https://ijrps.com

ISSN: 0975-7538
Review Article

An insight of *spondias mangifera* willd: an underutilized medicinal plant with immense nutraceutical and therapeutic potentials

Muhammad Arif*[1], Md. Azizur Rahman[1], Mohammed Imran[2], Mohammad Khalid[1], Mohammad Khushtar[1]

[1]Faculty of Pharmacy, Integral University, Lucknow- 226026, Uttar Pradesh, India
[2]Department of Biosciences, Integral University, Lucknow- 226026, Uttar Pradesh, India

ABSTRACT

Spondias mangifera, is best known for its fruits in Indo-Malaysia region. The fruit contains about 25 percent juicy and edible pulp. The pulp is used as a common ingredient in culinary preparations like condiments, curries, jams, sherbet, beverages in the countries where the plant grows naturally. Green fruits from the plant are pickled in brine, which is the rich source of phenolic compounds, acids, minerals, flavonoids, sugars, vitamins and peptides. The ripe fruit is full of acids and micro- and macro- nutrients, which combine well with sugars, and used for the preparation of a variety of traditional highly energetic and refreshing drinks. It is considered nowadays as a valuable source for the development of several industrial products and of several unique products of the medicines against several diseases. Amara is relatively a new item to be explored for its full potential and it needs publicity and promotion in the international market. This review includes comprehensive information on traditional uses, chemical constituents, pharmacological actions and nutraceutical values of raw materials and processed products.

Keywords: Amara; Biological activities; Hog plum; Nutraceutical potentiality; Phytochemistry; Processed product; *Spondias mangifera*

INTRODUCTION

Illness management through medication has entered into an era of rapid development. In the past, almost all medicines used were from the plant origin. Kingdom plantae still constitutes many species containing many chemical constituents of medicinal and nutraceutical values which have yet to be discovered. Vegetables and fruits are 'treasure house' for nutritional compounds. Modern pharmaceutical industries require a large quantity of authentic plants for the manufacture of medicines. Extraction of active constituents and manufacture of medicine formulations are sophisticated technology and require capital intensive with attractive remunerations.

Spondias mangifera Willd (synonym *Spondias pinnata* Linn) belonging to family Anacardiaceae is a small woody and aromatic medicinal plant distributed in almost all regions of India. Different parts such as leaves, fruit, root and bark of the plant are being used in the treatment of various ailments and famed for its medicinal and nutraceutical values. It is a tree allied to *Mangifera*, commonly known as Wild mango, Bile-tree, Hog-plum or Amrata in Ayurvedic system of medicine (Anonyms, 2001). It is distributed widely in the tropics and abundantly in the eastern and northeast regions of India. It is a terrestrial coarse-gained, deciduous, woody and perennial tree up to 15-18 meter high with straight trunk and smooth grey colored bark having turpentine-like pleasant smell when broken or brushed of its wood (Anonyms, 1992). It is best adapted to the humid, hot and low land tropics. It may, although, be found up to an elevation of 1800 meter having life span of 20-30 years and grows in warm sub-tropical regions where no frost takes place or where only occasional light frost occurs. It grows best in well-drained fertile soil but can't grow in poorer soil even if it is supplied with adequate and proper nutrients (Morton et al, 1987). At present, Hog-plum is being cultivated in 34 countries, 12 in its native range (Daniel et al, 1986). It is conventionally propagated through vegetative cutting and seeds. However, it bears seeds during summer only and the frequency of germination of seeds is too low. It may be grown via seeds but vegetative propagation is preferred for superior selection. Rooting of cuttings of mature wood is the most widely used method. Large limbs are cut down from the tree and they are set directly in the ground where they grow if favorable atmospheric conditions are there. It flourishes in humid, tropical and sub-tropical areas. Young tree is set in larger holes to adequately accommodate a root system at a depth higher than the trees grew in the nursery (Killer and Barley, 2004). The tree is grown in full sun light for satisfactory production of fruits. The trees reaching to maturity are quite tolerated of drought and do not require any supplemental irrigation. Slight irri-

* Corresponding Author
Email: arif_sweet@rediffmail.com
Contact: +91-9918464963
Received on: 25-04- 2015
Revised on: 27-04-2015
Accepted on: 02-05-2015

gation is preferred for the establishment of young tree throughout the first year after planting (Chopra et al, 1992). Per year, one main crop is produced. The fruits mature from June through October. Fruits are generally harvested at any time of maturity for the preparations like pickles, condiments, etc., and harvested as determined by pulp softening and a change of external green colour to yellow. If fruit is ripened on the tree, satisfactory eating quality and better flavors are found. A single tree can provide a steady supply for a complete family from fall to mid-winter at a time when many other popular fruits are out of season. Its fruit is generally harvested by hand and often by shaking from the tree and picking up the fruits from the ground (Burkill, 1996; Umadevi and Daniel, 1998; Tripathi and Nishi, 2010; Hasan and Das, 2005; Narayan and Manandhar, 2002).

The leaves are compound and imparipinnate having 5-7 pairs of leaflets. The leaflets are eleptic, opposite, 9-13 cm long, 2-9 cm wide and oblong with oblique base, acuminate apex and entire margin. Stem is woody living over winter, arborescent, succulent, fleshy and hard in texture. Flowers are small 3.5 mm long, pedicilate, polygamous, bisexual, hypogamous, actinomorphic, complete, yellowish-green colour, scented and spreading terminal in dense panicles. Its fruit is drupe type, simple, succulent, fleshy, oblong or ovoid up to 4-5 cm in diameter and greenish yellow when ripe. Its pulp is soft, aromatic, acidic, stony, fibrous and semi-woody with many outside cavities, 1-5 celled and cells opening by cavities through the top of the stony-seeds. The bark is silvery grey colored with aromatic and pleasant smell of wood (Umadevi and Daniel, 1998). Ripened fruits are hard stone with sweet-sour, whilst unripen ones are sour. Ripened fruits are tonic aphrodisiac, refrigerant and cure ''vata'', biliousness, ulcer, phthisis, blood complaints and burning sensation (Anonyms, 2001). Ripened fruit juice is highly acidic and the richest source of vitamins, having nutraceutical potentials of a minor fruit of Assam. Immature fruits are acidic, rich in vitamins, nutrients preferred for pickle industry having high commercial values (Singh, 1997).

Almost all part of the tree has been traditionally used as medicine for the household remedies against several human diseases as documented in Indian systems of medicine such as Unani and Ayurveda (Kangilal and Das, 1984). It has also been investigated scientifically to confirm to its curative properties. The present review highlights its traditional uses, recent studies on the active compounds isolated from it, biological activities on its active constituents and its therapeutic effects. The information provided here may serve as a useful reference tool for the users of *S. mangifera* products.

TRADITIONAL USES

Green fruit of the plant is pickled in brine and used commonly in culinary preparations like condiments, jams, curries and sherbet in the countries where the plant grows naturally. Powdered ripened fruits of the plant are used as an antidote for the wounds done due to poison arrows and are also reported to have antitubercular property (Chopra et al, 1956). Mixture of tender fruit juice (10 g), black pepper powder (0.6-0.8 g) and sugar (50 g) is popular home remedy for biliousness (Nandkarni, 1976). Ripened fruit's juice (50 ml once daily) is given in the treatment of dysentery (Kumar and Rao, 1987). Ripened fruit boiled with sugar solution is used especially as food preparation, jams and for medicinal purposes (Northrup, 1994; Anonyms, 2000) which may be stored for numerous months without any remarkable alteration in its quality.

The bark is rubifacient and is being used in Indian indigenous medicine over painful joints. Its paste is utilized as an embrocation for the both articular and muscular rheumatisms. It is refrigerant, aromatic and astringent too which is given to prevent vomiting and is used in the treatment of dysentery and diarrhea (Kritikar and Basu, 1975). Paste with three bulb of garlic is given commonly twice a day for three consecutive days in stomach pain in Majidi area of Hazaribag district (Jain et al, 1977). Equal quantity of the bark juice and *Syzygium cuminii* Linn is prescribed as a home remedy for iarrhea and dysentery (Mahanta et al, 2006). Decoction of the root bark is given in regulating menstruation and in gonorrhea (Sharma, 2002; Pal and Jain, 2000). Malaysian and Indian tribal women use hot aqueous root extract internally for regulating menstrual anomaly and its paste externally as massage balm for remission of muscular pain.

Leaves are astringent, aromatic and acidic used as flavoring agent while their juice is used as drops against earache (Puri, 1983). The leaves and fruits are used for tenderization of the meat and to make it delicious (Macmillan, 1943).

The dark brown colored gum derived from it is used as demulcent, adhesive and fumigating agent (Benthall, 1993). It is also used in the treatment of infectious diseases such as bronchitis, dysentery, ulcer, diarrhea and skin diseases (Valsaraj et al, 1997; Melendez and Capriles, 2006).

PHYTOCHEMISTRY

Phytochemical analysis of leaf, fruit and stem bark of the plant revealed the presence of reducing sugars, phenolic compounds, flavonoids, glycosides, steroids, tannins and terpenoids (Arif et al, 2009; Arif and Fareed, 2010). The phytoconstituents cycloartanone-24-methylene, daucosterol, lignoceric acid, *β*-sitosterol, oleanolic acid, stigmast-4-en-3-one, *β*-amyrin and *β*-D-glucoside were isolated from the fruits and aerial parts of the plant (Tandon and Rastogi,

1976). Other constituents of the fruit are ascorbic acid, galloylgeranin, minerals like aluminum, calcium, iodine, iron, potassium, sodium, vitamins like riboflavin, niacin, amino acids like glycine, cystine, leucine, alanine and fibers (Rastogi and Mehrotra, 1970; Saxena and Singh, 1977). The stem bark contains minerals, ellagitannins and lignoceric acid glucosides of *β*-sitosterol (Tandon et al, 1993). Purified, acidic, homogeneous polysaccharide isolated from the gum exudates of the plant and its degraded products were found to contain D-galactose, D-galacturonic acid and L-arabinose (Ghoshal and Thakur, 1981). LC-MS/MS analysis of pale yellow coloured essential oil from the pulp of immature fruit revealed the presence of carboxylic acids and esters (gallic acid, salicylic acid, chlorogenic acid, 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid, ellagic acid, *p*-coumaric acid, tetradecanoic acid, ethyl-decanoate, ethyl-3-phenylpropenoate, hexadecanoic acid, methyl-14-methylpentadecanoate), alcohols (*cis*-3-hexenol, hept-5-en-2-ol, 9,12,15-octadecatrien-1-ol), aldehydes and ketone **(**furfural and 6,10,14-trimethyl-2-pentadecanone), isopropyl myristinate and aromatic hydrocarbons (1-methyl-4-propan-2-ylcyclohexa-1,3-diene) as the major compounds followed by monoterpenes and sesquiterpenes accountable for the flavor (Satpathy et al, 2011; Keawsa-ard et al, 2005; Saxena and Singh, 1976; Edeoga et al, 2005). Methanolic extract of the fruits contains 3-hydroxyolea-12-en-28-oic acid commonly known as oleanolic acid possessing antimicrobial activity against *Candida albicans, Escherichia coli, Bacillus subtilis* and *Staphyllococcus aureus* (Kandali and Konwar, 2011). A new triterpenoidal saponins known as echinocystic acid [3-O-*β*-D-pyrogalactopyranosyl (1→5)-O-*β*-D-xylofuranoside] was isolated from root of this plant (Saxena and Mukharya, 1997). The fruit of the plant indicated the nutritive and mineral potentials and possess food energy 189-203 kcal/g, crude fat 12.23-12.54%, crude protein 2.10%, crude fiber 33.13-34.03%, total carbohydrate 23.54-16.30%, sodium 1.38-0.96%, calcium 0.93-0.15%, iron 1.5-1.3%, and copper 0.9-1.23 0% (Andola-Harish and Purohit-Vijay, 2010; Duke, 2000; Sivaprasada et al, 2010; Joshi, 2006).

PHARMACOLOGICAL ACTIONS

Biological activities of *S. mangifera* have been reported from the crude extract and their different fractions and isolates from the fruit, leaf and bark.

Anti-inflammatory and analgesic activities

Traditionally, lotion or paste of the bark extract is rubbed onto the affected part of the body for the treatment of sprain and strain in case of both the articular and muscular rheumatic pains (Chopra et al, 1956). Both ethyl acetate and *n*-butanol fractions of alcoholic extract of *S. mangifera* stem bark reduced the oedema induced by Carrageenan in rat hind paw and showed a significant prolongation in the tail-flick latency of the rats when compared to the standard drug ibuprofen and untreated control group (Sachan et al, 2011).

Antibacterial, antidiarrhoeal and ulcer-protective activities

Methanolic extract of the bark was tested for castor-oil induced diarrhoea and its effect on indomethacin-induced ulceration in rats utilizing atropine cimetidine as control. Antibacterial activity of both methanolic and aqueous extracts was evaluated too against *Vibrio cholerae, Escherichia coli* and *Salmonella typhimurium* bacteria. The extracts significantly reduced the castor oil induced diarrhoea and subdued the ulcerogenic effect caused by indomethacin and showed promising antibacterial activity (Arif et al, 2008). Resinous extract of the plant was studied for antimicrobial activity on *Saccharomyces cerevisiae, Bacillus subtilis, Escherichia coli, Enterobacter sakazakii* and *Acinetobacter baumannii* by disc diffusion method and macrodilution assays. The microorganism most susceptible to the resinous extract was found to be a Gram +ve bacteria, *B. subtilis*. The extracts did not inhibit the growth of Gram -ve bacteria and also *S. cerevisiae,* a fungus (Gupta et al, 2010).

Anti-oxidant activity

The plant *S. mangifera* was found to be a highly potent antioxidant. Its fruit extract was found the most potent anti-oxidant as it exhibited scavenging activity against nitric oxide, peroxide and DPPH radicals and outstanding reducing power. Scavenging activity was correlated with total phenolics and flavonoid contents. As the involvement of free radicals in the pathogenesis of a various diseases is well known, a potent radical scavenger can serve as a probable preventive intervention for various diseases (Arif et al, 2011). Methanolic extract of stem bark was studied for total antioxidant activity, iron chelating capacity, reducing power and for scavenging of superoxide anions, peroxynitrite, hydroxyl radicals, hydrogen peroxide, nitric oxide, hypochlorous acid and singlet oxygen and, its correlation with phenolic and flavonoid contents. The results of the study indicated that it contains phenolics and flavonoid compounds in large quantity and exhibits high free radical scavenging and antioxidant activities. It has also iron chelating activity and strong reducing power. These assays indicated that the extract of the bark is an important source of antioxidants helpful in preventing the progress of diverse diseases associated to oxidative stress (Hazra et al, 2008). Methanolic extract of the root was evaluated for its antioxidant power. Assays for radical scavenging of DPPH and nitric oxide, and reducing power ability were performed and compared with standard ascorbic acid. The extract showed effective reducing power and scavenging activities (Acharyya et al, 2010). Powder of the dried leaves was extracted with ethyl acetate and hexane and evaluated for antioxidant activity by using multiple models these extracts showed a varied level of scavenging activities.

Over all, ethanolic extract exhibited the potent scavenging activity at tested concentrations. Ethyl acetate extract exhibited high scavenging activity while hexane extract showed poor antioxidant activity. The reducing power was increasing in dose dependent manner in all the cases. Highest total phenolic content was shown by ethanolic extract 27.76±1.11 mg GAE/g dried extract while the highest flavonoid content was shown by ethyl acetate extract 86.53±1.95 mg QE/g dried extract (Jain et al, 2014).

Hypoglycaemic activity

The various extracts of the root and bark of *S. mangifera* were evaluated for the hypoglycaemic activity at different doses of 100, 200 and 400 mg/kg *po* respectively by using glucose loaded and alloxan induced hyperglycaemic rats using Glibenclamide (2.5 mg/kg) as standard. The methanolic extract was found to possess promising results comparable to that of the Glibenclamide (Acharyya et al, 2010; Mondal and Dash, 2009).

Hepatoprotective activity

The methanolic and ethyl acetate extracts of stem heart wood were tested for the hepatoprotective activity against CCl_4 induced hepatotoxicity in rats. Alteration in the levels of marker biochemicals of hepatic damage (SGOT, SGPT, bilirubin, ALP) was tested in both treated and untreated groups. The altered levels of biochemical markers were brought back to the near normal levels in the dose dependent manner by treatment with ethyl acetate extract (100, 200 and 400 mg/kg). It was obvious from significant reduction in serum enzymes (SGPT, ALP, SGOT) and total bilirubin. Various pathological changes such as centribular necrosis and vacuolization were also observed in CCl_4 treated rats showing significant protective activity in silymarin and *S. mangifera* treated groups (Ganga-Rao and Jaya-Raju, 2010).

Anticancer activity

Methanolic extract of *S. mangifera* bark (MESM) showed promoting apoptosis in lung adenocarcinoma cell line (A549) and breast adenocarcinoma cell line (MCF-7). A normal cell line and these two malignant cell lines were treated with varying concentrations of MESM and cell viability was assessed. MESM showed significant cytotoxicity to both A549 and MCF-7 cells with an IC_{50} value of 149.34±13.30 and 147.84±3.74 µg/ml respectively. No cytotoxicity was found in normal lung fibroblast cell line (WI-38) with an IC_{50} value of 932.38 ± 84.44 µg/ml. Confocal microscopic studies and flow cytometric analysis confirmed that MESM has the ability to induce apoptosis in both the malignant cell lines. The pathway of apoptosis induction by increasing Bax/Bcl-2 ratio in both cell types resulting in the activation of the caspasecascade and ultimately leading to the cleavage of poly adenoribose polymerase was proposed by immunoblot result (Baban-Ghate et al, 2014). The chloroform and ethanolic extracts of the bark were tested for cytotoxic potentiality by using brine shrimp lethality bioassay test. In case of cytotoxicity of ethanolic extract, LC_{50} was found to be 65 µg/ml and LC_{90} 160 µg/ml while chloroform extract exhibited LC_{50} value of 170 µg/ml and LC_{90} value of 325 µg/ml (Das et al, 2011).

Platelet aggregation inhibitory activity

Dry powder of *S. mangifera* fruits was extracted with ethyl acetate and methanol. These extracts were evaluated for platelet aggregation inhibitory activity. The ethyl acetate extract showed potential platelet aggregation inhibitory activity with an IC_{50} value of 0.33 mg and 0.43 mg for antagonists like collagen and ADP respectively. The methanolic extract also revealed high platelet aggregation inhibition with very low IC_{50} value of 0.26 mg and 0.35 mg for antagonists like collagen and ADP respectively (Sivaprasad et al, 2011; Mohammad et al, 2013).

Anthelmintic activity

Methanolic extract of stem bark and heart wood were evaluated for anthelmintic activity on the earthworm, *Pheretima posthuma*. The bark extract was found more effective than stem heart wood extract at lower concentrations (20-40 mg/ml) leading to paralysis and death of *Pheretima posthuma* (Gangarao and Jayaraju, 2009). In a comparative study of acetone and ethanolic extract for anthelmintic activity, both the extracts showed anthelmintic activity comparable to standard drugs, with the ethanolic extract exhibiting better activity than the acetone extract (Panda et al, 2011).

Antimicrobial activity

Methanolic extract of the fruit had been evaluated for antimicrobial efficacy against six Gram +ve bacterial strains (*Enterococcus faecalis*, *Bacillus subtilis*, *Micrococcus luteus, Listeria monocytogenes Staphylococcus aureus and Listeria innocua*) and three Gram -ve bacterial strains (*Enterobacter cloacae, Enterobacter aerogenes and Pseudomonas aeruginosa*) by agar well diffusion method. It was found to be effective against all the strains. Highest zone of inhibition was found against *B. subtilis* (23 mm of clear zone) followed by *L. innocua* (16 mm). The findings indicated its promising antibacterial activity (Borkotoky et al, 2013).

Laxative and diuretic activities

The laxative and diuretic activities of different extracts of the bark were evaluated in Wistar albino rats using furosemide (10 mg/kg, *po*) and agar-agar (300 mg/kg, *po*) respectively as the reference standards. Urinary levels of sodium, potassium (by flame photometry) and chloride (by titrimetry) were estimated. The methanolic and chloroform extracts produced significant laxative and diuretic activities. The petroleum ether extract was lacking any significant activity (Mondal et al, 2009).

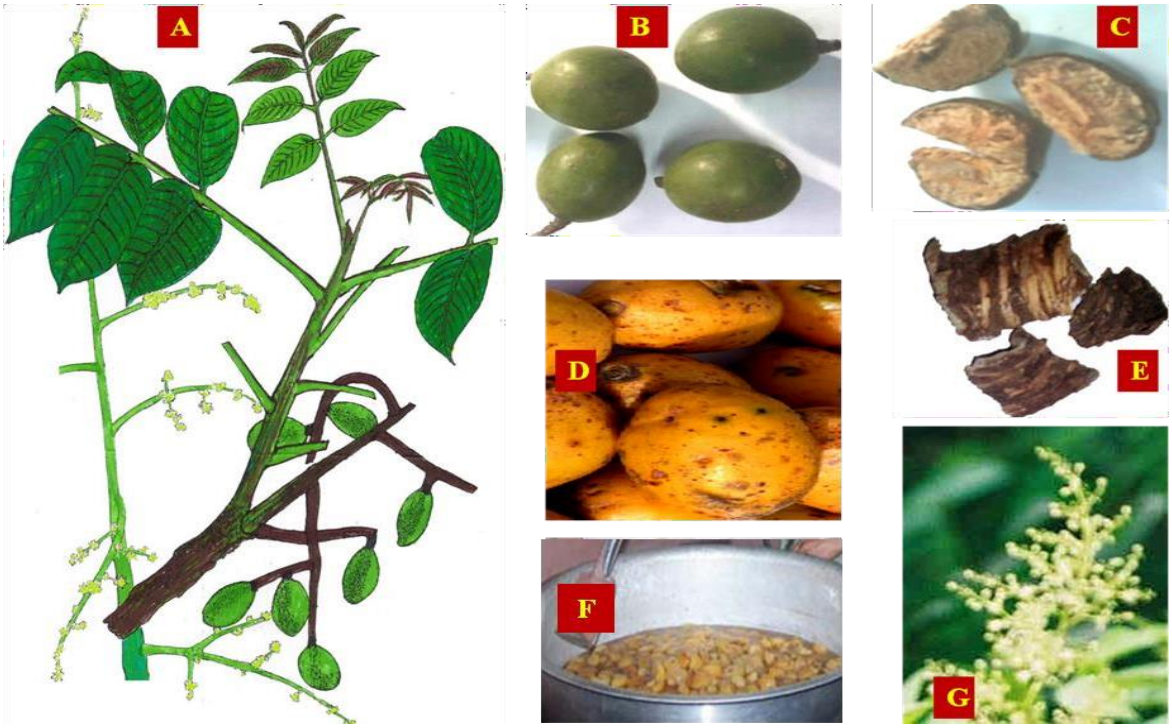

Figure 1: (A) *S. mangifera* twig with leaves, flowers and immature fruits; (B) *S. mangifera* immature fruits; (C) *S. mangifera* fruits in section; (D) *S. mangifera* mature fruits; (E) *S. mangifera* bark; (F) *S. mangifera* fruit (Murabba); (G) *S. mangifera* fresh flowers

Toxicity study

Ethanolic extract of *S. mangifera* was investigated for the safety profile by shaping its potential toxicity after acute and chronic administration. Acute toxicity of extract was found to be safe at the dose of 2000 mg/kg body weight orally as per OECD guidelines No.423. General behavior adverse effects and mortality were determined for 14 days. The extract was administered orally at doses of 100, 200 and 400 mg/kg once in a week for 6 weeks in the chronic toxicity study. Biochemical and hematological parameters were determined after 6 weeks. No toxicity/ death were observed at the dose of 2000 mg/kg body weight in the acute toxicity study. No significant treatment-related changes in the levels of renal, hepatic and haematological parameters such as , SGPT, SGOT, cholesterol, uric acid, creatinine, urea, glucose and protein, and serum ALP were observed at the termination of the chronic toxicity study. It was suggested that the ethanolic extract of the plant does not appear to have significant toxicity profile (Kumar and Sastry, 2013).

MEDICATED FORMULATIONS

Formulation for premature whitening of hair

The fruit powder of *S. mangifera* with combination of *Terminalia citrine, Phyllanthus emblica* and *Terminalia arjuna* is used orally with drinking water for the treatment of premature whitening of hair. Fruits of *Phyllanthus emblica* and *S. mangifera* are considered to promote hair growth according to Ayurveda (Sadia et al, 2012).

Formulation for articular and muscular pain

Dried aqueous extract of the bark emulsified with cow ghee, known as *Dadhika Ghrita*, is used for the treatment of muscular and articular rheumatic pain (Anonyms, 2001).

Formulation for diarrhoea

Bark of *S. mangifera* is made into paste. A soup is prepared by mixing green fruit extract of *Musa paradisiaca* and petiole of *Borasus flabellifer* to it. Half cup of the soup is taken daily in empty stomach twice a day to relieve loose motion (Mondal and Rahaman, 2012).

Formulation for diabetes/glucose intolerance

The bark of *S. mangifera* is one of the ingredients of HERBLISS-M~UST: Special Diet / Supplement which is a delicious, nutritionally balanced, ready to use diet made from herbal extracts, minerals, vitamins and nutrients as per US-RDA. It is also a specially formulated diet useful for the persons with diabetes/ glucose intolerance and also for the persons wanting/ prescribed fixed calorie diet.

Formulation against snake bite

Juice of the leaves and fruit of the plant is used to reduce the effect of snake bite (Houghton and Osibogun, 1993).

FRUIT PULP JUICE AND PROCESSED PRODUCTS

Flavored pulp of the plant is rich in pectin, reducing sugar, vitamins, minerals and organic acids which are

Table 1: Nutritional constituents of *Spondias mangifera*

Components	Fruit	Bark
Polyphenol (mg %)	634.53	91.47
Flavonoids (mg %)	710.23	350.5
Total acids (g %)	944.34	154.75
Total Protein (g %)	17.32	3.21
Total crude fat (g %)	12.23	5.14
Fibres (g %)	42.53	33.9
Carbohydrate (g %)	23.54	16.3
Aluminum (mg %)	87	58
Iodine (mg %)	24	9
Iron ((mg %))	150	128
Phosphorus (mg %)	66	32
Sodium (mg %)	96	-
Calcium (mg %)	115	72
Niacin (mg %)	0.16	-
Riboflavin (mg %)	0.09	-
Thiamine (mg %)	1.8	0.8
Energy (kcal/g)	189	-
Ash (g %)	11.70	7.87
Copper (mg %)	123	90

(Andola-Harish and Purohit-Vijay, 2010; Duke, 2000; Sivaprasada et al, 2010; Joshi, 2006).

used for a wide variety of domestic purposes. It is eaten raw or sweetened with sugar and used to prepare jam, syrup, candy and juice. The utility of this fruit can be increased by processing products from it or by preserving the fruit by adopting suitable means of food preservation. The mature fruits can be used to prepare good preserved materials like murabba, jam, syrup and pickle (Ahmed, 1966; Hedrick, 1919).

Jam: Fresh ripened fruits are washed and boiled for 90 min at 70°C. Pulp is then drained and separated from fibres and seeds. Every cup of pulp is mixed with two cups of brown sugars and then mixture is cooked with constant stirring until boiling. It becomes of thick consistency. The resultant jam is cooled and packed in dry sterilized jar and sealed (Paul et al, 2012).

Syrup: Ripened fruits of Amra are boiled with salt and baking soda. Half tea spoon of baking soda is added and boiled in one liter of water at 100°C for every cup of juicy pulp. Mixture is then boiled down to one half of the original quantity removing the rising scum in the process. The juice is again strained. A quarter cup of sugar is added for every cup. The mixture is again boiled for 40 min. The cold syrup is poured into sterilized bottle and sealed (Chen et al, 1999).

Pickles: Immature green fruits of the plant are often eaten by children and adults and dipped in salts snacks. More commonly, the acidic pulp juice of ripened mature fruits is used as favorite ingredient in culinary preparation and immature unripened fruit is used in preparation of curies, chutney souse and sharbet where the tree grows naturally. In the prepared pickles, there is no need to add any additional preservatives because of the presence of high quantity of acidic constituents. For making pickles, the unripe fruit is washed in fresh water, cut horizontally, mixed with some quantity of turmeric powder and dried under sun light for two days. Then, mixture of spices, salt (40g/kg) and mustard oil 250ml/kg are added. The product is then packed into pre-sterilized glass jar and subjected to direct sunlight for further processing for a specified period of time. After one week, pickles are prepared for marketing. The pickles can be stored in small polythene bags or clean jars and sealed. Precaution is taken in withdrawing the materials from the jar to avoid contaminations. It is stored in cool place and care is taken to avoid air bubbles trap in the pickles. A layer of oil covers the product to reduce the microbial growth. The pickles are available in the urban market of Vietnam, Indonesia, Bangladesh, India and Sri Lanka (Chandra and Ghosh, 1993; Whitmore, 1998).

Fresh and dried hog-plum contain substantially higher nutrient content than fresh one with the exception of vitamin C which was almost half of that present in fresh one (Munmun et al, 2005). Fruit of the plant is rich in vitamins, nutrients and minerals such as protein, carbohydrate, calcium, iron, carotene, vitamin B_1, B_2, C, etc (Ali-keramat et al, 1977; Islam, 2004; S-Akther et al, 2012).

Drinks: Refreshing drink is prepared by Ahum people of Assam and some other tribe people of North-East region of India. It is prepared by mixing the pulp of boiled fresh unripe fruit of *S. mangifera* with roasted, powdered cumin with black salt and water (Shankaran et al, 2006).

COMMERCIAL USES

Its wood is employed for packing cases, tea chests and match-splints. Young branches are used for making

basket and for fuel used as fire wood (Badoni and Bisht, 2009).

The bark is applied for tanning hides and dyeing and also applied in the preparation of ink and fixing dyes (Storrrs, 1995).

Leaves extracts of the plant is used for controlling citrus canker of Lime (Leksomboon et al, 2001).

Through value addition of this wild edible fruit, the local people make chutney, pickle and jam. They may increase their socio-economic status by production and marketing of these products.

CONCLUSION

The underutilized, edible green raw fruit of *Spondias mangifera* from the North- Eastern region of India was overviewed for their therapeutic and nutraceutical potentials. Nutritional insight of the fruit demonstrated that it is a source of energy, minerals, natural antioxidants and phenolic compounds. It is a major source of ascorbic acid, calcium, phosphorus and other nutrients. Current review explained the nutritional as well as medicinal utility of the fruit, which is a rich source of minerals and antioxidants such as phenols and flavonoids.

The plant *Spondias mangifera* is easy to cultivate, free of serious pest and disease, utilized as food or parts of food may provide medical health benefits including the prevention and or treatment of diseases. The bioactive ingredients of the plant that protect or promote health whether delivered from leaves, raw fruits, flowers or processed foods, dietary supplements, beverages, extracts or other products. The ingredients of this plant have tremendous impact on the health care system and may provide medical health benefits including the prevention and or treatment of several diseases. The phytoconstituents of the fruit having potential of organic acid, minerals, vitamins and flavonoids can act against ulcers, allergies, tumors, platelet aggregation, and control hypertension. Over the centuries, this plant has served as a major source of medicines for treating diarrhea, dysentery and prevention of diseases. There is an information gap on utilization, development and diversification required for commercial exploitation in Asian and African countries. There is a need to identify and scientifically screen for various activities of such useful trees for their utilization in beverages, food and in preparation of phytopharmaceuticals of importance. Amara is relatively a new item to be explored for the full potential and a fruit that needs publicity and promotion in the international market. It has been identified as a new addition to the available tropical fruit range with multiple uses. Demand for its fruit is limited mainly due to lack of awareness on food value of the fruit, its uses and non-availability of organized supply. So, it is necessary to establish large scale cultivation units where sizable quantities are made available for market promotion. Market promotion should focus mainly to create awareness on quality attributes; nutritional value and health value multiple uses to introduce a product in the local and overseas markets. Research and development would be an important area to make the product to meet international standards. Fruits of the plant have played a prominent role in the diet and medicine of human beings particularly in the tribal and rural areas of the country for thousands of years. If educated/ uneducated and unemployed youth of this region engage themselves fully in the preparation of quality food and other related products from Amara fruits as a source of income, the threat of unemployment could certainly be minimized.

REFERECES

Acharyya S, Dash GK, Mondal S, Dash SK. Antioxidative and antimicrobial study of *Spondias mangifera* Willd root. Int J Pharm Pharm Sci, 2010; 2(4):68-71.

Acharyya S, Dash GK, Mondal S, Dash SK. Studies on Hypoglycaemic Activity of the Different Extracts of *Spondias mangifera* Willd. Root. J Pharm Sci Tech, 2010; 2(3):184-190.

Ahmed KU. 1966. Phul Fol abong shak- shobji. Dhaka, Bangladesh: Usha printers.

Ali-keramat SS, Malek MA, Islam K, Salamatullah K. 1977. Dhaka University, Bangladesh: The food values of indigenous foods Institute of food and Nutrition.

Andola-Harish C, Purohit-Vijay K. Evaluation of nutritive and mineral value in ripe fruits of *Spondias pinnata* from two locations of Western Himalaya, India, Medicinal Plants. Int J Phytomed Rel Ind, 2010; 2(3):233-236.

Anonymous. 1992. The Wealth of India: A dictionary of Indian Raw materials. CSIR, New Delhi, India: Publication and Information Directorate.

Anonyms. 2000. The useful plants of India. CSIR, New Delhi: National institute of science communication.

Anonyms. 2001. The Ayurvedic Pharmacopoeia of India. 1st ed. New Delhi, India: The Controller of Publications.

Arif M, Fareed S, Sarfaraj H. Estimation of antioxidant activity of microwave assisted extraction of total phenolics and flavonoids contents of the fruit *Spondias mangifera* Willd. Asian J Trad Med, 2011; 6(4): 146-155.

Arif M, Fareed S. Pharmacognostic Investigation and Authentication of Potentially Utilized Fruit *Spondias mangifera* (Willd). Int J Pharm Clin Res, 2010; 2(1):31-35.

Arif M, Zaman K, Fareed S, Badruddeen M, Sarfaraj H. Antibacterial, antidiarrhoeal and ulcer-protective activity of methanolic extract of *Spondias mangifera* bark. Int J Health Res, 2008; 2(1):3-8

Arif M, Zaman K, Fareed S. Pharmacognostical studies and evaluation of total phenolic contents of trunk bark of *Spondias mangifera* Willd. Nat Prod Radiance, 2009; 8(2):146-150.

Baban-Ghate N, Hazra B, Sarkar R, Mandal N. *In vitro* anticancer activity of *Spondias pinnata* bark on human lung and breast carcinoma. Cytotechnology, 2014; 66:209-218.

Badoni A, Bisht C. Importance and Problems in Natural Regeneration of *Spondias pinnata.* Rep Opin, 2009; 1(5):12-13.

Benthall AP. 1993. The tree of Culcutta and its Neighborhood. Thaker Spink & Co.

Borkotoky R, Kalita MP, Barooah M, Bora SS, Goswami C. Evaluation and screening of antimicrobial activity of some important medicinal plants of Assam. Int J Adv Res Techn, 2013; 2(4):132.

Burkill IH. 1996. A dictionary of the economic products of the Malay Peninsula Vol. II. Kuala Lumpur (Malaysia): Ministry of Agriculture and Cooperatives.

Chandra D, Ghosh RB. Family Anacardiaceae in West Bengal. J Econ Tax Bot, 1993; 17(3):587-591.

Chen Jin, Su Yin-Chun, Chen Gui-Qin, Wang Wen-Dun. Ethnobotanical studies on wild edible fruits in southern yunnan: Folk names; nutritional value and uses. Econ Bot, 1999; 53(1):2-14.

Chopra RN, Chopra IC, Honda KL, Kapur LD. 1992. Chopra's Indigenous Drugs of India. 2nd ed. Calcutta: Academic publishers.

Chopra RN, Nayar SL, Chopra IC. 1956. Glossary of Indian Medicinal Plants. New Delhi: Council of Scientific and Industrial Research.

Daniel J, CBole PV, Nahavati. J Bombay Nat Hist Soc, 1986; 12:542.

Das J, Mannan A, Md.-Mominur R, Md.-Abu-Monsur D, Erfan-Uddin M, Irfan NK, Md.-ThakurRazibul H, Hasan N. Chloroform and Ethanol Extract of *Spondias pinnata* & its Different Pharmacological activity Like Antioxidant, Cytotoxic, Antibacterial Potential and Phytochemical Screening through *In-Vitro* Method. Int J Res Pharm Biomed Sci, 2011; 2(4):1805-1812.

Duke JA. 2000. Handbook of phytochemical constituents of grass Herbs, and other Economic plant. CRC Press. Amazon.com Medical.

Edeoga HO, Okwu, DE, Mbaebie BO. Phytochemical constituents of some Nigerian medicinal plants. African J Biotech, 2005; 4(7):85-88.

Gangarao B, Jayaraju N. Anthelmintic activities of *Glycosmis pentaphylla* and *Spondias pinnata.* JPRHC, 2009; 1(1):91-96.

Ganga-Rao B, Jaya-Raju N. Investigation of Hepatoprotective activity of *Spondias pinnata.* Int J Pharm Sci Res, 2010; 1(3):193-198.

Ghoshal PK, Thakur S. Structural features of the acidic polysaccharide of *Spondias pinnata* gum exudates. Carbohydr Res, 1981; 98:75-83.

Gupta VK, Roy A, Nigam VK, Mukherjee K. Antimicrobial activity of *Spondias pinnata* resin. J Med Plants Res, 2010; 4(16):1656-1661.

Hasan MA, Das BC. 2005. Diversity of under-utilized fruit species in West Bengal. In: First International Conference on Crop Wild Relative Conservation and Use, Incorporating the PGR Forum Final Dissemination Conference. Sicily, Italy: Agrigento.

Hazra B, Biswas S, Mandal N. Antioxidant and free radical scavenging activity of *Spondias pinnata*. BMC Compl Altern Med, 2008; 63(8):1-10.

Hedrick UP. 1919. Sturtevant's Notes on Edible Plants. J B Lyon Company, State Printers, Albany: Report of the New York Agricultural Experiment Station for the Year 1919 II.

Houghton PJ, Osibogun IM. Flowering plants used against snakebite. J Ethnopharmacol, 1993; 39(1):1-29.

Islam MW. Studies on jam from hog-plum (Amra): A Project Report, Department of Food Technology and Rural Industries, Bangladesh Agricultural University. Mymensingh, 2004.

Jain P, Hossain KR, Mishu TR, Reza HM. Antioxidant and Antibacterial Activities of *Spondias pinnata* Kurz. Leaves. Eur J Med Plants, 2014; 4(2):183-195.

Jain SK, Hajra PK, Shampru R. A survey of edible plants in bazzars of Meghalaya. Bull Bot Surv India, 1977; 2:29-34.

Joshi SG. New Delhi, India: Medicinal plants Oxford and IBH Publishing , 2006: 491.

Kandali R, Konwar BK. Isolation and Characterization of Active Compound from Fruits of Medicinal Plant *Spondias pinnata* Kurz. Indian J Agr Biochem, 2011; 24(1):29-33.

Kangilal UN, Das PC. 1984. Flora of Assam. Government of Assam.

Keawsa-ard S, Pholsongkram K, Liawruangrath B, Kongtaweelert S. 2005. Chemical constituents of essential oil from the pulp of *Spondias pinnata* Kurz. 35th Congress on Science and Technology of Thailand.

Killer R, Barley N. 2004. Identification of Tropical Woody Plants in the Absence of Flower. 2nd ed.

Kritikar KR, Basu BD. 1975. Indian Medicinal Plants, Vol 1. M/S Bishen Singh. Dehradune, India: Mahendra Pal Singh.

Kumar PK, Sastry VG. Toxicity studies of ethanolic extract of *Spondias pinnata*, kurz. in experimental animals. Int J Med Chem Anal, 2013; 1(1):17-22.

Kumar YS, Rao RR. Further contribution to the Ethanobotany of Meghalaya: Plants used by War-Jaintia of Jaintia Hill district. J Econ Tax Bot, 1987; 11:65-70.

Leksomboon C, Thaveechai N, Kositratana W. Potential of Plant extracts for controlling Citrus Canker of Lime. Kasetsart Nat Sci, 2001; 35:392-396.

Macmillan HF. 1943. Hand book of Tropical plants, Medicinal Plants. New Delhi, India: Anmol Publications.

Mahanta RK, Rout SD, Shahu HK. Ethnomedicinal plant resources of similipal biosphere reserve, Orissa, India. Zoos print J, 2006; 21(8):2372-2374.

Melendez PA, Capriles VA. Antibacterial properties of tropical plants from Puerto Rico. Phytomedicine, 2006; 13:272-276.

Mohammad KM, Islam-Shawkat MA, Wahid-Md A, Mohammed MM, Kamal S, Islam-Md, Ahmed-Kh T. Investigation of *In Vitro* Antioxidant, Antimicrobial and Thrombolytic Activity of the Exocarp of *Spondias pinnata* (Anacardiaceae). Canadian Chem Trans, 2013; 1(3):191-201.

Mondal S, Dash GK, Acharyya S, Brahma DK, Bal S. Studies on diuretic and laxative activity of bark extracts of *Spondias pinnata* (Linn. f) Kurz. Phcog magz, 2009; 5(19):28-31.

Mondal S, Dash GK. Hypoglycemic activity of the bark of *Spondias pinnata* Linn. Kurz, Phcog magz, 2009; 5(19):42-45.

Mondal S, Rahaman CH. Medicinal plants used by the tribal people of Birbhum district of West Bengal and Dhumka district of Jharkhand in India. Indian J Trad Knowl, 2012; 11(4):674-679.

Morton J, Julia F, Miami FH. 1987. Ambarella: In Fruits of Warm Climates.

Munmun R. 2005. Study on air and osmotic dehydration of hog-plum (*Spondius mangifera*). M.S. Thesis department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh.

Nandkarni AK. 1976. Indian Materia Medica. Bombay: Popular Prakashan.

Narayan P, Manandhar. 2002. Plants and People of Nepal. Timber Press.

Northrup C. 1994. Women's Bodies Women's Wisdom. New York: Bantham Books.

Pal DC, Jain SK. Tribal Medicine. New Delhi: Naya Prakash.

Panda BK, Patro VJ, Mishra US, Panigrahi BK. Comparative Study of Anthelmintic Activity Between Acetone and Ethanolic Stem Bark Extracts of *Spondias pinnata* (Linn.f) Kurz. IJRAP, 2011; 2(4):1383-1385.

Paul A, Arif-Md HA, Islam MT, Biswas S, Arif SM, Arifuzzaman S, Paul AK, Rahmatullah M. Preventive medicinal plants consumed by the rural population of Bangladesh-a randomized survey of Silakhana village in Bagerhat district. American-Eurasian J Sust Agr, 2012; 6(4):276-280.

Puri HS. Medicinal plant of Tejpur (Assam). Bull Medico Ethano Bot Res, 1983; 4:1-13.

Rastogi RP, Mehrotra BN. Compendium of Indian Medicinal Plants, CDRI Lucknow & National Institute of Science communication, Vol. 2. New Delhi: 1970-1979.

Sachan NK, Arif M, Zaman K, Yatindra K. Anti-inflammatory, analgesic and antioxidant potential of the stem bark of *Spondias mangifera* Willd. Arch Biol Sci Belgrade, 2011; 63(2):413-419.

Sadia MM, Mahal MJ, Bhuiyan P, Zakaria ASM, Datta B, Rana M, Islam A, Khatun Z, Rahmatullah M. Medicinal plants and formulations of the Goala tribe of Moulvibazar. Bangladesh American-Eurasian J Sust Agr, 2012; 6(4):254-260.

S-Akther SMS, Shahriar F, Morshed AS, Islam MN. Study on Chemical Composition of Fresh Mymensingh & Barishal Hog-plum (*Spondius mangifera*) and Developed Leather, Jelly and Sensory Evaluation. J Environ Sci Nat Res, 2012; 5(2):29-36.

Satpathy G, Tyagi YK, Gupta RK. Preliminary evaluation of nutraceutical and therapeutic potential of raw *Spondias pinnata* K., an exotic fruit of India. Food Res Int, 2011; 44(7)2076-2087.

Saxena VK, Mukharya S. Echinocystic acid 3-O-*β*-D-pyrogalactopyranosyl (1→5)-O-*β*-D-Xylofuranoside from the root of *Spondias mangifera* Willd. Asian J Chemistry 1997; 9(2):253-260.

Saxena VK, Singh RB. Amino-acid contents of fruit of *Spondias mangifera*. J Inst Chemists India, 1977; 49:107-108.

Saxena VK, Singh RB. Chemical investigation on *Spondias mangifera*. J Inst Chemists India 1976; 48:299.

Shankaran M, Jaiprakash, Singh NP, Suklabaidya A. Wild edible fruits of Tripura. Nat Prod Rad, 2006; 5(4):302-305.

Sharma B. 2002. Udbhid Gyanakosh. 1st ed. Assam, India.

Singh S. 1997. Description of a new and notes on some other species of Encyrtus (Hymenoptera: Encyrtidae) parasitising scale insects in Assam, India. Assam, India. 419-26.

Sivaprasad M, Policegoudra RS, Swaroop Kumar HM, Aradhya SM. Platelet aggregation inhibitory activity

and radical scavenging activity of *Spondias mangifera* Willd. South Asian J Exp Biol, 2011; 1(1):1-6.

Sivaprasada M, Policegoudrab RS, Aradhyac SM. Biochemical changes associated with hardening of endocarp in *Spondias mangifera* (Willd.), fruits during developmental stages Scient Horticult, 2010; 123(2):192-199.

Storrrs AEG. Know Your Trees, Some common trees found in Zambia, Regional Soil Conservation Unit, (RSCU). Zambia, 1995.

Tandon S, Rastogi RP, Mehrotra BN. 1993. Compendium of Indian medicinal plants, Vol. II, Central drug research institute: Lucknow, UP, India.

Tandon S, Rastogi RP. Studies on the chemical constituents of *Spondias pinnata.* Planta Med, 1976; 29:190.

Tripathi M, Nishi K. Micropropagation of a tropical fruit tree *Spondias mangifera* Willd. through direct organogenesis. Acta Physiol Plant, 2010; 32:1011-1015.

Umadevi IM, Daniel J. Chemotaxonomic studies on some members of Anacardiaceae. Proceedings of the Indian Academy of Sciences Plant Sciences, 1988; 98(3):205-208.

Valsaraj R, Pushpangadan P, Smitt UW, Adsersen A, Nyman U. Antimicrobial screening of selected medicinal plants from India. J Ethnopharmacol, 1997; 58:75-83.

Whitmore TC. 1998. An Introduction to Tropical Rain Forests. 2nd ed. Oxford University press.