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Latex of plants: Wonders of nature for its therapeutic potentials and a valuable resource towards new drug development

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Abstract
This review article is an effort to provide the informative data on plant latex produced by a number of plants and various uses of latex viz. ethno-medicinal use, antimicrobial and anti-analgesic activity, wound healing properties and other necessary products like rubber, chewing gum, footwear, motor vehicle and machinery accessories etc. Among various phytochemicals, plant latex is a rich source of important bioactive compounds which show diverse biological activities against bacteria, fungi, viruses, protozoa, nematodes and insects. It contains glycosides, tannins, phytosterols, flavonoids, acetogenins and saponins of pharmaceuticals importance. In this article, data is accumulated for 30 latex producing plants. Maximum species producing latex is from Euphorbiaceae family. This article could be a valuable source for the researchers and plant latex could be a valuable resource to develop novel drugs against diverse diseases and other industrial useful products.

Keywords: Ethnomedicinal uses, novel drugs, plant latex, valuable resource

1. Introduction
Therapeutic use of plants, plant parts and plant produce has evolved with human civilization. Indigenous plants are used for centuries all over the world to manage a variety of ailments which have showed clear pharmacological activities. In recent times, use of natural products has increased, that results a very high demand of herbal products for therapeutic, clinical and agricultural purposes. Latex is produced by 20,000 species belonging to 40 families occurring in multiple lineages in both monocotyledons and dicotyledons [1]. Latex is produced by 10% of all flowering plants as a plant defense activity around the globe [2]. The Latex has multiple uses for humans, but for the plant they are often known as plant venom. When exposed to air such as when a snail or insect cuts a leaf, the oxygen level coming in contact with the latex makes the chemical change to become poisonous to the herbivore such as an insect or snail or slug or other animals. Therefore, it is used as pesticides and has immune allergens activity.
Among various phytochemicals, plant latex is a rich source of important bioactive compounds which show diverse biological activities against bacteria, fungi, viruses, protozoa, nematodes and insects. It contains glycosides, tannins, phytosterols, flavonoids, acetogenins and saponins of pharmaceuticals importance. It is also used as disinfectant, anticoagulant, anti-inflammatory, antioxidant and anti-proliferative agent that provide protection in wounds. Latex of some plants is also used in treating cancer and tumors.

2. Materials and Methods
The objective of this review article is to systematically gather the best available information of plant latex and the presence of bioactive compounds such as phenols, phytosterols, along with its antimicrobial activity, ethno-medicinal and other uses. The review includes the studies conducted on ethomedicinal, antibacterial, wound healing properties and effectiveness of bioactive compounds present in 30 latex yielding plant species. For this study a three staged search strategies were used to identify all the relevant published literature. Data bases searched were PubMed, Researcgate, MedNar and Med Know. Secondary search was carried out using Google Scholar and Elsvier's Scirus to identify the articles that are not indexed well in traditional bibliographic data bases. The search stategy used or modified for the various data bases and search engines was the initial keywords and search terms like 'phytochemicals, plant latex, antibacterial and medicinal uses of plant latex.

3. Results & Discussions
3.1 Composition of Plant Latex
Latex as found in nature is a thick, creamy white, milky emulsion, although sometimes it may be a thin, clear, yellow or orange, aqueous suspension found in 10% of all flowering plants consisting of proteins, alkaloids, starches, sugars, oils, tannins, resin and gums that coagulate on exposure to air. It is usually exuded after tissue injury. In most plants, latex is white, but some have yellow, orange, or scarlet latex. Since the 17th century, latex has been used as a term for the fluid substance in plants. It serves mainly as defense against herbivorous insects [2]. Latex is not same as plant sap, rather it is a separate substance, produced separately having various functions. Latex is produced in vessels or special cells called laticifers, single cells, or strings of cells that form tubes, canals, or networks in various plant organs and are quite different from the internal secretory tissues like pockets, cavities or canals in which most resin is produced.

3.2 Families Producing Latex
Latex is produced by over 40 families occurring in multiple lineages. Plant families that produce copious amounts of latex include spurge/castor family (Euphorbiaceae), milk weed family (Asclepiadaceae), mulberry family (Moraceae), dogbane family (Apocynaceae), and chicory tribe

(Lactuceae) of the sunflower family (Asteraceae). Many latex bearing plants *Euphorbia antiquorum, E. antisyphilitica, E. caducifolia, E. neerifolia, E. nivulia, E. royleana, Calotropis procera, C. gigantea, Cryptostegia grandiflora, Plumeria alba, Nerium indicum and Mimusops elengi* were evaluated as potential renewable sources of energy crops for liquid fuels, non-polar constituents and chemicals [2]. It is also found in conifers and pteridophytes. Data revealed that 14% of tropical plant species produce latex, as opposed to 6% of temperate plant species. Among the families, Euphorbiaceae is one of the largest and most diverse families of the angiosperms comprising 317 genera grouped in five subfamilies with 7500 species. In this review article maximum latex yielding species belong to Euphorbiaceae family (Table 2, Fig. 1) The members of the family are economically very important and produce a variety of chemicals such as rubber, oils, waxes, hydrocarbons, resins, sterols, triterpenes, balsams and other biochemicals.

3.3 Uses of Plant Latex

Latex has many uses in traditional systems of medicines, used in clothing and paint industry. Natural plant latex, which is nearly chemical free, is used in the manufacturing of natural latex mattresses, beauty application pads and cushioning. Apart from this, plant latex is used by the indigenous groups as their phytomedical remedies based on practice for primary health care. Literature data revealed that latex of many plant species showed antifungal, antibacterial and anti-insecticidal activities.

3.4 Ethno medicinal Properties of Plant Latex

The ethno medicine covers healthcare systems that include beliefs and practices related to diseases and health, by the indigenous groups as their personal phytomedical remedies as well as for spiritual reasons. The milky sap of *Apocynum caanabinum* is used as a folk medicine to treat veneral warts [3].The juice of *Euphorbia hirta* is used as tonic, narcotic, antiasthmatic, and effective against dysentery, diarrhea, and colic, especially amoebiasis. *C. procera* latex is mixed with turmeric powder and boiled in sesame oil to make apaste and the paste is applied to the joint to relieve from arthritis [4]. It was studied the antibacterial properties properties of leaf extract of *Cryptostegia grandiflora*, the leaf extract was also used as antitumor agents [5] ; *C. grandiflora* leaf extract was also reported as a potential source of industrial raw materials and an alternative for conventional oil [6] . Latex of this plant is used to cure ulcers and skin problems like scabies [7].

3.5 Antimicrobial Activity of Plant Latex

The literature data revealed the potent antimicrobial activity of *Euphorbia thymifolia* against microbes like *Escherechia coli*, *Psudomonas aeruginosa*, *Bacillus subtilis*, *Salmonella typhii*, *Staphylococcus aureus*, and *Klebsiella pneumonia* and extracts of *Euphorbia thymifolia* were usedin drugs like fluconazole and ciprofloxacin to control microbes [8]. It was reported that the methanolic extracts of *Croton bonplandianum* showed antifungal activity against selected fungal pathogens like *Mucor* sps, *Aspergillus flavus*, *Rhizopus* sps, and *Penicillium* sps [9]. *Calotropis gigantea* latex extract proved as the important source of potentially useful structures for the development of novel chemotherapeutic agents [10]. The study was aimed to evaluate the antifungal effect of partially purified *C. gigantea* latex extract on some human pathogenic fungi. Ethanolic extract of the latex were tested *in vitro* against fungi strains. The inhibitory effect was assessed by disc diffusion method. The minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) were also determined by serial dilution method. The ethanolic extract was subjected to qualitative phytochemical screening for the presence of bioactive ingredients. The ethanolic extract shows the presence of many biologically active molecules such as flavonoids, alkaloids, triterpenoids, steroids, saponins, phenols and glycosides. The latex extract showed significant zone of inhibition in dose dependent manner and was concluded that the latex extract possesses potent fungicidal activity which might be because of the presence of biologically active ingredients with antimicrobial activity in the ethanolic extract of *C. gigantea* latex.

3.6 Wound Healing Activity

Latex of several plants gained medicinal importance and is exclusively used as a common remedy to stop bleeding on fresh cuts and wound healing. The foundation laid for the search of pharmacologically active plant molecules is by the traditional knowledge which is passing from generation to generation. The observed pharmacological activity of plant latices is attributed to the presence of proteolytic enzymes in it. Proteases found in plant latices belong to either cysteine or serine protease family, only one is a member of aspartate protease family. Plant latex proteases exhibit procoagulant action irrespective of the plant species and family. The wound healing activity of latex of *Calotropis gigantea* R.Br. was studied by using excision and incision wound model and the latex showed the significant wound healing activity as like as standard FSC (Framycetin sulphate cream). It was reported that *Euphorbia caducifolia* (ECL) latex [11] is used by the local inhabitants for treatment of bleeding wound, cutaneous eruption and other skin diseases and therefore, was scientifically evaluated the ECL for the wound healing activity by *in vitro* methods. Clotting of platelet free plasma and angiogenesis in chick chorioallantoic membrane (CCM) were used for studying effect of ECL on clotting and angiogenesis. Excision and incision wounds model were used to study effect of ECL on wound contraction, tensile strength and hydroxyproline and DNA content. Plant derived molecules have found to be potential intervention with the human physiological events. The nature of procoagulant action of plant latices (serine proteases) is not clear. Whereas cysteine proteases from plant latices exhibited specificities upon coagulation factors in inducing plasma coagulation. Therefore, *E. caducifolia* latex is used to treat accidental bleeding wounds [11]. Ficin derived from *Ficus carica* shown to activate coagulation factor X. Cysteine proteases present in the latices of Asclepiadaceae plants have got thrombin like activity. Thrombin like activity of plant latex cysteine proteases is due to specific cleavage of fibrinogen molecules releasing fibrinopeptides.

3.7 Analgesic Activity of Latex

Latex of *Calotropris procera* showed analgesic activity (Deewan 2000). The dry latex (DL) was evaluated against the analgesic activity of *C. procera*. A single oral dose of DL ranging from 165 to 830 mg/kg produced a significant dose dependent analgesic effect against acetic acid induced

writhings. The effect of DL at a dose of 415 mg/kg was more pronounced as compared to a 100 mg/kg oral dose of aspirin. On the other hand DL (830 mg/kg) produced marginal analgesia in a tail-flick model which was comparable to aspirin. Hepatoprotective effect of *Ficus religiosa* latex on cisplatin induced liver injury in Wistar rats was experimented [12]. The chemical constituents of *F. religiosa, a tropical plant* reported to contain tannin, saponin, gluanol acetate, β-sitosterol, leucoanthocyanidin, and leucoanthocyanin. These are used for the treatment of pain, inflammation, impotence, menstrual disturbances, urine related problems and also used as uterine tonic (Table 1).

3.8 Products Obtained from Plant Latex

The three most common products made from latex are rubber, chewing gum, and opium. It contains wide variety of industrially important metabolic substances which can be harvested, modified, quenched and polymerized easily for making goods and materials by up-gradation of technology [13, 14]. *Guayule* is one such plant extract that is used as latex or rubber to make rubber bottom sandals, and also to fight bacteria such as tuberculosis [15].

Table 1: Latex yielding plants and its important uses

Sl. No	Plant species	Family	Odia name	Common name	Uses
	Apocynum cannabinum	Apocynaceae		Indian hemp	Chewing gum (Kunkel, 1984), to treat fever, dysentery.
	Croton bonplandianum	Euphorbiaceae	Vana tulasi/jungle tulasiLankamaricha	Bonpland's croton	Wound healing, head ache [16]
	Calotropis gigantea	*Apocynaceae*	Sweta Arakha	Crown flower/Giant Milkweed	antifungal activity
	C. procera	*Apocynaceae*	Arakha/rakta Arakha	King's crown/Apple of sodum	Relieve from ear ache, arthritis, latex used for commercial preparation of eye tonic
	Cryptostegia grandiflora	*Apocynaceae*	Chabuk chhuri/ Bilati bakhandi	Rubber vine/Purple almonda	Antitumor, antibacterial, ulcers, skin infections especially scabies
	Euphorbia antisyphilitica	Euphorbiaceae	--	Wax plant/Candelilla	Effective for treatment of veneral disease, chewing gum, cosmetics, shoes, candles, artificial flowers, leather dressing, cloth waterproofing, adhesives, cement, crayons, lead pencils [1]
	E. antiquorum	Euphorbiaceae	Siju/Deulia siju	Malayan spurge/Triangular spurge	Latex has inhibitory effects on several different cancer cell lines [17]
	E. caducifolia	Euphorbiaceae	Khira siju/Danda siju	Leaf less milk hedge	To treat weak eyes, leprosy, body pain, jaundice, tumors, skin allergy [18]; boils [19]; injuries and fracture [20]; increase male sexual vigour [21]; colic [22]; snake bite, scorpion bite[23]
	E. hirta	Euphorbiaceae	Chita kutei	Asthma weed/Cat's hair/garden spurge	To treat warts, fungal infections between the toes, removal of thorns from the skin [24]
	E. nerifolia	Euphorbiaceae	Trikona siju/Tina siju/Gurda	Indian Spurge tree/milk spurge	Laxative, carminative, whooping cough, expectorant, gonorrhea, leprosy, asthma, jaundice, stone in bladder, enlargement of spleen, toumors, abdominal troubles and leucoderma [25, 26]
	E. nivulia	Euphorbiaceae	Bada siju/Katha siju/ Svarasana	Leafy milk hedge/Dog's tongue	bronchodilating activity and skin, ear disorders, retention of urine, swelling and worm infection[27]
	E. pulcherima	Euphorbiaceae	Khrist masa gachha	Poensettia	Dreid latex showed anticonvulsant effect [28]
	E. royleana	Euphorbiaceae	Kanta siju/Danda siju	Royel's spurge/Danda Thur	Anti-inflammatory, anti-arthritis [29]
	E. tirucali	Euphorbiaceae	Khadi siju/Khira sagara/Danguli siju	Milk bush	whooping cough, gonorrhea, leprosy, asthma, jaundice, colic, stone in bladder, stone in bladder [30]
	E. thymifolia	Euphorbiaceae	Patra siju/laghu dugdhika/ Ranga alati	Chicken weed	Used to treat acne vulgaris, menorrhagia [31, 32]
	Ficus benghalensis	Moraceae	Bara gachha	Banyan tree	Low quality rubber, aphrodisiac, tonic, reduces inflammation, piles, nose diseases, gonorrhea [33]
	F. benjamina	Moraceae	Kuji bara gachha	Weeping fig/Benjamin tree	Liver disease [34]
	F. carica	Moraceae	Anjeer	Common fig	Hypolipidemic, expectorant, diuretic, anthelmintic, anemia, laxative [35]
	F. elastica	Moraceae	Rabara	Indian rubber tree/Assam rubber	insect bite [36], trichuriasis (whipworm infections) tires, components of cars, foot wear, gloves [15]
	F. hispida	Moraceae	Bai dimiri		Ring worm, unripe fruit latex is used to treat vitiligo, diabetic ulcer [37], mild anti-inflammatory activity [38]
	F. racemosa	Moraceae	Dimiri	Indian Fig tree/Cluster fig	Leaf latex is used to treat boils, blisters and measles [39]
	F. religiosa	Moraceae	Aswastha	Pipal tree	Latex is used as tonic [40]
	Hevea brasiliensis	Euphorbiaceae	--	Para rubber tree	Foot ware, belts, ware cables, tires, tubes of vehicle, toys, gloves [41, 42]
	Mimusops elengi	Sapotaceae	Baula/Bakula	Spanish cherry	Scabies and skin sores [43]

	Nerium indicum	*Apocynaceae*	Karabira	Oleander	ear pain [44]
	Papaver somniferum	Papaveraceae	Aphima	Opium poppy	Analgesic, antitiussive, antidiarrhoeal, sedative
	Parthenium argentatum	Asteraceae	Gajar ghasa	Guayule	Rubber alternative production, no medicinal uses known till now
	Pegularia daemia	Asclepiadaceae	Brusha gandha/Uturudi	Trellis vine/hair not plant	Veneral diseases, arthritis, muscular pain, asthma, rheumatism, snake bite [45]
	Plumeria alba	*Apocynaceae*	Champa	Frangipani	In treating ulcers and skin infections [46] ; herpes, scabies and skin ulcers [47]
	P. rubra	*Apocynaceae*	Katha champa	Temple flower or Pagoda tree	To treat boils and rheumatic pain, removal of worms and germs from wound, to treat tooth ache [48]; with coconut oil to treat itching [49]

Table 2: Percentage of plants species in different families

Sl. No.	No. of plant species	Families	Total no of plants	Percentage
1.	7	Apocynaceae	30	23.33
2.	1	Asclepiadaceae	30	3.33
3.	1	Asteraceae	30	3.33
4.	1	Papaveraceae	30	3.33
5.	1	Sapotaceae	30	3.33
6.	7	Moraceae	30	23.33
7.	12	Euphorbiaceae	30	40

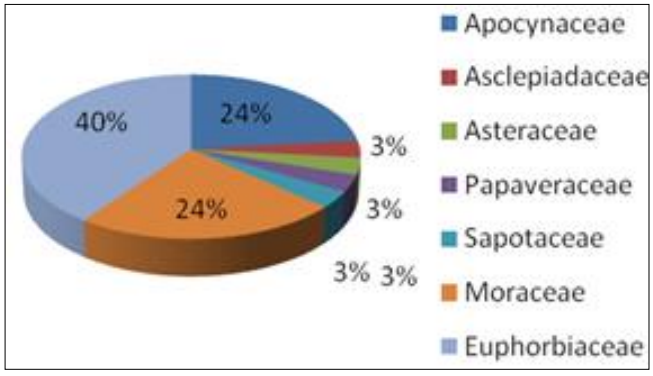

Fig 1: Latex producing plants in various families

Latex of *Euphorbia royleana boiss* is considered as the source of gomutra silajit (silajatu) and known as an ancient miraculous drug of India. The latex of *E. royleana* contains a mixture of water solubles, alcohol solubles, and caoutchouc, a vegetable gum. It emits a sweet odour and flavours. There are a number of factors responsible for the variability of composition of latex. Organic products so far reported in the latex are resins, gums and mucilages, albumins, waxy matter; fat and fatty acids and their esters. Papain isolated from crude latex of *Carica papaya* L. found in various proteolytic activities and is used in cosmetic industries and also utilized in agricultural farms to accelerate production and reduction of environmental hazards. Papain is used in brewing and wine making industries, textile and tanning industries [50].

4. Conclusion

The flora of India has rich latex yielding plant diversity, with potential for developing drugs for to treat bacterial and fungal diseases besides its general used as chewing gum, rubber components for vehicles, machines and other consumer products like footware, toys, gloves etc. The latex can be used in cosmetics industry for skin care and also can be used as anti- insecticide products. This accumulation of data on 30 latex yielding species could be a valuable resource for the researchers to develop various drugs and other industrial products. Maximum species producing latex is from Euphorbiaceae family. No doubt plant latex will be a future raw material for many bioengineering and biotechnological industries proposed.

Conflicts of Interest: There is no conflict of interest.

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