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Phytochemistry, pharmacological activities and traditional uses of *Emblica officinalis*: A review

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ABSTRACT
From the ancient time, plants have been playing a key role for the betterment of mankind presenting as an extraordinary source of natural medicine. The complexity in formulating chemical based drugs as well as their health related side effects and uprising cost has led worldwide researchers to focus on medicinal plant research. Bangladesh has a vast repository of diverse plant species where about five thousand plants species have been claimed as having significant medicinal values. The researched papers on medicinal plants publishing from last few decades mention the activities of different plant bioactive compounds that are used widely in the treatment of various human ailments. *Emblica officinalis* is reported to possess bioactive compounds like tannins, flavonoids, saponins, terpenoids, ascorbic acids and many other compounds which are confirmed to have diverse pharmacological activities like antimicrobial, antioxidant, anti-inflammatory, radio-protective, hepatoprotective, antitissuive, immunomodulatory, hypolipedemic and many other activities. This medicinal plant is also reported to have anticancer, anti HIV-reverse transcriptase, antidiabetic, antidepressant, antiulcerogenic, wound healing activities and so forth. The current review paper summarizes the phytochemical constituents, pharmacological activities and traditional uses of the plant *Emblica officinalis*.

***Key Words*:** Euphorbiaceae, Amla, Bangladesh.

INTRODUCTION

Emblica officinalis Gaertn. (Family–Euphorbiaceae) also known as *Phyllanthus emblica*, is commonly known as 'Amla' or 'amlaki' in Bengali and 'Indian gooseberry' in English. This species is medium sized deciduous tree with 8-18 meters height and is native to tropical southeastern Asia, particularly in central and southern India, Pakistan, Bangladesh, Sri Lanka, southern China, the Mascarene Islands and Malaysia (Table 1). In India, Amla trees are found throughout the forests of tropical area ascending up to 4500 ft on hills (Rai *et al*., 2012; Thilaga *et al*., 2013). Amla is rich in fiber, carbohydrate, iron and is reported as the richest source of vitamin C (Singh *et al*., 2011) (Table 2). The fruit is also used in a combination form known as Triphala meaning three fruits which is a Thai traditional herbal formulation composed of *Emblica officinalis, Terminalia belerica* and *Terminalia chebula* (Phetkate *et al*., 2012).

Many herbal and patent drugs have been formulated by the constituents of this plant (Rai *et al*., 2012). *E. officinalis* primarily contains tannins, flavonoids, phenolic compounds, saponins, terpenoids, ascorbic acids, carbohydrates and many other compounds (Khan, 2009). Supplements of fresh amla fruit is very favorable to individuals suffering from anemia. The juice of fresh amla fruit is given as diuretic, anti-bilious remedy and as a tonic. It is also helpful in over thirst, dyspepsia, burning sensation and other complaints of digestive system (Kumar *et al*., 2012b).

Taxonomy

Taxonomical classification of *E. officinalis* is summarized in table 3.

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PHYTOCHEMISTRY

This herb has many bioactive compounds including apigenin, gallic acid, ellagic acid, chebulinic acid, quercetin, chebulagic acid, corilagin, isostrictiniin, methyl gallate, luteolin and so on. Emblicanin A, emblicanin B, phyllaemblicin B, punigluconin and pedunculagin are tannins present in *Emblica officinalis* (Table 4). Glutamic acid, proline, aspartic acid, alanine, and lysine are 29.6%, 14.6%, 8.1%, 5.4% and 5.3% respectively of the total amino acids. The pulpy portion of fruit, dried and freed from the nuts contains: gallic acid 1.32%, tannin, gum 13.75%; albumin 13.08%; crude cellulose 17.08%; mineral matter 4.12% and moisture 3.83%. Amla fruit ash contains chromium, 2.5 ppm; zinc 4 ppm; and copper, 3 ppm (Kumar *et al*., 2012a). Nickel and lead metals were not found in leaves of *Emblica officinalis*. The level of copper was found higher in the sample leaves of *Emblica officinalis* followed by chromium, manganese and zinc (Kumar *et al*., 2013). Chemical constituents from different plant parts of are illustrated below:

Leaves: It contains gallic acid, chebulic acid, ellagic acid, chebulinic acid, chebulagic acid, amlic acid, alkaloids phyllantine and phyllantidine (Khan, 2009).

Seeds: A fixed oil, phosphatides and a small quantity of essential oil. The fixed oil (acid value 12.7; saponification value 185; iodine value 139.5; acetyl value 2.03; unsaponifiable matter 3.81%; sterol 2.70% ; saturated fatty acid 7%. Contains linolenic acid (8.78%), linoleic (44%). oleic (28.40%), steric (2.15%), palmitic (2.99%) and miristic acid (0.95%) (Khan, 2009).

Barks: Contain leukodelphinidin, tannin and proanthocyanidin (Khan, 2009).

Roots: Contain ellagic acid and lupeol (Khan, 2009).

Table 1: Botanical description of *E. officinalis*.

Feature	Description	Reference
Habitat	Central and southern India, Pakistan, Bangladesh, Sri Lanka, Malaysia, southern China, the Mascarene Islands, South East Asia and Uzbekistan.	Rai *et al*., 2012; Thilaga *et al*., 2013; Khan, 2009
Appearance	Medium sized deciduous tree, 8-18 meters height with thin light grey bark exfoliating in small thin irregular flakes.	Meena *et al*., 2010
Used parts	Dried fruits, fresh fruit, seed, leaves, root bark, flowers.	Khan, 2009; Kumar *et al*., 2012b
Leaves	Simple, sub sessile, closely set along the branchlets, light green having the appearance of pinnate leaves.	Meena *et al*., 2010
Fruits	15-20 mm long and 18-25 mm wide, nearly spherical or globular wider than long and with a small and slight conic depression on both apexes. Mesocarp is yellow and endocarp is yellowish brown in ripened condition	Khan, 2009
	Globose, fleshy, pale yellow with six obscure vertical furrows enclosing six trigonous seeds in 2-seeded 3 crustaceous cocci.	Meena *et al*., 2010
	Seedlings start bearing fruits in 7-8 years after planting, while the budded clones will start bearing fruits from the 5th year onwards.	Kumar *et al*., 2012a
	Fresh fruits are light green and ripe fruits turn light brown in colour. The average weight of the fruit is 60 -70 g.	Kumar *et al*., 2012b
Flowers	Greenish yellow, in axillary fascicles, unisexual, males numerous on short slender pedicels, females few, sub sessile, ovary 3-celled.	Meena *et al*., 2010; Rai *et al*., 2012
Seeds	Four-Six, smooth, dark brown	Khan, 2009
Barks	Thick to 12 mm, shining grayish brown or grayish green	Khan, 2009
Flowering and fruiting	February - May and December - January	Rai *et al*., 2012
Edible part	Mesocarp and endocarp that forms the hard stone which encages the seed	Patel and Goyal, 2011

PHARMACOLOGICAL INVESTIGATIONS

Antibacterial activity

Antibacterial activities of different solvent extracts and isolated compounds from *Emblica officinalis* are shown in table 5.

Antifungal activity

Antifungal property of *E. officinalis* was reported against *Aspergillus* (Satish *et al*., 2007). Fruit ethanol and acetone extracts showed moderate activity against *Fusarium equiseti* and *Candida albicans* where Grisofulvin was used as standard antibiotic (Hossain *et al*., 2012). Plant methanolic extract of *E. officinalis* did not show antifungal activity against phytopathogenic fungi *Aspergillus niger* F2723 (Bobbarala *et al*., 2009).

Antioxidant and free radical scavenging activity

Galic acid equivalent as total phenolic content from fruit and seed of *E. officinalis* has excellent antioxidant properties and play an important role as free radical scavengers required in the maintenance of "redox homeostasis" responsible for diverse degenerative diseases (Prakash *et al*., 2012). The methanolic seed extract of *Emblica officinalis* has promising free radical scavenging activity of 1,1, Diphenyl-2-picryl-hydrazil (DPPH) in a concentration dependant manner (Priya *et al*., 2012). Methanolic extract of fruit pulp also have antioxidant and free radical scavenging activity (Mehrotra *et al*., 2011; Liu *et al*., 2008a; Liu *et al*., 2008b, Hazra *et al*., 2010, Majumdar *et al*., 2010). Methanolic extracts of dried leaves of *Phyllanthus emblica* was used for the comparative study of antibacterial and antioxidant activity and the research work was ended positively showing the extract has both these activities (Shivaji *et al*., 2010). In a separate research work, it is seen that the water extract of *E. officinalis* fruit prepared according to Thai Herbal Pharmacopoeia has a strong potential for free radical scavenging, ferric reducing as well as inhibiting ROS (reactive oxygen species) production (Charoenteeraboon *et al*., 2010).

Insecticidal activity

Saponins which are important constituents of *E. officinalis* have insecticidal or cytotoxic properties to certain insects (Chaieb, 2010). Although saponins which had shown insecticidal activity was collected from natural sources other than *E. officinalis*. But as saponins are bioactive compounds found in *E. officinalis* too, it is obvious that *E. officinalis* might have insecticidal activity and further evaluation can be conducted to get more precise evaluation.

Larvicidal and mosquitocidal activity

In a mosquitocidal property evaluation test Murugan *et al.* (2012) observed larvicidal and pupicidal activities of methanol extract of *E. officinalis* against the malarial vector, *Anopheles stephensi* showing 98% mortality rate at 100 ppm. The ethanol and methanol extracts of *E. officinalis* also exerted 100% mortality (no hatchability) at 400 ppm and above (Murugan *et al*., 2012). Jeyasankar *et al.* (2012)

Table 2: Nutritional value of *Emblica officinalis* (redrawn from Singh *et al*., 2011).

Chemical components	Percentage
Fruits: Moisture	81.2%
Protein	0.5%
Fat	0.1%
Mineral matter	0.7%
Fiber	3.4%
Carbohydrate	14.1%
Bulk elements Mg/100g	Net weight
Calcium	0.05%
Phosphorus	0.02%
Iron	1.2 mg/100g
Vitamin C	600 mg/100g
Nicotinic acid	0.2 mg/100g

Table 3: Taxonomical classification of *E. officinalis*.

Kingdom	Plantae (Plants)
Subkingdom	*Tracheobionta* (Vascular plants)
Superdivision	*Spermatophyta* (Seed plants)
Division	Angiospermae (Flowering plants)
Class	Dicotyledonae (Dicotyledons)
Subclass	Rosidae
Order	Geraniales
Family	Euphorbiaceae
Genus	*Emblica*
Species	*officinalis* Geartn.

reported that the larvicidal activity of *Phyllanthus emblica* ethyl acetate leaf extracts. The study concluded that the ethyl acetate extract of *P. emblica* exhibited the maximum larvicidal activity (99.6%) with LC50 (lethal Concentration brings out 50% mortality) value of 78.89 ppm against the larvae of *Aedes aegypti* (Jeyasankar *et al*., 2012).

Antidepressant activity

Pemminati *et al.* (2010) has checked the antidepressant activity of aqueous extract of fruits of *E. officinalis* in inbred adult male Swiss Albino mice weighing 25-30g. The test was carried out by forced swim test (FST) and tail suspension test (TST). The result of this test showed the antidepressant activity of *E. officinalis* as comparable to the of standard antidepressant drug imipramine.

Immunomodulatory activity

Reports suggest that triphala can stimulate the neutrophil functions in the immunized albino rats (Srikumar *et al*., 2005). There was considerable dose dependent raise in haemagglutination antibody titre, macrophage migration index, hypersensitivity reaction, respiratory burst activity of the peritoneal macrophages, total leukocyte count, percentage lymphocyte distribution, serum globulin and relative lymphoid organ weight in *Emblica* treated albino mice indicating its ability to stimulate humoral and cell mediated immunity along with macrophage phagocyte (Suja *et al*., 2009).

Anti-inflammatory activity

E. officinalis showed anti-inflammatory activities in carrageenan induced acute and cotton pellet induced chronic inflammation in Sprague-Dawley rats by reducing paw volume in acute inflammation and by decreasing cotton pellet induced granulomas tissue lipid peroxidation, the granulomatous tissue mass, myeloperoxidase activity and plasma extravasation in chronic inflammatory condition (Muthuraman *et al*., 2011). *E. officinalis* water extract has reported to have inhibitory effect on the synthesis and release of inflammatory mediators in rats (Jaijoy *et al*., 2010).

Radioprotective activity

It has been reported that mice treated with *Emblica officinalis* extract before exposure to different doses of gamma radiation can reduce the severity of symptoms of radiation sickness and mortality (Singh *et al*., 2006). Similar delayed onset of mortality and reduction in the symptoms of radiation sickness in mice were seen in consecutively triphala treated mice before irradiation when compared with the non-drug treated irradiated controls (Jagetia *et al*., 2002).

Hypolipidemic activity

Amla fruit have been reported to have significant anti-hyperlipidemic, hypolipidemic, and anti-atherogenic effect (Santoshkumar *et al*., 2013). Treatment with *Emblica officinalis* caused significant reduction of Total Cholesterol (TC), Low Density Lipoprotein (LDL), triglyceride (TG) and Very Low Density Lipoprotein (VLDL), and a significant increase in High Density Lipoprotein (HDL) levels in patients with type II hyperlipidemia. Both treatments from *E. officinalis* and simvastatin produced significant reduction in blood pressure; however, this beneficial effect was more marked in patients receiving *E. officinalis* (Gopa *et al*., 2012). Histopathological study of thoracic aorta of *Emblica officinalis* treated group has shown decrease in atherogenicity compared to untreated high cholesterol diet fed rats. The data demonstrated that *Emblica officinalis* formulation was associated with hypolipidemic effects on the experimentally induced hypercholesteremic rats (Kumar and Kalaivani, 2011). It is also seen that *E. officinalis* treated rat showed more hypoglycemic and hypolipidemic activity than *Phyllanthus acidus* treated diabetic rats (Modilal and Pitchai, 2011).

Cytotoxic effects

To evaluate the immunostimulatory and side effects of Triphala in a clinical phase I, all the volunteers took Triphala for two weeks (3 capsules per day). As complete physical examinations, routine laboratory analysis and immunological studies were performed before ingestion and after initial meeting for 4 consecutive weeks. The result revealed significant immunostimulatory effects on cytotoxic T cells (CD3−CD8+) and natural killer cells (CD16+CD56+). Both of them increased significantly when compared with those of the control samples. However, no significant change in cytokine secretion was detected. All volunteers were healthy and showed no adverse effects throughout the duration of the study (Phetkate *et al*., 2012). Flavonoids, a group of essential bioactive secondary metabolites of *Emblica officinalis*, were evaluated for antioxidant potential, cytotoxicity and intestinal absorption. The research concluded that flavonoids from *E. officinalis* and some other medicinal plants hold a good prospective as nutraceutical & chemotherapeutics agents because of their antioxidant potential, no cytotoxicity and good intestinal absorptive property (Sharma *et al*., 2010). But it is confirmed that the chloroform soluble fraction of the ripe fruits of Amlaki containing alkaloids have both antimicrobial and cytotoxic activity (Rahman *et al*., 2009).

Anti-diabetic and hypoglycemic activity

Herbal formulations prepared by extracts of *Tinospora cordifolia*, *Trigonella foenum* and *Emblica officinalis* were

Table 4: Properties, functions and some common sources of bioactive compounds isolated from *E. officinalis*.

Compound names	Molecular formula	Molecular weight	BP/ MP	Biological activity	Common sources	References
Chebulinic acid	$C_{41}H_{32}O_{27}$	956.67 gm/mol	1460°C at 760 mmHg (BP)	Antioxidant activity, Anti-secretory and cryo-protective activity	*Phyllanthus emblica, Terminalia arborea, and T. chebula*	Baliga and Dsouza, 2010; Mishra, 2013
Chebulagic acid	$C_{41}H_{30}O_{27}$	954.66 gm/mol	1610.6°C at 760mmHg (BP)	Antispasmodic action	*E. officinalis, Terminalia Chebula, T. citrine, T. catappa*	Reddy *et al*., 2009 Chen and Li, 2006
Emblicanin-A	$C_{34}H_{22}O_{22}$	<1,000 gm/mol	Not con-firmed	Antioxidant activity	*E. officinalis*	Madhuri *et al*., 2011
Emblicanin-B	$C_{34}H_{22}O_{22}$	<1,000 gm/mol	Not con-firmed	Antioxidant activity	*E. officinalis*	Madhuri *et al*., 2011
Gallic acid	$C_7H_6O_5$	170.12 gm/mol	252° C (MP)	Radioprotective effect, chemopre-ventive effect, anti-carcinogenic, antioxidative, antimutagenic, anti-allergic and anti-inflammatory activities.	*E. officinalis; T chebula; T bellerica, C sinensis L., Arctostaphylos uva-ursiL., C avellana, O biennis, V viniferaL.*	Baliga and Dsouza, 2010; Vazirian *et al*., 2011; Negi *et al*., 2005; Karamaæ *et al*., 2006
Ellagic acid	$C_{14}H_6O_8$	302 gm/mol	≥350 °C (MP)	Radioprotective and chemopreven-tive effect, antityrosinase Activity, antioxidant, antiproliferative, and antiatherogenic Properties, estrogenic/antiestrogenic Activity	*E. officinalis, Castanea sativa, Euca-lyptus camaldulensis, Juglans regia*	Baliga and Dsouza, 2010; O¨zer *et al*., 2007; Papoutsi *et al*., 2005
Quercetin	$C_{15}H_{10}O_7$	302.24 gm/mol	316.5 °C (MP)	Radioprotective, chemopreventive, hepato protective effect	*E. officinalis*	Baliga and Dsouza, 2010; Madhuri *et al*., 2011
Phyllantine	$C_{14}H_{17}NO_3$	247.29 gm/mol	Not con-firmed	Not confirmed	*E. officinalis*	Khan, 2009
Phyllantidine	$C_{13}H_{15}NO_3$	233.2631 gm/mol	Not con-firmed	Neuropharmacological activity (CNS activity)	*E. officinalis, P. discoides; Seurinega suffruticosa*	Khan, 2009; Beutler et al., 1985
Punigluconin	$C_{34}H_{26}O_{23}$	802.556 gm/mol	1448.6°C at 760 mmHg (BP)	Antioxidant activity	*E. officinalis*	Bhattacharya *et al*., 1999
Pedunculagin	$C_{34}H_{24}O_{22}$	784.54 gm/mol	1578.039 °C at 760 mmHg (BP)	Antitumor activity, Antioxidant activity	*E. officinalis*	Chang *et al*., 1995; Bhattacharya *et al*., 1999

evaluated for hypoglycemic effects and Oral Glucose Tolerance Test (OGTT) in normal and Alloxan induced diabetic rats and significant, marginal and very less decrease in blood glucose level was observed when different herbal combinations were used (Deep *et al*., 2011).

The polyherbal combination of extracts *E. officinalis* (fruit), *Momordica charantia* (fruit) and *Trigonella foenum-graecum* (leaves and seeds) had shown synergistic activity, as the glucose levels were decreased more significantly by the combination of extracts compared to the individual extract when used separately in streptozotocin induced diabetic rats (Satyanarayana *et al*., 2010). The aqueous fruit extract of *Phyllanthus emblica* was evaluated on type-II diabetes, triglycerides (TG) and liver-specific enzyme, alanine transaminase (ALT). This study showed that in a dose of 200mg/kg body weight the aqueous fruit extract can significantly reduce the blood glucose level in alloxan-induced diabetic rats (Qureshi *et al*., 2009). Another study reports that *Phyllanthus emblica* treated rat showed more hypoglycemic and hypo lipidemic activity than *Phyllanthus acidus* treated diabetic rats when the effect of orally administered aqueous extracts (350 mg/kg body weight) of fruits of *Phyllanthus emblica* and *Phyllanthus acidus* on serum glucose, glycosylated hemoglobin, insulin, cholesterol, triglycerides, HDL-cholesterol, protein, urea and creatinine were examined in control and extract-treated diabetic rats (Modilal and Pitchai, 2011).

Hepato-protective activity

The histopathological study of liver cells of rats was examined by administering *E. officinalis* as a preventative agent to reduce paracetamol induced hepatotoxicity and it has been observed that fruit extract has the ability to rectify toxicity or hepatic damage (Malar and Bai, 2009). Another histological study was undertaken to demonstrate the protective effect of 50% hydroalcoholic extract of the fresh fruit of *E. officinalis* against chronic toxicity induced by carbon tetrachloride and thioacetamide in rats. From the liver sections of the tested rats, it was observed that *E. officinalis* reversed the abnormal histopathology by accelerating the regenerative activity and in a few cases, the hepatocytic injury was found negligible in *E. officinalis* treated group of rats (Mir *et al*., 2007).

Anti-cancer and anti-proliferative activity

E. officinalis exhibits its anticancer activities through inhibition of activator protein-1 and targets transcription of viral oncogenes responsible for development of cervical

Table 5: Antibacterial activity of deferent solvent extracts and isolated compounds from *Emblica officinalis*.

Used extracts/ other compounds	Used organisms	Extract conc.	Max. zone of inhibition (mm)	Organism(s) showed highest activity	Extract or extract conc. showed highest activity	Reference
Ethanol, Acetone (Fruit extract)	*V. cholerae, S. aureus, P. aeruginasa, B. subtilis, Shigella dysenteriae, S. pyogenous, E. coli, B. megaterium*	0.5 mg/disc	12.7	*Shigella dysenteriae*	Ethanol	Hossain *et al*., 2012
Hexane, Chloroform, Methanol (Fruit extract)	*E. coli, K. pneumoniae, P. vulgaris, M. luteus, B. subtilis, E. faecalis, S. faecalis*	50 mg/ml 100 mg/ml	34 36	*E. faecalis* *E. faecalis, K. pneumoniae*	Methanol	Jyothi and Rao, 2011
Petroleum ether, Chloroform, Alcohol (Fruit extract)	*E. coli, P. aeruginosa, S. aeruginosa, S. aureus, B. subtilis*	10 mg/ml 20 mg/ml	12 22	*S. aureus* *S. aureus*	Alcohol	Dhale and Mogle, 2011
Methanolic seed extract	*E. coli, S. aureus, K. pneumoniae, P. aeruginosa, Enterococcus*	50 mg/ml 100 mg/ml 150 mg/ml 200 mg/ml	14 17 18.5 21	*P. aeruginosa* *E. coli* *S. aureus* *S. aureus*	200 mg/ml extract conc.	Priya *et al*., 2012
Polar flavanoides (Leaf extract)	*P. vulgaris, S. aureus, E. coli, S. typhi*	100 mg/ml 500 mg/ml 1000 mg/ml	17 18 19	*S. typhi* *S. aureus, E. coli, S. typhi* *E. coli, S. typhi*	No significant differences	Bansod, 2012
Non-polar flavanoides (Leaf extract)	*P. vulgaris, S. aureus, E. coli, S. typhi*	100 mg/ml 500 mg/ml 1000 mg/ml	16 19 19	*S. aureus, E. coli* *E. coli* *P. vulgaris*		
Tannin (isolated from leaves of *E. officinalis*)	*E. coli, Pseudomonas aeruginosa, B. subtilis, Shigella boydii, Shigella flexneri, S. aureus, S. epidermidis*	0.5 mg/ml 1 mg/ml 1.5 mg/ml 2 mg/ml 2.5 mg/ml 3 mg/ml 3.5 mg/ml 4 mg/ml 4.5 mg/ml 5 mg.ml	Negligible 4.2 8.5 9.5 10.7 11.5 12.9 15.2 17.9 18	NA *S. subtilis* *E. coli, S. subtilis* *E. coli* *E. coli* *E. coli* *E. coli* *E. coli* *E. coli* *E. coli*	5 mg/ml	Shinde *et al*., 2010
Tannin (isolated from fruits of *E. officinalis*)	*E. coli, Pseudomonas aeruginosa, B. subtilis, Shigella boydii, Shigella flexneri, S. aureus, S. epidermidis*	0.5 mg/ml 1 mg/ml 1.5 mg/ml 2 mg/ml 2.5 mg/ml 3 mg/ml 3.5mg/ml 4 mg/ml 4.5 mg/ml 5 mg.ml	Negligible Negligible 2.2 3.1 5.3 6.2 6.8 8.3 8.3 10.1	*NA* *NA* *E. coli* *E. coli* *E. coli* *E. coli* *E. coli* *S. boydii* *S. boydii* *E. coli*	5 mg/ml	Shinde *et al*., 2010

cancer thus demonstrating its potential efficacy for treatment of human papillomavirus-induced cervical cancers (Mahata *et al*., 2013).

An in vitro cytotoxicity was performed against five human cancer cell lines and the activity was done using 100µg/ml of the ethanolic whole plant extract of *E. officinalis*. Against lung (A-549) cell line plant extract showed 82% growth inhibition. In case of liver cell line (Hep-2), it showed no activity, whereas in colon 502713 cell line, the plant extract displayed maximum activity. In case of IMR-32 neuroblastima cell line and HT-29 liver human cancer line, the plant extract showed 97% and 98% activity, respectively (Verma *et al*., 2012). *E. officinalis* fruit extract at 50–100 µg/mL can significantly inhibit cell growth of six human cancer cell lines, A549 (lung), HepG2 (liver), HeLa (cervical), MDA-MB-231 (breast), SK-OV3 (ovarian) and SW620 (colorectal). (Ngamkitidechakul *et al*., 2010). HepG2 and A549 cells were treated with *P. emblica* and *T. bellerica* extracts alone or in combination with doxorubicin or cisplatin and effects on cell growth were determined using the sulforhodamine B (SRB) assay. Both the plant extracts demonstrated growth inhibitory activity against the two cancer cell lines tested (Pinmai *et al*., 2008). Studies also demonstrated that *amla* extracts are cytotoxic and restrain the in vitro proliferation of some tumor cell lines such as MK-1 (human gastric adenocarcinoma) and B16F10 (murine melanoma) (Zhang *et al*., 2004).

HIV-reverse transcriptase inhibitory activity

Inhibition of HIV-Reverse Transcriptase (HIV-RT) by *P. emblica* plant extract fractions was tested on Peripheral Blood Mononuclear Cells. From this test it was observed

Table 6: Traditional uses of *Emblica officinalis*.

Used part	Preparation/Administration	Dose	Activity	Treatment	References
Fruit	The fruit or fresh fruit is pickled or pre-served in sugar. Used when dry.	One or two fruits daily	Laxative	Constipation	Kumar *et al*., 2012b; Baliga and Dsouza, 2010
Leaves, fresh fruit, seed	Decoction of leaves or decoction of seed, dried grapes and sugar (for gargling) or decoction of fresh fruit and compounds containing equal part of Emblica seed, chitrak root, chebulic myrobalan and pipli is given.	Not confirmed	Refrigerant and aperient	Fever	Kumar *et al*., 2012b; Patel and Goyal, 2011; Srivasuki, 2012
Fruit	Tablespoon of juice is mixed with a cup of bitter gourd juice	taken daily for two months	Antidiabetic activity	Diabetes, eye complication in diabetes	Kumar *et al*., 2012a; Singh *et al*., 2011
Fruit, bark, root, leaves	Fruit decoction is mixed with sour milk or, bark partakes of the astringency of the fruit. Decoction and evaporation of the root solution produces an astringent extract equal to catechu. An infusion of the leaves with fenugreek seed is also given.	Not confirmed	Anti-diarrheal activity	Diarrhoea, chronic diarrhea	Kumar *et al*., 2012b; Srivasuki, 2012
Root, leaves, node	10 gm roots are taken and ground.	Taken twice after meal per day.	Pain killing, anti-inflammatory activity	Dental problems	Kumar *et al*., 2012b; Srivasuki, 2012
	Leaves are squeezed and the juice extracted	A few drops of juice is put in the ear			
	Grind the node and mix it with water. After vigorous stirring it is filtered through a cloth. Water drop is given to right ear left sided teeth are in pain and vice versa.	Only few drops			
Bark	The juice of the bark combined with honey and turmuric is given	Not confirmed	Antimicrobial activity	Gonorrhoea	Kumar *et al*., 2012b; Srivasuki, 2012
Fruit	Fresh fruits or crushed fruits	Not confirmed	Growth promoting effects	Hair growth	Singh *et al*., 2011; Patel and Goyal, 2011;
Fruit	A paste of the fruit is a useful application to	Not confirmed	Headache, nausea or vomiting inhibitory effect	Cephalalgia (headache)	Kumar et al., 2012b; Patel and Goyal, 2011
Leaves, root bark	Decoction of the leaves or root bark mixed with honey is applied to inflammations of the mouth	Not confirmed	Anti-inflammatory, bactericidal activity	Treatment of aphthae or aphthous stomati-tis	Kumar *et al*., 2012b
Fruit	One teaspoonful of powder of the dry fruit mixed with two teaspoon full of jaggery	Taken twice daily for a month	Anti-rheumatic activity	Rheumatism	Kumar *et al*., 2012a

that aqueous fraction and n-hexane fraction have highest inhibition of recombinant HIV-RT (91% and 89%, respectively) at 1 mg/ml concentration. Chloroform fraction showed highest inhibition of HIV-RT at 0.5 mg/ml and carbon tetrachloride fraction at 0.12 mg/ml concentration. At 0.12 mg/ml and 0.5 concentrations 50% of the HIV-RT activity is inhibited in n-hexane fraction and carbon tetrachloride fraction respectively (Estari *et al*., 2012).

Anti ulcerogenic activity

The ethanolic extract of *E. officinalis* has found highly effective in controlling growth of *H. pylori in-vitro* with minimum inhibitory control ranging from 0.91 to 1.87 µg/µl. The result concluded that the plant ethanolic extract is well retained with total phenolics, reducing power, flavanoids and the antioxidant properties which make amla a proper remedial use against *H. pylori* infection and gastric ulcer (Mehrotra *et al*., 2011).

Antimutagenic and wound healing activity

An investigation on Swiss albino mice showed that 50% methanolic extract of Emblica fruit can protect mice against the chromosome damaging effects of the well-known mutagen cyclophosphamide (Agrawal *et al*., 2012). Ascorbic acid and tannins of *E. officinalis*, namely emblicanin A and emblicanin B have strong antioxidant action and it is proposed that the addition of these antioxidants support the repair process of cells. Emblica

increases cellular proliferation at the wound site, as supported by a raise in the action of extracellular signal-regulated kinase 1/2, along with an increase in DNA, type III collagen, acid-soluble collagen, aldehyde content, shrinkage temperature and tensile strength (Sumitra *et al*., 2009).

In vitro propagation

A simple and one step reproducible protocol was developed by Thilaga *et al*. (2013) for induction of high frequency somatic embryogenesis from juvenile leaf tissues of *Emblica officinalis* in vitro. Highest percentage of callus (67.5%) was obtained on media containing 0.45 µM 2, 4-dichlorophenoxyacetic in combination with 22 µM 6-benzylaminopurine. Somatic embryogenesis and plantlet regeneration of *Emblica officinalis* was performed by using *in vitro* germinated seeds derived cotyledon explants to produce proembryos directly in MS media (Al-Sabah *et al*., 2012). Another efficient protocol for in vitro shoot proliferation of *Emblica officinalis* has been evaluated by using nodal explants where MS medium was found the best for shoot proliferation (Goyal and Bhadauria, 2007).

TRADITIONAL USES

Traditionally *E. officinalis* have been used for the ailments of different diseases in different countries for ancient periods. Traditional uses of *E. officinalis* are summarized in table 6.

CONCLUSION

Amla or Indian gooseberry has been playing a significant role from ancient times in traditional medicine, Ayurveda and in tribal medicine. The major group of phytochemicals of like tannins, flavonoids, terpenoids, tannins and other polyphenolic compounds extracted from Amla has been screened for diverse biological and biopharmaceutical investigations from last few decades. Some important Amla phytochemicals like gallic acid, ellagic acid, emblicanin A, emblacani B, quercetin, phyllantine, phyllantidine and so forth have been confirmed as having different biological activities like antioxidant, antimicrobial, anti-inflammatory, antidiabetic, antitissuive, anti, radioprotective, chemopreventive, wound healing activities and so on. From the current investigation, it has seen that some bioactive compounds from *Emblica officinalis* are also common in other medicinal plant species. These phytochemicals extracted from other plants has been investigated for different bioscreening showing significant results but have not been researched from *Emblica officinalis* solvent extraction yet. Therefore, further evaluation of unexplored bioactive compounds of Amla, is needed which can reveal more and more new biological activities of this potent medicinal plant.

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