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Bael Patra as Anti-Oxidant: A Review

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Abstract: ***Bael, Aegle marmelos (Linn.) Correa ex Roxb., a tree of Indian origin is known from pre-historic time. It has a great mythological significance for Hindus. Utilization of bael in day-to-day life has great nutritional, environmental as well as commercial importance. It has been in use from time immemorial in traditional systems of medicine for relieving constipation, diarrhoea, dysentery, peptic ulcer and respiratory infections. Important medicinal properties of bael are antidiabetic, antimicrobial, anti-inflammatory, antipyretic, analgesic, cardioprotective, antispermatogenic, anticancer and radioprotective. The present review deals with chemical profile such as antioxidant property and its uses.***
Keywords: Bael patra, chemical constituent, Antioxidant properties, Marketed preparation, Health benefits.

I. INTRODUCTION

World Health Organization has listed over 21000 plant species used around the world for medicinal purposes.
In India, about 2500 plant species belonging to more than 1000 genera are being used in indigenous system of medicine.[1] In terms of both quantity and value of the medicinal plants exported, India ranks second in the world.[2] India is one of the 12 mega biodiversity centers of the world with 16 agro-climatic zones [3,4] and has about 45000 plant species of which 15000 species are of flowering plants having about 7000 species identified as medicinal plants. [5]. There are about 400 families in the world of the flowering plants, of which at least 315 are represented by India.[4] Despite of our rich heritage and knowledge of the use of plant drugs, little attention has been paid to harness the inexpensive remedies to modern requirements. [3] Only 40 plant species are currently used by the pharmaceutical industries (29 indigenous species and 11 exotic).
Bael, Aegle marmelos(Linn.) Correa ex Roxb., a plant of Indian origin having tremendous therapeutic potential is not fully utilized. It belongs to family Rutaceae, the family of citrus fruits. It is known with different names in different languages [8-12] Bel, Beli, Belgiri (Hindi); Bilva, Shivadruma, Shivaphala, Vilva (Sanskrit); Bael, Bengal quince, Golden apple (English);Bel, Bel Kham (Urdu); Bel (Assamese and Marathi); Bilivaphal (Gujrati);Marredy (Malyalam); Belo (Oriya); Vilvama, Vilva marum (Tamil); and Bilva, Bilva pandu (Telugu). Bael is known in India from pre- historic time [13] and has been mentioned in the ancient system of medicine. It has a great mythological significance also. Every part of plant such as fruit, seed, bark, leaf and root are important ingredients of several traditional formulations. Due to its curative properties, it is one of the most useful medicinal plants of India. The products obtained from bael, being highly nutritive and therapeutic are getting popularized in Indian as well as in international market. In India, there is a large area, which is waste land and and remains unproductive which can be exploited with bael cultivation. It can be cultivated commercially on waste land and unproductive land for the upliftment of farmers.[14]
Bael plant acts as a 'Sink' for chemical pollutants as it absorbs poisonous gases from atmosphere and make them inert or neutral. It is a member of plant species group known as 'Climate Purifiers', which emit greater percentage of oxygen in sunlight as compared to other plants. The tree is also considered under the category of 'Fragrant' species, whose flowers and volatile vapours neutralize bad smell of pterified organic matter & the bad odour of the air [15] The present review deals with general and chemical profile and its antioxidant properties including medicinal and other uses.

A. Origin and Distribution

The Bael tree has its origin from Eastern Ghats and Central India. It is indigenous to Indian subcontinent and mainly found in tropical and subtropical regions. The tree is also found as a wild tree, in lower ranges of Himalayas up to an elevation of 500 meters. Bael is found growing along foothills of Himalayas, Uttar Pradesh, Bihar, Chattisgarh, Uttaranchal, Jharkhand, Madhya Pradesh, The Deccan Plateau and along the East Coast [8,12].
Hiuen Tsiang, the Chinese Buddhist pilgrim who came to India in 1629 A.D. noticed the presence of this tree along with other trees in this region.[16] It is also grown in some Egyptian gardens in Surinam and Trinidad.Specimens of Bael have been procured and maintained in Citrus Collection in Florida. [17]

Bael fruit has been used traditionally in making paints in Burma [18] In Bangladesh, the tree has been used for fertility control and antiproliferative and in Sri Lanka it has been used for its hypoglycemic activities [19-21]. Bael fruit was introduced in Europe in 1959(Ref.22). The tree has also been reported to be cultivated in Ceylon, Northern Malaya, Java and Philippine Island where it was first fruited in 1914 (Ref.23)

B. Bael in Mythology

Hindus hold the tree in great venerations. It is one of the most sacred trees of India. The leaves are ternate and hence one of the vernacular names is Tripatra [24]. It is generally cultivated near temples and is offered to Lord Shiva, whose worship cannot be completed without the leaves of this tree. Lord Shiva is believed to live under the Bael tree. It is also called Shivadurme, the tree of Shiva. According to Hindu mythology, the tree is another form of Lord Kailashnath. [12] It is also sacred to Parvati and is the Vilva rupra, one of the Patricas, or nine forms of Goddess Kali.

C. Chemical Constituents

Bel is a holy native tree of India, which has high ethnomedicinal, therapeutic, and pharmaceutical importance. Bel contains many diverse bioactive components in leaves, flowers, fruits, wood, root, and bark which show multiple biological activity and high therapeutic importance. Plant contains coumarins, marmelosin, marmesin, imperatorin, marmin, alloimperatorin, methyl ether, xanthotoxol, scoparone, scopoletin, umbelliferone, psoralen and marmelide and marmenol, aegelin, aegelenine, marmeline, dictamine, fragrine which show anticancer, antioxidant, antimicrobial, anti-plasmodial, and hepatoprotective activities. Plant possesses various polysaccharides such as galactose, arabinose, uronic acid, and L?rhamnose. Its seed oil contains palmitic, stearic, oleic, linoleic, and linolenic acids which possess very high nutritive value. Plant also possesses very high tannin contents (9%) in fruits, pulp leaves. Tannin found in leaves as skimmianine. Marmelosin, skimmianine, and umbelliferone are therapeutically important active principles. Aegle marmelos is also a good source of gum, wound healers, carotenoids, vitamins, sugars, and nutritive oils. The plant is used to cure digestive disorders, ulcers, headache, hypertension, diabetes, constipation, and numerous other ailments. The ripe fruits are used as a laxative, while unripe Bel fruit, promotes digestion, and cures diarrhea.

D. Anti-oxidant activity

Umbelliferon-α-D-glucopyranosyl-(2I→1II)-α-D-glucopyranoside(UFD) from A. marmelos Correa shows free radical scavenging activity in normal and streptozotocin (STZ)-induced diabetic rats.[43] It acts as a bifunctional inducer since it induces both phase I and phase II enzyme systems. UFD significantly decrease the activity of lactate dehydrogenase and formation of malondialdehyde in the liver. A. marmelos plays an important role in cytoprotection as well as protection against pro-oxidant-induced membrane damage. A. marmelos extract was found effective in inducing glutathione S-transferase, DT-diaphorase, superoxide dismutase, and catalase in the lung. These significant changes occur in body fluids display levels of drug-catabolism. Leaf extract also protects antioxidant defense system and restore histological changes of pancreatic β-cells in STZ-induced diabetic rat [44] and gastroduodenal ulceration.[44] A. marmelos Correa (Bael) fruit shows antioxidants activity[42] in STZ.[43] and alloxan-induced diabetic rats.[45] Bel is used to remove oxidative stress and cure diabetes by local people.

II. PHYSICO-CHEMICAL CHARACTERISTICS OF FRUIT

Physical characteristics such as average fruit weight, pulp, seed, fibre, rind thickness and shell percentage etc. have been studied by various researchers. Ram and Singh (2003) investigated four bael varieties viz. NB-5, NB-9, NS-1 and Kaghzi. Average fruit weight was varied from 1.011 to 2.09 kg. Cultivar NB-9 recorded highest value followed by cultivar, NS-1. Similar variability in bael fruit weight was also reported by Jauhari and Singh (1971).It was observed that pulp (%) varies from57-68.13% and cultivar NB-5 had the highest percentage of pulp (68.13%). Pulp of fruit exhibited various shades of yellow to orange colour. Seed content of bael fruit varied from 2.23 to 3.47%. Cultivar, Kaghzi has highest (3.47%) and cultivar NB-5 has lowest (2.33%) value for seed content. Fibre content varied from 9.91 (Kagazi) to 4.49% (NB-9). The highest percentage of shell was found in cultivar Kagazi (29.50%) while it was lowest in cultivar NB-5 (23.16%). Similar findings have been reported by Roy and Singh (1978).[24]

Physical characteristics of bael cultivars PB7B, PB10, PB11, PB14, Pant Aparna, Pant Shivani, Pant Sujata and Pant Urvashi were studied by Singh et al. (2000). It was observed that the fruits vary in shape such as spheroid- oblong (PB7B and PB11), spheroid (PB10, Pant shivani, Pant Urvashi), Ellipsoid (Pant Aparna), Onlate (Pant Sujata) and Pyriform (PB14). Maximum fruit length was observed in Pant Urvashi (53.27 cm) and minimum in PB14 (39.87 cm). Diameter was maximum in Pant Sujata (54.53 cm) and minimum diameter was in PB10 (37.37 cm). Fruit weight varied from maximum 2.06 kg in Pant Urvashi to 1.0 kg in PB 14.

The mucilage content was maximum in PB7B (17.36%). Minimum pulp content was found in PB 7B (38.19%). Seed content was found maximum in PB11 (3.17%). Similar variation in fibre, mucilage, peel and pulp content was reported by Jauhari et al. (1969).[25] Prasad and Singh (2001) categorized bael fruit into extra large size (ELS) >1000 g; large Size (LS) >750 to 1000 g; medium Size (MS) >400 to 750 g and small size (SS) <400 g. The results showed that the polar diameter of ELS bael ranges from 13.57 to 17.36 cm. The transverse diameter varies from 13.50 to 17.60 cm. The peel thickness varies from 0.18 to 0.27 cm. The pulp content varies from 78.56 to 78.82%. Maximum sugar content, TSS and non reducing sugars were observed, 4.59%, 34.70 brix and 14.93%, respectively. Physicochemical characteristics of three genotypes of bael viz. NB-5, NB-9 and Kaghzi growing under rainfed conditions of Jammu was studied by Bhat and Kumari (2006). They showed variation in fruit weight, pulp, seeds, fiber, shell, TSS, acidity, sugars, ascorbic acid and phenols. NB-9 having larger sized fruits, more pulp, lesser seeds and fiber is ideal for processing. Pulp was extracted by adding water equal to the weight of the pulp and it was utilized for preparing beverages in different proportions. Organoleptic evaluation revealed that bael nectar consisting of 35% pulp, 25°Brix and 0.3% acidity was ideal combination whereas squash having 50% pulp, 1.5% acidity and 50°Brix was more acceptable.[26]

The chemical composition of bael fruit was studied by Ram and Singh (2003). Moisture content of bael fruit varied from 59.0 to 66.67%. Cultivar Kagazi recorded highest moisture content (66.67%) followed by NB-5 (64.20%) and NB-9 (61.77%). The TSS varied from 30.50 (Kaghzi) to 38.50% in NS-1. Carotene content was highest in cultivar NB-9 followed by NS-I and varied from 85.0 to 97.0 IU/100 g. Highest acidity (0.40%) was found in NS-I while lowest was in Kagazi (0.32%). Ascorbic acid content varied from 73.30 to 17.25% and was highest in NB-9. Phenol content varied from 2.38 to 2.87% and was lowest in NS-I. Highest reducing sugar (4.87%) and non- reducing sugar (15.57%) content was found in NB-5 and NB-9, respectively. Total sugar content varied from 16.84 to 19.44% and was highest in cultivar NB-9. Similar observations were also reported by Roy and Singh (1978). [27] Studies were carried out on bael seed protein concentrate (BSPC) to evaluate the proximate, mineral and amino acid composition, nitrogen extractability and functional properties. The protein content was found to be 70.8 g/100 g BSPC. Calcium and phosphorus were observed in major quantities. The bael seed meal (BSM) lipid is found to be rich in unsaturated fatty acids (75%). Essential amino acids occurred in good quantities in BSPC. Nitrogen extractability of BSPC in water was found to be higher at 1:40 (w/v) ratio and an extraction time of 40 min. Minimum and maximum nitrogen extractability as 14 g/100 g protein and 97 g/100 g protein were observed at pH 4 and 12, respectively. In the presence of sodium chloride (0.1 and 0.5 M), the nitrogen extractability was found to be increased between pH 4- 10. Protein precipitability was maximum (90 g/100 g protein) at pH 5.5. SDS-PAGE of BSM and BSPC showed different polypeptides with molecular weights from 205 to 12 kDa (Rao et al., 2011). Volatile compounds in bael fruit pulp were analyzed using the solid-phase micro extraction (SPME)/ gas chromate- graphy (GC)/ mass spectrometry (MS) method (Charoensiddhi and Anprung, 2008). A total of 28 volatile compounds were identified, and the dominant components were monoterpenes and sesquiterpenes. Among these components, limonene was the major constituent producing the characteristic bael fruit flavor. [26-27]

Plant parts	Biological activity
Leaves	Antidiabetic anti-inflammatory, wound healing, antipyretic and analgesic antifungal activity, radioprotective, spontaneous beating and calcium-paradox of myocardial cells, wound healing properties
Leaf and rind essential oil	Antioxidant and antimicrobial, antifungal nematicidal, insecticidal
	Antimicrobial, insecticidal, larvicidal activities
Poultice of leaves	Applied to inflamed parts
Bitter fresh juice	Diluted with water, used as remedy for catarrh and fever
Decoction of leaves	Used for asthma cure
Fresh juice of leaves	Sweetened with honey, used as laxative or febrifuge
Leaf paste	Stop premature hair fall
Leaf powder	Hepatoprotective, antioxidant, hypoglycemic, testicular activity
Fruit, ripe or unripe	Digestive, antiulcer, constipation, ailments, highly nutritive
Dry fruit pulp	Moistened with cold water, yields a red liquid containing mucilage used in burn
Wood	Source of soluble potassium and sodium compounds, 0.16%; phosphates of calcium and iron, 0.13%; calcium carbonate, 2.16%; Magnesium carbonate
Plant stem bark gum	Dysentery, antiulcer
Bark extract	Cytotoxic
Roots, leaves and bark	Dysentery, antiulcer, antidiabetic, anti-inflammatory, antinociceptive, antipyretic
Fruit pulp	Treatment of scum in vinegar manufacture
Fresh, ripe fruit	Edible, use for pickling or as preserves, refreshing and
	Mildly, laxative drink or sherbet
Tender fruit	For slices, immunomodulatory
Young shoots and leaves	Used as vegetable and food seasoning
Mucous fluid (SF)	Rubbed on the hair in place of oil by the rural folk
Decoction of root-bark	Used for hypochondriasis, melancholia, intermittent fever, palpitations
Sweet-scented flower extract	Used as lotion for the eyes
Infusion of flower	Used as cooling drink
Flowers	Limonene-rich oil is used as scent and perfume scenting hair
Unripe or half-ripe fruit	Used to cure diarrhea, acute dysentery, gastroprotective
Pulp ripe fruit	Pleasant laxative and a simple cure for dyspepsia
Bael-marmalade	Anticonvalescence, antidysentery or diarrhea, prevent the growth of piles
Fruit	Antituberculosis
Decoction of unripe fruit	Hemorrhoids
Powder of dried pulp	Dysentery and gripping pains
Wood	Used for small-scale turnery, tool and knife handle, pestles and combs
	Shell of hard fruits fashioned into pill and snuff boxes
Seeds	Abundant gum from the seed used as household glue and adhesive by jewelers
Fruit pulp	Show detergent action, used as a soap substitute for washing clothes
	Used to make water-proofing walls mixed with lime plaster and added to cement. Added to watercolors or as protective coating for paintings
Wild fruit pulp	Contains 9% tannin. Rind yields a yellow dye for calico and silk fabrics
Insecticidal	Leaf extract used as insecticidal against the brown plant hopper, a rice plant pest in Asia

III. PROCESSING OF BAEL FRUIT

Tropical fruits, which are at present under-utilized, have an important role to play in satisfying the demand for nutritious, delicately flavored and attractive natural foods of high therapeutic value. They are in general accepted as being rich in vitamins, minerals and dietary fibre and therefore are an essential ingredient of a healthy diet. Apart from nutritive, therapeutic and medicinal values, quite a few of these tropical fruits have excellent flavor and very attractive colour. Bael fruit is not an easy to eat out of hand item. The bael fruit can be processed for preparation of various products. For all type of products, bael pulp is the first requisite.As the storage quality of the whole fruit cannot be maintained for long period of time, improvement in the post harvest processing will enhance the effective utilization of the fruit. Because of its hard shell, mucilaginous texture and numerous seeds, it is not popular as a fresh fruit. The fruit has excellent aroma which is not destroyed even during processing. Therefore, there is tremendous potential for processing this fruit into various products. It is usually processed into products like preserves, refreshing beverages, powder, leather, squash, nectars, toffee, jam, syrup. These roducts being highly nutritive and therapeutically important can be very easily popularized in internal as well as international markets (Kaushik et al., 2000). [28-29]

A. Extraction of bael pulp

Ripened bael fruits are used for extraction of pulp. The important factors in consideration for ideal extraction of pulp are incorporation of water into pulp, inactivation of enzymes by application of heat and pH adjustment. Extraction of bael pulp was obtained successfully by the addition of water to pulp successfully in the proportion of 1:1 and 2:1. A clear juice was obtained by centrifugation of pulp (fruit: water, 1: 2) at 4000 rpm for 10 min. The power law model was used to determine the viscometric constants. Residual enzyme activity was determined for pulp and juice. Pectin methyl esterase activity was minimum (1.163 U) for juice and was maximum (1.375 U) for pulp (fruit: water, 1:1) (Ghosh and Gangopadhyay, 2002). Bael fruit pulp was successfully extracted by addition of water to pulp in proportion of 1:1 and 2:1 and a clear juice was obtained by centrifugation of the pulp (Fruit-water, 1:2) at 4000 rpm for 10 min.

The extraction of pulp from bael fruit is the main hindrance to the processing. Shrestha (2000) reported that the bael fruit pulp extracted by passing through the sieve without addition of water results in very sticky pulp. The pulp so obtained is unfit for handling and nearly 10% loss of pulp results during extraction, partly left with the pomace and partly sticking to the sieve. This may be due to mucilage content of the pulp. Incorporation of water and application of heat results in dilution of mucilage considerably and make the pulp possible to extract commercially.

Moisture desorption isotherm of bael pulp and adsorption isotherm of pulp powder were determined at 20, 30, 40 and 50°C. Static gravimetric method was used by exposing the samples to controlled atmospheres maintained by saturated salt solutions. The isotherms were found to be of type II sigmoid. The isostearic heat of sorption varied between 47.5 - 44.55 kJ g-1 mol-1 at moisture levels 0.5 - 3.5 g/g dry matter for bael pulp and 46.12 - 44.40 kJ g-1 mol-1 at moisture level between 0.25 - 1.125 g/g dry matter for powder (Bag et al., 2009).

The characterization of bael fruit hydrolysate treated with commercial pectinase enzyme was investigated by Charoensiddhi and Anprung (2010).

The characteristics of bael fruit hydrolysate showed that bael fruit hydrolyzed at time longer than 2 and 4 h gave greater total carotenoids and antioxidant activities, respectively. Hydrolysis of bael fruit at 6 h resulted in the smallest particle size at 79.92 µm. The hydrolysis of bael fruit resulted in higher soluble dietary fiber and volatile compounds, but it did not affect the prebiotic activity score as compared to non treated sample.

The antioxidant potential of bael fruit pulp extracts was studied by Rajan et al. (2011). Results of phyto- chemical screening of the aqueous extract revealed the p resence of steroid, terpenoid, saponin, tannins, lignin and flavonoids. Alcoholic extract showed the availability of

alkaloids and devoid of saponin. In vitro antioxidant activity of the plant extract revealed that both extracts showed good antioxidant power.

Singh et al. (2012) studied the effect of incubation temperature (28.18-61.82°C), incubation time (97.5-652.5 min) and pectinase concentration (0.64-7.36 mg/25 g bael pulp) on juice yield, viscosity and clarity of juice. The recommended enzymatic treatment conditions were incubation time (425 min), incubation temperature (47°C), pectinase concentration (5.0 mg/25 g bale pulp) and the juice yield, viscosity and clarity under these conditions were 84.5%, 1.35 cps and 22.43%, respectively.

Singh et al. (2014) studied the effect of pre-treatment on various physical and thermal properties of bael pulp.The fruit pulp of bael fruit was extracted and TSS of the extracted pulp was raised to 25°Brix by adding 65°Brix sugar syrup. The pH of pulp was set at 3.0 and 3.5, which was heated at 80- 85°C for 15, 20 and 25 min and kept at refrigerated conditions for 80 days.

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The TSS, pH, titratable acidity, colour-L*, a*, b*, thermal conductivity and specific heat ranged between 18-25°Brix, 2.6-3.5, 0.15-0.35%, 20.32-56.87, 2.95-20.28, 23.58-64.01, 0.37- 0.76 w/m°C, 1.73-2.50 J/g°C respectively. Minimum colour change and maximum sensory score was observed at pH 3and 15 min heating under refrigerated storage. The zero or first order models were well fitted for the responses of the bael pulp (3 pH, 15 min) stored under refrigerated conditions. [29]

B. Bael Wine

C. Bael Juice

D. Bael fruitjam

IV. MEDICINAL USES

1) *Diarrhoea and Dysentery:* The unripe or half ripe fruit is the most effective remedy for chronic diarrhoea and dysentery without fever. Best results are obtained by the use of dried fruit or its powder. The fruit, when it is still green, is sliced and dried in the sun. The dried fruit slices are reduced into powder and preserved in air-tight bottles. The unripe fruit can also be baked and taken with jaggery or brown sugar41. The fruit appears to have little effect in acute dysentery when there is definite sensation to defecate without the significant amount of faeces, blood and mucus alone are passed. The powdered drug is specially recommended in sub-acute or chronic dysentery. After the use of the fruit powder in these conditions, the blood gradually disappears and the stools resume a more feculent and solid form42. The mucus also disappears after continued use for sometime. It is also a valuable remedy for chronic dysenteric conditions characterized by alternate diarrhoea and constipation43, 44. Its use has also been reported in the cases of amoebic dysentery.

2) *Hypoglycemic/ Antidiabetic:* Activity Leaf extract has been used in Ayurveda as a medicine for diabetes. It enhances the ability to utilize the external glucose load in the body by stimulation of glucose uptake similar to insulin. Bael extract significantly lowers blood urea and cholesterol in experimental diabetic animals, Extract also decreases oxidative stress in experimental diabetic animals as indicated by significant reduction in lipid peroxidation, conjugated diene and hydroperoxide level and increased levels of superoxide dismutase, catalase, glutathione peroxidase and glutathione levels in serum as well as liver. Juice of leaves is employed as anti-diabetic drug in Unani system of medicine also.
3) *Anticancer Activity:* Bael inhibited in vitro proliferation of human tumour cell lines including the lecukenic K562,T-lymphoid Jurhat, Beta-lymphoid Raji, Erythro leukemic HEL20. Extract of A. marmelos is antiproliferative but it produces effect on MCF-7 and MDA-MB-231 breast cancer cell line when it is in high concentration56-58.
4) *Cardio Protective Effects:* The leaf extract has preventing effects in isoprenaline (isoproterenol)- induced myocardial infarction in rats. The activity of creatine kinase and lactate dehydrogenase was significantly increased in serum and decreased significantly in heart of isoprenaline-treated rats59. Use of Bael as cardiac depressant and in palpitation has also been reported.
5) *Antispermatogenic Activity:* The leaf extract possesses anti-spermatogenic activity as it resists the process of spermatogenesis and decreases sperm motility in rats60. Leaves were used for fertility control in Bangladesh.
6) *Antimicrobial/Antifungal Activity:* Bael extract manifests antiviral and antimicrobial activities. It has been found active against various species such as Staphylococcus aureus, S. epidermidis, Proteus vulgaris, Escherichia coli, Salmonella typhimurium and Bacillus subtilis. It has also been used for Ranikhet disease virus and intestinal parasites, The essential oil isolated from the leaves of Bael exhibits variable efficiency against different fungal isolates and causes concentration as well as time dependent inhibition of spore germination of all the fungi tested, including most resistant fungus, Fusarium udum.
7) *Radioprotective Effect:* Treatment with extract of bael reduces the severity of symptoms of radiation induced sickness and increases survival in mice. The radio protective action might be due to free-radical scavenging and arrest of lipid peroxidation accompanied by an elevation in glutathione concentration in liver, kidney, stomach and intestine.
8) *Antipyretic and Analgesic Activities:* Bael extract exhibits antipyretic, anti-inflammatory and analgesic activities, as it has shown a significant inhibition of the carrageenan induced paw odema, cotton-pellet granuloma and paw itching in mice and rats64. It is also used as febrifuge in night and intermittent Fever.
9) *Constipation:* Ripe fruit is regarded as best of all laxatives. It cleans and tones up the intestines. Its regular use for two to three months helps in evacuation of even theold accumulated faecal matter from the bowels65. For best result, it should be taken in the form of Sharbat, which is prepared from the pulp of the ripe fruit. After breaking the shell, the seeds are removed and contents are then taken outwith the help of a spoon and passed through a sieve. Milk and sugar may be added to make it more palatable. The pulp of ripe fruit can also be taken with the spoon without addition of milk and sugar. About 60g of the fruit/edible part is sufficient for an adult.
10) *In Burn Cases:* The traditional healers of southern Chhatisgarh use dry powder of fruit with mustard oil for the treatment of burn cases. One part of powder and two parts of mustard oil are mixed and is applied externally.
11) *Pepticulcer:* An infusion of leaves is an effective remedy for peptic ulcer. The leaves are soaked overnight in water. This water is strained and taken as a drink in the morning. The pain and discomfort are relieved when this treatment is continued for a few weeks. The fruit taken in the form of beverage has also great healing properties on account of its mucilage, which forms a coating on the stomach mucosa and thus helps in the healing of ulcers.
12) *Respiratory Infections:* Medicated oil prepared from leaves gives relief from recurrent cold and respiratory infections. The juice extracted from leaves is mixed with equal quantity of sesame oil and heated thoroughly, a few seeds of black pepper and half a teaspoonful of black cumin are added to the hot oil, and then it is removed from the fire and stored for use when necessary. A teaspoonful of this oil should be massaged onto the scalp before a head bath. Its regular use builds up resistance against cold and cough. A common practice in South India is to give the juice of leaves to bring relief from wheezing cough and respiratory spasm. The leaf juice is mixed in warm water with a little pepper and is given as a drink.

V. MISCELLANEOUS PROPERTIES

Bael leaves are useful in jaundice and in the treatment of wounds. The extract of leaves is beneficial in the treatment of leucorrhoea, conjunctivitis and deafness. Fruits give feeling of freshness and energy. It is used as carminative and astringent and used in thyroid related disorders. It is also used in treatment of snakebite. It is a cardiac stimulant. Applications have also been reported in anaemia, fractures, swollen joints, pregnancy troubles, typhoid, coma, colitis, bleeding sores and cramps. It is also used as anthelmintic. It is used in treatment of acute shigellosis, as diuretic, in gonorrhea and in conjuctivitis. The powder is used as stomachic. It is used in the treatment of irritable bowel syndrome.

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VI. CONCLUSION

Bel contains diverse bioactive components in leaves, flowers, fruits, wood, root, and bark which show multiple biological activity and high therapeutic importance. Plant contains coumarins, marmelosin, marmesin, imperatorin, marmin, alloimperatorin, methyl ether, xanthotoxol, scoparone, scopoletin, umbelliferone, psoralen, and marmelide and marmenol, aegelin, aegelenine, marmeline, dictamine, fragrine which show different biological activities such as anticancer, antioxidant, antimicrobial, anti-plasmodial, and hepatoprotective. The plant possesses various polysaccharides that contains palmitic, stearic, oleic, linoleic, and linolenic acids which have very nutritive value. The fruit pulp of wild Bel plant also possesses very high tannin contents (9%). Plant leaves contain skimmianine, marmelosin, carotenoids, and umbelliferone which are therapeutically important active principles of Bel plant.A marmelos plant leaves contain an essential oil that shows chemotypic and seasonal variations. Bel fruit restores digestive health and destroy worms in the intestine. It is a good remedy for digestive disorders and recommended for chronic dysentery. Plant unripe fruits are used for the treatment of diarrhea, dysentery, fever, diabetes, and to cure peptic ulcer or piles. Aqueous extract of ripen Bel fruit shows the laxative property. It is used to avoid constipation, discomfort, provide relieve from pain, and other associated health risks. Its leaves are used to reduce inflammation, appetite and water thrust. Dried flower, root, leaf extracts showed anti-inflammatory, anti-spermatogenic activity, improve and protect tissue antioxidant defense system. A. marmelos crude extracts and its chemical constituents show multiple biological activities such as antipyretic, analgesic activity, radioprotective, anti-diabetic, anti-hyperlipidemic, hepatoprotective, antimicrobial activity against various species such as S. aureus, S. epidermidis, P. vulgaris, E. coli, S. typhimurium, and B. subtilis. It also manifests antiviral activities and found active against viruses such as Ranikhet disease virus and HIV.

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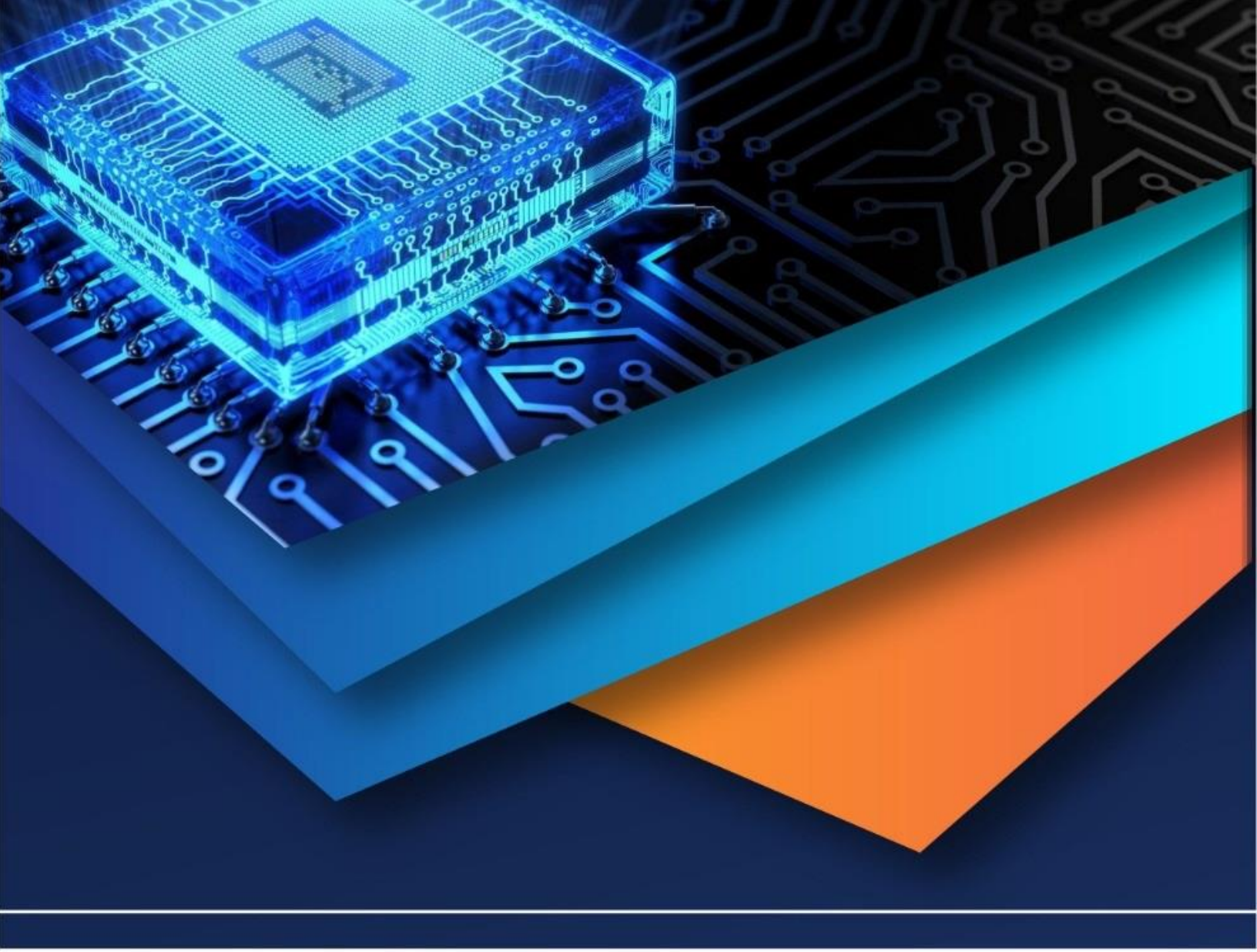

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