Indian J. Exp. Biol 17: 289.

Kirtikar KR and Basu BD. 1987. Indian Medicinal Plants, International Book Distributors, Dehradun, India 2: 1511.

Krishnaswamy M and Purushothaman KK. 1980a. Antifertility properties of *Embelia ribes*. Indian J Exper Biol 18(6): 638-639.

Krishnaswamy M and Purushothaman KK. 1980b. Antifertility properties of *Embelia ribes* (embelin). Indian J Exper Biol 18(11): 1359-1360.

Kuichi F, Suzuki N, Fukumoto Y, Goto Y, Mitsui M and Tsuda Y. 1998. Chemical transformation of embelin through dimerization during preparation of a decoction. Chemical and Pharmaceutical Bulletin 46(8): 1225-1228.

Kumara Swamy HM, Krishna V, Shankarmurthy K, Abdul Rahiman B, Mankani KL, Mahadeven KM, Harish BG and Raja Naika H. 2007. Wound healing activity of embelin isolated from the ethanol extract of leaves of Embelia ribes Burm. J. Ethnopharmacol 109 (3): 529-534.

Lakshmanan KK and Naryanan ASS. 1990. Antifertility herbals used by the tribals in Anaikkatty Hills, Coimbatore district, Tamil Nadu India. Journal of Economic and Taxonomic Botany 14(1): 171-173.

Latha C. 2007. Microwave-assisted extraction of embelin from *Embelia ribes*. Biotechnol. Lett 29: 319–322.

Ma OSW and Saunders RMK. 2003. Comparative floral ontogeny of Maesa (Maesaceae), Aegiceras (Myrsinaceae) and Embelia (Myrsinaceae): taxonomic and phylogenetic implications. Plant Syst. Evol 243: 39–58.

Mahendran S, Thippeswamy BS, Veerapur VP and Badami S. 2010. Anticonvulsant activity of embelin isolated from *Embelia ribes*. Phytomedicine 18(2-3): 186-188.

Mathur R. 1986. Histochemical localization of alkaline phosphatase in the uterus of rats: response to a few indigenous plant extracts. Acta Eur. Fertil 17(4): 297-300.

Menon K. 1999. *Embelia ribes* – a medicine for influenza. Indian Forester 45: 210.

Mhaskar M, Joshi S, Chavan B, Joglekar A, Barve N and Patwardhan A. 2011. Status of *Embelia ribes* Burm f. (Vidanga), an important medicinal species of commerce from northern Western Ghats of India. Current Science 100(4): 547-552.

Mitra M. 1995. 'Vidanga' (*Embelia ribes*) - an Ayurvedic drug can help family planning. Applied Botany Abstracts 15(4): 267-82.

Myers N, Mittermeier R, Mittermeier C, Da Fonseca G and Kent J. 2000. Biodiversity hot-spots for conservation priorities. Nature 403: 853-858.

Narang GD, Garg LC and Mehta RC. 1961. Preliminary studies on antibacterial activity of *E. ribes* (myrisinaceae). J. Vet. Anim. Husbandry 5(1): 73–79.

Paranjpe P and Kulkarni PH. 1995. Comparative efficacy of four Ayurvedic formulations in the treatment of acne vulgaris - A double-blind randomised placebo-controlled clinical trial. Current Research on Medicinal and Aromatic Plants. 343-347.

Prasertsang P and Chavasiri W. 2003. Bioactive phenolic lipids from the fruits of *Ardisia colorata* Roxb. In 29th Congress on Science and Technology of Thailand.

Prashanth D, Padmaja R and Samiulla DS. 2001. Effect of certain plant extracts on alpha- amylase activity. Fitoterapia 72(2): 179-181.

Purandare TV, Kholkute SD, Gurjar A, Joshi UM, Dattatreyamurthy B, Sheth AR, Sheth XR, Swamy XR, Yayaraman S and Munshi SR. 1979. Semen analysis and hormonal levels in bonnet macaques administered *Embelia ribes* berries, an indigenous plant having contraceptive activity. Ind. J Exp. Biol 17: 935-936.

Raghu AV, Geetha SP, Martin G, Balachandran I and Ravindran PN. 2006. Direct shoot organogenesis from leaf explants of *Embelia ribes* Burm. f.: a vulnerable medicinal plant. Journal of Forest Research 11(1): 57-60.

Rajakumar N and Shivanna MB. 2010. Traditional herbal medicinal knowledge in Sagar Taluk of Shimoga district, Karnataka, India. Indian Journal of Natural Products and Resources 1(1): 102-108.

Rao IG and Singh DK. 2001. Combinations of *Azadirachta indica* and *Cedrus deodara* Oil with Piperonyl Butoxide, MGK-264 and *Embelia ribes* against *Lymnaea acuminata*. Chemosphere 44: 1691-1695.

Rao TVP and Venkateswarlu VV. 1965. Some natural and synthetic methyl bisbenzoquinones. Bull. Natl. Inst. Sci. India 28: 14.

Rathi SG, Bhaskar VH and Patel PG. 2010. *In-Vitro* Anti-fungal Screening of *Embelia ribes* Plant Extract through EUCAST Method. International Journal of Pharma Sciences and Research 1(2): 134-138.

Ravikumar K and Ved DK. 2000. Illustrated field guide of 100 red listed medicinal plants of conservation concern in southern India. Foundation for Revitalisation of Local Health Traditions, Bangalore.

Retuer S, Prasad S, Phromnoi K, Kannappan R, Yadav VR and Agarwal BB. 2010. Embelin suppresses osteoclastogenesis induced by receptor activator of NF-êB ligand and tumor cells *in vitro* through inhibition of the NF-êB Cell signaling pathway. Mol. Cancer. Res. 8(10): 1425-36.

Satyavati GV. 1984. Indian plants and products with antifertility effects (A review of literature between 1975-1982. Ancient Sci Life 3 (Suppl 4): 193-202.

Seth SD, Johri N and Sundaram KR. 1982. Antispermatogenic effect of Embelin from *Embelia ribes*. Indian J. Pharmacol 14: 207–211.

Shah CS and Khanna PN. 1961. Pharmacognostic comparison of *Embelia ribes* Burm. and E. robusta C. B. Clarke fruits. The Indian Journal of Pharmacy 23(10): 275-276.

Shah NK. 1971. A Study of an Indigenous Drug, Maswin as an Oral Contraceptive. Curr. Med. Pract 15(2): 614-616.

Sharma GK. 1997. Ethnomedicinal flora: Ayurvedic system of medicine in a remote part of the Indo-Tibetan Himalayas. Journal of the Tennessee Academy of Science 72(3-4): 53-55.

Sharma PC, Yelne MB and Dennis TJ. 2002. Database on medicinal plants used in Ayurveda. CCRAS 478–489.

Sharma RS, Rajalakshmi M and Jeyaraj DA. 2001. Current status of fertility control methods in India. J. Biosci 26(4): 391-405.

Singh A and Singh DK. 2001. Molluscicidal activity of *Lawsonia inermis* and its binary and tertiary combinations with other plant derived molluscicides Ind. J. Exp. Biol 39: 263-268.

Singh D, Singh R, Singh P and Gupta RS. 2009. Effects of Embelin on Lipid Peroxidation and Free Radical Scavenging Activity against Liver Damage in Rats. Basic Clin Pharmacol Toxicol

Singh IP, Bharate SB, Singh A and Bhutani KK. 2007. Fate of Embelin in Pippalyadi Yoga, an Ayurvedic oral contraceptive Structure of Embelin borax complex and evaluation of anti-fertility activity. Indian Journal of Chemistry 46(B): 320-325.

Sreepriya M and Bali G. 2005. Chemopreventive effects of embelin and curcumin against N, nitrosodiethylamine/phenobarbital, induced hepatocarcinogenesis in Wistar rats. Fitoterpia 76: 549-555.

Srivastava RK, Singh RC, Bharadwaj SK, Kapoor KN, Sharma MK and Munna Lal MD. 1988. A Comparative Study of Antidiarrhoeal Drugs most commonly used - Allopathic, Ayurvedic and Homeopathic Drugs 3: 181-184.

Suthar M, Patel R, Hapani K and Patel A. 2009. Screening of *Embelia ribes* for Antifungal Activity. International Journal of Pharmaceutical Sciences and Drug Research 1(3): 203-206.

Tabassum N and Agarwal SS. 2003. Hepatoprotective activity of *Embelia ribes* against paracetamol induced hepatocellular damage in mice. JK-Practitioner 10(1): 43-44.

Talbot WA. 1911. Forest flora of the Bombay Presidency and Sind. Bishensingh Mahendra Pal Singh, Dehradun Vol 2. 146-147.

Tambekar DH, Khante BS, Chandak BR, Tltare AS, Boralkar SS and Aghadte SN. 2009. Screening of antibacterial potentials of some medicinal plants from Melghat forest in India. Afr. J. Trad. Complementary and Alternative Medicines 6(3): 228-232.

Tipu MA, Akhtar MS, Anjum MI and Raja ML. 2006. New Dimension of Medicinal Plants as animal feed. Pakistan Vet. J 26(3): 144-148.

Ved DK and Goraya GS. 2007. Demand and Supply of Medicinal Plants in India. NMPB, New Delhi and FRLHT, Bangalore, India.

Warrier PK, Nambiar VPK and Rarnankutty C. 1994. Indian Medicinal Plants, Orient Longman, Hyderabad, India 1(4).

Zutshi U, Johri RK and Atal CK. 1989. Possible interaction of potassium embelate: A putative analgesic agent, with opiate receptors. Ind. Journal of Experimental Biology 27: 656-657.