REVIEW ARTICLE

Anti-termite and antimicrobial efficacy of latexes from certain plant families

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Abstract

The present article explains the effect of plant latex and its formulations on termite control. Latex is natural plant polymer secreted by highly specialized cells known as laticifers. It is a milky white thick complex mixture of proteins, alkaloids, starch, sugars, oils, tannins, resins, and gums. Both latex and its components show multiple deleterious effects such as toxic, antifeedant, and repellent activities. These effectively inhibit growth and reproductive behavior in number of insect species. Latex components delay egg maturation, development, and inhibit gonad development in termites. Latex constituents display contact and systemic action and primarily used as poison baits to control soil termite. Latex-based combinatorial anti-termite formulations could be used in spray for termite control. The usage is safer than synthetic chemicals and will minimize the risk of poisoning of food chain, soil, and aqueous environment. This review article suggests the use of slow release of latex components inside soil when applied as poison baits for control of field termites.

Key words: Plant latex, Anti-termite activity, Latex secreting plant species, Latex component, Natural plant polymer

INTRODUCTION

Termites are one of the most agriculturally important insects and are known to cause enormous economic losses to many crop plants and tree species, buildings, etc. Termites are detritus feeders and feed on dead plants and trees. The main factors behind the presence of a large population of termites are humidity, mild temperature, and other climatic factors. The Indian white termite, *Odontotermes obesus* (Rambur) (Isoptera: Odontotermitidae), is highly destructive polyphagous insect pest, lives in huge mounds, and feeds on cellulose material and almost anything which contains carbohydrate. It causes economic damage to commercial wood, fibers, cellulose, sheets, papers, clothes, woolens and mats, and woody building material and infests green standing foliage, and cereals stored in go down. Both worker and soldier termites harm non seasoned commercial wood and its formed materials. Whether it is a rural area or an urban domestic site, termite menace is everywhere. Termites are known as silent destroyers because of their ability to chew wood, clothes, and harm to crop fields. Each year termites cause about $ 30 billion in property damage.

There are about 2000 known termite species in the world. There are four types of termites found in all over the world, that is, subterranean dry wood damps wood and powder post. Subterranean termites are highly dreadful damage about 95% of crop systems and other materials all over the world. In Tarai belt of Gorakhpur termites, menace is seen in different local regions, mainly in crop fields, household, and forests. In this area, the main species of termite are *O. obesus* (Indian white termite and red termite *Coptotermes* sp.). Subterranean termites are major pest worldwide, causing billion of loss in crops and household things annually. Similarly, at the global level in both tropical and sub-tropical countries, the infestation of drywood termite *Cryptotermes brevis* (Kalotermitidae) is one of the most important wood structural pests in the world.[1] Termites have presented human society with some of its greatest development challenges by consuming crops and damaging infrastructure. From report, these reported goods and services are a rough estimate that invasive insects cost a minimum of US$30.0 billion per year globally[2] The subterranean termite *Globitermus sulphureus* are an important Southeast Asian pest causes damages to agriculture

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crops and building structures.[3] Latexes are secreted by many flowering plant families. In this article, the latex and other plant natural products have been suggested for termite control. They inhibit metabolism in termites and kill them due to antifeedant, repellent, and toxic action.

Termites infest at various stages of plant growth and cause severe losses in sugarcane, maize, wheat, fruits, etc.[4,5] In crop fields, termites cause 50–100% losses in yield.[6,7] Termite heavily damages plant foliage and destroys young saplings. However, for controlling termite attack, harmful synthetic chemical pesticides are extensively applied.[8] For controlling termite on crop plants, various synthetic pesticides such as cyclodiene,[9,10] hydroquinone, and indoxcarb[11] have been used. Dursban spray was found highly effective in the management of wood destroying termites.[12] These chemicals put serious deleterious effect on non-targeted biotic and abiotic factors of environment.[13] Although, chemical insecticides are highly effective against termite, they are hazardous to non-target organisms in the ecosystem.[14] It's bound residues persists for longer duration in the environment, and through various trophic levels, they entered into the food chain. Hence, there is a need to replace chemical pesticides by natural plant origin pesticides.

SOURCE OF INFORMATION

For writing this comprehensive research review on plant latexes, various databases were searched. For the collection of relevant information, specific terms such as phytochemical subject headings (PhytoSH) and key text words, such as "Family Apocynaceae, Moracae, Companulaceae," "plant latexes," and "insecticidal activity," published till 2022 were used in MEDLINE. Most specially for retrieving all articles pertaining to the use of plant latexes, electronic bibliographic databases were searched and abstracts of published studies with relevant information on the plant latexes were collected. Furthermore, additional references were included through searching the references cited by the studies done on the present topic. Relevant terms were used individually and in combination to ensure an extensive literature *s*earch. For updating the information about a subject and incorporation of recent knowledge, relevant research articles, books, conferences proceedings, and public health organization survey reports were selected and collated based on the broader objective of the review. This was achieved by searching databases, including "SCOPUS, Web of Science, EMBASE, PubMed, PMC, Publon, Swiss-Prot, and Google searches." From this common methodology, discoveries and findings were identified and summarized in this final review.

LATEX SECRETING PLANT SPECIES

More than 12,000 plant species secrete latex.[15] The major producers of latex are *Hevea brasiliensis*, *Ficus benjamina*, *Campanula glomerata,*[16] and *Chelidonium majus* (Papaveraceae).[17] Some common latex secreting plants from family Euphorbiaceae are *H. brasiliensi*, *Euphorbia bicolor*, *Synadenium grantii, Sapium glandulosum, Jatropha gossypiifolia, Hura epitans,* and *oton urucurana.* Major latex secreting plants from Moraceae are *Ficus carica, Maclura tinctoria, Maclura pomifera, Brosimum gaudichaudii, Antiaris toxicaria, Artocarpus heterophyllus,* and *Dorstenia luamensis. Taraxacum koksaghyz, Scorzonera latifolia, Lactuca serriola, Parthenium argentatum, Solidago virgaurea*, and *Artemisia annua* are common latex bearing plants from family Asteraceae. *Cannabis sativa* and *Humulus lupulus* are two common latex secreting plants from family Cannabaceae.[18] Plants secrete larger amounts of latex that is used to fight against herbivorous insect pests.[19]

Latex is the milky sap that is produced by specialized cells known as laticifers of several plant species. This tissue is found distributed in the mass of parenchymatous cells throughout plant body.[15] They contain numerous nuclei which lie embedded in the thin lining layer of protoplasm. This tissue consists of thick walled, greatly elongated and much branched ducts containing milky or yellowish-colored liquids.[20] Latex cell is also called as "non-articulate latex ducts," these ducts are independent units which extend as branched structures for long distances in the plant body.[21] Latex vessels are mostly found in many latex secreting plant families such as Papaveraceae, Compositae, Euphorbiaceae, and Moracesae.[22]

Apocynaceae is one of the largest and important families in angiosperm. This family is famous for latex secreting plants, that is, *Allamanda*, *Alstonia*, *Calotropis*, *Catharanthus*, *Cerbera*, *Dyera*, *Kopsia*, *Nerium*, *Plumeria,* and *Vallaris.*[23,24] The common latex secreting plants of family Apocynaceae are *Allamanda cathartica*, *Alstonia angustiloba*, *Calotropis procera*, *Catharanthus roseus*, *Cerbera floribunda*, *Dyera costulata*, *Nerium oleander*, *Plumeria alba*, *Vallaris glabra*, *Hancornia speciosa*, *Acokanthera oblongifolia*, *Apocynum cannabinum*, *Thevetia peruviana*, *Rauvolfia serpentine*, *Plumeria rubra*, *Tabernaemontana divaricata,* and *Himatanthus drasticus*).[25] The milkweed plant secretes white or milky thick latex rich in cardenolides, proteinase, alkaloids, terpenoids, steroids, flavonoids, glycosides, simple phenols, lactones, and hydrocarbons and other bioactive compounds.[25] Cysteine proteases and chitin-related proteins and other proteins play major role in defending plants from herbivores.[26] These ingredients are responsible for their antibacterial, antifungal, anthelmintic, cytotoxic, and insect repellent activities.[27] They show synergism to prevent the plants from herbivory or infection.[21] Campanulaceae are recognized by their white latex.

Family Euphorbiaceae is well known for latex secretion. *Euphorbia* species contain diverse phytochemicals such as terpenoids, flavonoids, and polyphenols, which constitute the secondary metabolites.[28,29] *Euphorbia* latex is highly toxic, irritant, and strongly inhibit feeding in herbivorous insects.[30]

The latex is the most valuable product obtained from *Euphorbia* species. *F. benjamina* and *H. brasiliensis* latex coagulation mechanisms deter termites from feeding.[31] *Euphorbia* plants are believed to be a promising source of phytochemicals used in the pharmacy and food industries (Table 1).

TERMITE CONTROL BY PLANT LATEX

Plants synthesize so many secondary metabolites including latex which protect plants from physical damage caused by chewing herbivores insects pests.[21,32,33] Latex exudes from plant parts after having an injury. Plant latex contains alkaloids mainly glycosides which heavily deter herbivorous insects and target insect pests effectively.[34] Alkaloid glycosides also display strong anti-termitic activity.[35] Latex also contains proteins which inhibit feeding behaviors in termites.[17] It protects from wound injuries against insect bites and infection.

Plant latex is secreted to maintain plant defense against a diverse group of organisms.[36-38] Latex is secreted by 10% of plant families to prevent plants from chewing herbivory.[21] Plant latex shows counterattack insect invasion. It can be used in environmental-friendly pest management of not only termites but also other insect pests. It may help to control pests and reduces harmful use of pesticides. Termites can be controlled by green pest management using clean cultivation, sanitation, biological and cultural control, least toxic chemical pesticides, and minimum use of chemicals and avoid killing of non-target species by spraying in target locations.[39] Plant latices with various formulations were found toxic when applied as contact or spray against termites. A high termite repellency and mortality are reported after direct or forced indirect exposure to the plant latexes. Plant latex-based formulations could be used for soil treatments to check menace of soil termites.[40] Use of synthetic chemicals is harmful for non-target organisms, these persist for longer time in environment. Hence, there is a need to search for plant-derived compounds as an alternative for termite control.[41]

There are few prominent plant families which produce larger amount of latex are Euphorbiaceae, Asclepiadaceae, Moraceae, Caricaceae, Papaveraceae, Apocynaceae, Cannabaceae, and Asteraceae.[42,43] Few other families Loganiaceae and Rubiaceae are monoterpenoid indole alkaloids in latex (Table 2).[44]

Bio-organic Products from Latexes

Cardenolides

Plant latex is a potential source of bioactive compounds mainly mixture of proteins, carbohydrates, oils, and secondary metabolites. Toxic cardenolides (cardiac glycosides) are also secreted by milkweeds and deter herbivores from feeding.[45] Cardenolides are chief constituent of latex of family Apocynaceae members.[46] Both Apocynaceae and *Asclepediaceae* possess more than 300 cardenolides.[47,48] Cardenolide mainly cardiac glycosides, that is, strophanthidin beta-D-glucomethylosido-D-alloside and beta-D-digitoxosido-D-alloside has been isolated from Moraceae plants. Cardenolides and its derivatives covenosigenin, glucopyranoside, and acospectoside play an important role as antifeedant in termites.[49,50] Various cardenolides have been isolated from *Pergularia tomentosa*,[51] *Calotropis gigantean*,[52] *Asclepias curassavica,*[53] and *Nerium indicum* showed high toxicity against termites.[54] Similarly, ischarin and ischaridin from *C. procera* found toxic against termoites,[55] while cerberin from *Cerbera odollam* is toxic to termites and causes significant mortality.[56]

Alkaloids

Indole alkaloids such as ervatamines and its derivatives are major components of the latex in latex secreting plants.[57,58] These exhibit good insecticidal activity against insects much similar to rotenone.[59,60] The alkaloids vinblastine and vincristine are bisindole alkaloids derived from coupling vindoline and catharanthine, monoterpenoid indole alkaloids produced exclusively by the Madagascar periwinkle (*C. roseus*). These are used for insect suppression of insect population.[61] Iridoids alkaloids exhibit anti-insect properties. These could be used to produce bioinsecticides.[62]

The alkaloid rauvomitorine A-I and C-9-methoxymethylene-sarpagine isolated from latex of *Rauvolfia vomitoria*, inhibit acetylcholinesterase inhibitory activities in termites.[63] Alkaloids from *T. divaricata* named Taberniacins A and B show anti-termite efficacy.[64] Few important alkaloids alkaloid tabernaines from *Tabernaemontana bufalina* latex; melotenine A and aspidosperma isolated from the latex of *Melodinus axillaris*, were found toxic to termites.[28,65] Other alkaloids isolated from melotenuines A-E isolated from *Melodinus henryi have* anti-termite properties.[66,67] Alkaloids isolated from *Melodinus tenuicaudatus*[68] and *Leuconotis eugeniifolia* show antiplasmodial activities and toxic to termites (Table 2).[69]

Peptidases

Plant latexes from family Apocynaceae contain peptidase which showed rich cysteine-protease activity. Cysteine proteases, such as ficin and bromelain, show toxicity against termites.[70] Cysteine peptidases are the most abundant enzymes in latex fluids. These also provide defense against phytopathogens.[71] Similarly, cysteine peptidases: Procerain and procerain B isolated from latex of *C. procera* also show strong of proteolytic activity.[72] The presence of enzymatic activities in latex is used to make potential resistance against phytopathogens and insects.[71] A rich amount of cysteine peptidases is also reported in latex from *T. peruviana.* It also contains peptidase inhibitor, cysteine peptidases, peroxidases, and osmotin.[73]

Philibertain, caricain,[74] and asclepain[75] are cysteine peptidases inhibitor. Latex-bearing plants also host insects. Latex peptidase inhibitors also compete with inhibitors of

Table 1: Anti-termite activity of different plants latexes.

S. N.	Name of plants	Common Name	Activity against species
1.	*Ficus lacor*	Java fig	Anti-antiarthritic, antidiabetic, anti-inflammatory
2.	*Ficus hirta*	Hairy mountain fig	Antibacterial and anti-cancerous
3.	*Ficus sarmentosa*	Nepal fig	Antibacterial, antifungal, antioxidant activity
4.	*Ficus palmate*	Jungli anjir	Antimicrobial, antibacterial activity.
5.	*Ficus neriifolia*	Willow –leaf fig	Anti-inflammatory effects of phenolic compounds
6.	*Ficus semicordata*	Drooping fig	Antioxidative and antibacterial activities
7.	*Ficus pumila*	Creeping fig	Cause phytophotodermatitis potentially serious skin inflammation
8.	*Ficus virens*	White fig	Anti-inflammatory activity
9.	*Milicia excels*	African Teak	*In vitro* antioxidant staphylococcal activity
10.	*Ficus racemosa*	Goolar	Various diseases/disorders including diabetes, liver disorders, diarrhea, inflammatory conditions, hemorrhoids, respiratory, and urinary diseases
11.	*Ficus religosa*	Pippal	Treatment of pain, inflammation, impotence, menstrual disturbances, and urine related problems, and as uterine tonic
12.	*Ficus benghalensis*	Banyan	Used for the treatment of neuralgia, rheumatism, lumbago, bruise, nasitis, gonorrhea, inflammations, cracks of the sole and skin disease and in Ayurveda for diarrhea, dysentery, and piles
13.	*Morus alba*	White mulberry	Insecticidal activity
14.	*Ficus auriculata*	Elephant ear fig	Anti-bacterial and antioxidant activity
15.	*Ficus carica*	Common fig	Inhibition of cancer cell growth in digestive tract
16.	*Ficus hispida*	Devil fig	Anti-diarrheal activity
17.	*Ficus elastic*	Rubber fig	Anthelmintic activity and parasitic worm infection etc.
18.	*Ficus ampilissima*	Indian Bat fig	Antibacterial, antifungal, antioxidant activity
19.	*Artocarpus heterophyllus*	Jackfruit	Anti-inflammatory effects of phenolic compounds
20.	*Ficus sycomorus*	Sycamore fig	Antibacterial, anti-inflammatory

Table 2: Anti-termite activities of plant latexes from different family

S. No.	Name of plant	Common Name	Activity against species
1	*Hevea brasiliensis*	Rubber tree	Coagulation mechanisms among the more than 20,000 Latex-bearing plant species are lacking
2	*Chelidonium majus*	Greater celandine	Traditional folk medicine to treat papillae, warts, condylomas, which are visible effects of human papilloma virus infections
3	*E. peplus*	Radium weed	Constitutive defense metabolites against insect herbivores and pathogens for the plant
4	*Thevetia peruviana*	Yellow oleander	Antifungal activity against the isolates followed by *Manilkara zapota*
5	*P. amapa*	Amapa-Amargoso	Change *Chrysomya megacephala* post-embryonic development
6	*Plumeria pudica*	Golden Arrow	Animals against inflammatory ulcerative colitis
7	*Synadenium grantii*	African milk bush	Nematicidal activity on *Meloidogyne incognita* and *Panagrellus redivivus*
8	*Euphorbia obtusifolia*	Spurge	Inhibitory activity on the mammalian mitochondrial
9	*Euphorbia tirucalli*	Indian tree spurge	Determine the molecular basis of the laticifers functions in this plant
10	*Plumeria rubra*	White Frangipani	Against *Aedes aegypti* and *Anopheles stephensi*

gut peptidases and show resistance susceptibility of plant latex to termites.[76] Araujiain is latex cystein peptidases from *Araujia angustifolia* shows proteolytic activity and can be used as a potent termicidal agent to kill the symbionts of termites.[77] Cystein peptidases ervatamin-A, ervatamin-B, and ervatamin-C from *Ervatamia coronaria* show anti-termitic activity (Ghosh *et al.*, 2008).[78] Cysteine peptidases named 12, 16-dihydroxicalotropin, calotropin, corotoxigenin 3-O-glucopyranoside, and desglucouzarin isolated from the latex of *Asclepias subulata*, it promotes cell death through caspase-dependent apoptosis in termites. Plant latex acts as an anticoagulant to stop bleeding and wound healing.[79]

Cysteine proteases from family Apocynaceae plants latex exhibited both thrombin and plasmin like activities.

Flavonoids

Flavonoids are secondary metabolites having a polyphenolic structure. These are widely found in fruits, vegetables, and certain beverages.[80] Biochanin A flavonoids from Apocynaceae plant latex found most effective in reducing fecundity and it also acts as antifeedant against *Coptotermes formosanus* Shiraki.[81] The chief flavonoids from the latex of *Apocynum venetum* are plumbocatechin A, 8-O-methylretusin and kaempferol 3-O-(6″-O-acetyl)-β-D-galactopyranoside. These easily kill termite gut symbionts that result in death of termites.[82] Similarly, flavonoids kaemperol-3-O-rutinoside, quercetin-3-O-glucoside, and kaemperol-3-O-glucoside isolated from *Holarrhena floribunda* show antioxidant activity.[83] Flavonoids named kaempferol 3-rhamnogluco-7-glucoside, kaempferol 3-rhamnogluco-7-galactoside, quercetin 3-rutino-7-glucoside, and quercetin 3-rhamnogluco-7-glucoside from the latex *Vinca minor* show termicidal activity.[84] Flavonoids naringenin, aromadendrin (dihydrokaempferol), and kaempferol are chief constituents of *Echites hirsute* latex, they show termicidal properties[85] and flavonoids isolated from *Trachelospermum jasminoides* named apigenin, apigenin 7-O-beta-glucoside, apigenin 7-O-beta-neospheroside, naringin, and 6,8-di-C-glucopyanosylapigenin show antifeedant activity.[86]

Terpenes

Like alkaloids, the abundance of terpenes and their derivatives has been reported in many members of the family Apocynaceae. Terpenoids isolated from *N. oleander* are mainly oleandric acid, ursolic acid, betulinic acid, betulin, and derivatives of epoxydammarane 3β, 25-diol show significant anti-termitic activity.[87] Among the various isolated terpenes, vulgarone B, apiol, and cnicin exhibit significantly higher mortalities in termites. These are highly toxic compounds to termites.[88] The terpenoids constitute the largest class of natural products and many interesting products are extensively applied in insect pest management such as termicides.[89] Terpenes ursolic acid isolated from *Pleiocarpa pycnantha* show toxic against termites.[90] *Pentalinon andrieuxii* latex contains urechitol A terpenes show antifeedant activity.[91] Major terpenes perisomalien A, lupeol acetate, *β*-amyrin cycloart-23Z-ene-3*β*, 25-diol, and *β*-sitosterol-3-*O*-*β*-D-glucopyranoside isolated from *Periploca somaliensis latex* showed toxic effects against termites.[92]

Sterols

Stigmasterol, β-sitosterol, and campesterol are phytosterols or steroid alcohols. These show play important role in insect growth and development and its scarcity seize them at any stage of life including larval to adults forms. Sterols show strong insecticidal activities against adult termites and a negative impact on fecundity.[93] Latex of *Gymnema sylvestre* contains beta-sitosterol, campesterol, and stigmasterol. These show antifeedant activity against termites.[94] Sterols pentalinonside and pentalinonsterol isolated from *P. andrieuxii* show termicidal activity.[95] *Alstonia scholaris* latex contains sterols named poriferasterol, epicampesterol, β-sitosterol, 6β-hydroxy-4-stigmasten-3-one, and ergosta-7,22-diene-3β,5α,6β-triol show anti-termitic activities.[96] β-sitosterol and β-daucosterol are chief sterols found in the latex of *Periploca forrestii*, they are highly toxic to termites. In the latex of *P. tomentosa,* 3-acetyltaraxasterol, 3-taraxasterol, and 16α-hydroxytaraxasterol-3-acetate are chief sterols which are responsible for the significant mortality in termites.[97] Similarly, *Cynanchum limprichtii* latex contains limproside A and limproside B which are proven to be toxic against termites.[98]

Simple phenolic compounds

The phenolic compounds show insecticidal activity and use in insect control because of their strong action on insect digestion.[99] Phenolic compound ellagic acid derivatives (Shi *et al.*, 2010),[100] protocatechuic acid, catechin, and quercetin isolated from *H. speciosa* showed deterrent and insecticidal activity against termites.[101] p-coumaric and ferulic acid both are phenolic compounds found in *Asclepias linaria* latex showed toxic effect against termites.[102] The phenolic compound present in the latex of *Cynanchum wilfordii* is 2-*O*-β-laminaribiosyl-4-hydroxyacetophenone responsible for significant mortality in termites.[103]

Lignans

Lignan glycoside, (+)-pinoresinol 4-O-[6″-O-vanilloyl]-β-d-glucopyranoside isolated from the latex of *C. gigantea* show insecticidal activity.[104] Similar activity is also reported in reveled carbinol as phenolic lignan found in *Carissa carandas* and *Carissa carandas*. Recently, syringaresinol 4-O-b-glucopyranoside isolated from *Vinca major* is an insect deterrent.[105]

Insecticidal Activity of Latex

Various plants belongs to moraceae family such as Ficus lacor, Ficus hirta, Ficus sarmentosa, Ficus palmate, Ficus neriifolia, Ficus semicordata, Ficus pumila, Ficus virens, Milicia excels, Ficus racemosa, Ficus religosa, Ficus benghalensis, Morus alba, Ficus auriculata, Ficus carica, Ficus elastic, Ficus ampilissima, Artocarpus heterophyllus and Ficus sycomorus have different potential like Antibacterial, antifungal, antioxidant, Termiticidal, Antimicrobial, antibacterial activity, Anti antiarthritic, antidiabetic and anti inflammatory activities (Table 1). Latexes from different family plants like Hevea brasiliensis ,Chelidonium majus,E. peplus,Thevetia peruviana, P. amapa ,Plumeria pudica, Synadenium grantii, Euphorbia obtusifolia, Euphorbia tirucalli, Plumeria rubra showed high potential as antifungal, antioxidant, Termiticidal, Antimicrobial and antibacterial activity (Table 2).

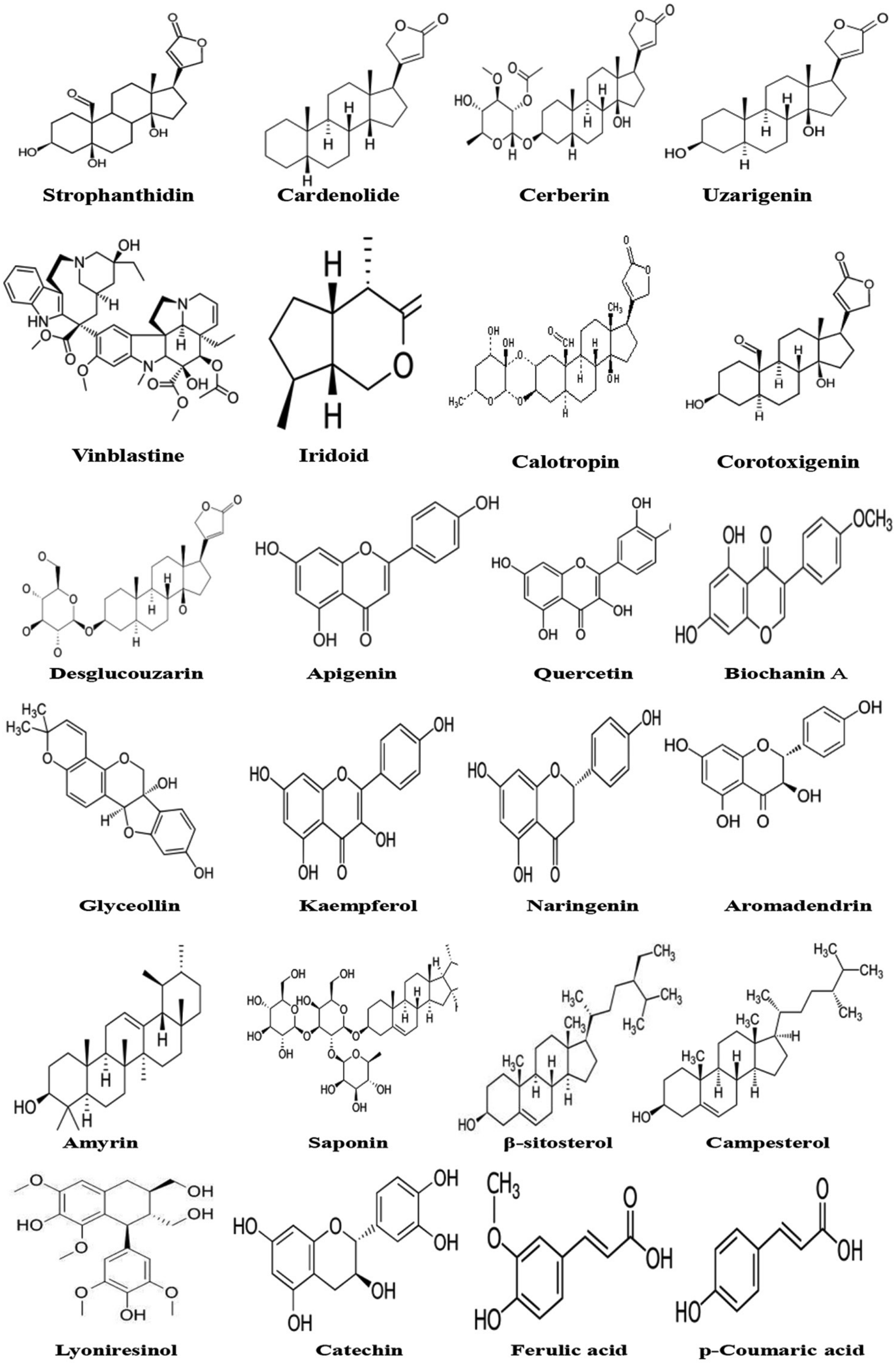

Figure 1: Chemical structures of major latex components isolated from various plant species

Latex components if used as insecticide are safe and do not put any adverse effects on environmental quality and non-target organisms including human health.[106] Latex ingredients are bioactive substances and are useful as medicines and pesticides.[107] Plant latex provides an alternative way in the insect control strategy. These are secondary chemicals synthesized by plants[108] which are non-toxic and biodegradable and can be used to control insects as an alternative to chemical insecticide.[109] The latex from the different plant families used since long time in medicine as well as in the control of some insects.[110] Latex fractioned with different solvents shows a variable degree of anti-termitic activities. In the latex of *Euphorbia kansui,* there are six triterpenoids, one of them is identifies as euphane-3β and 20-dihydroxy-24-ene (Figure 1). All these compounds have insecticidal activity.[111]

A cysteine protease isolated from seeds of *Albizia procera* ApCP encapsulated with graphene quantum dots showed enhanced toxicity against insects.[112] Most of protease activity is seen toxic to insect midgut and to the cuticle).[113] The leaf *Aloe* sp. latex is found active against microbes and insects.[114] Latex contains highly active anti-termite compounds which showed high toxicity against insects.[115] Plant latex contains secondary metabolites help the plant in making defense against insect pests. Latex components act antifeedant[116] and act as insect growth control agents. The insecticidal activities of latex are dose dependent.[117]

Latex from *Morus alba* contains protein a and b (LA-a and LA-b) which show significant chitinase and chitosanase activities. LA proteins hydrolyze chitin surface of insects.[118] *Lobelia siphilitica* shows reduced latex production and high herbivores attack.[119] *Carica papaya* latex solvent extracts showed larvicidal properties against a number of insects.[117] Plants also bear morphological structures, that is, waxes, trichomes, and latices make the feeding more difficult for the insects.[120] The latex from the leaves of *Aloe trigonantha* is a sticky poisonous exudates that make insect mouth parts functionless.[21] It acts as feeding deterrent. The latex of *Garcinia morella* (Gaertn.) possesses 5-Oxohexanenitrile (18.7%), phenol, 2, 4-bis (1, 1-dimethylethyl) (24.64%), and hexadecanoic acid (22.85%) (Figure 1). These latex compounds show toxicity against many insects.[121] In cucurbit plants, phloem latex exudates from phloem from cut sieve tubes used to make defense against herbivores.[122] Latex exudates stop development of first and third instar larvae enclosed on *Lobelia cardinalis* (Campanulaceae) failed to develop.

ANTIMICROBIAL ACTIVITY

Besides insecticidal activity plant latex component also showed strong antimicrobial effects. A latex component aloesin is a C-glycosylated chromone, it exhibits antibacterial activity against pathogens.[123] The leaf latex of *Amanita citrina* shows antimalarial activity. *Hevea* latex allergy shows IgE-mediated allergy. *C. majus* (Papaveraceae) latex found active against bacteria, fungi, viruses, protozoans, nematodes, and insects. It also shows some anti-cancer properties.[124] Iridoid alkaloids possess good to excellent activities against phytopathogenic fungi *Fusarium graminearum. Euphorbia* plant latex shows antimicrobial activity but its exposure is harmful for humans' microbes. Euphorbiaceae plant latexes showed string antimicrobial activity. It is also used for making traditional medicine to combat microbial infections. Chrysanthemum and Uniflower Swisscentaury root extracts showed anti-angiogenic effects in zebrafish. Latex contains hydrolytic active proteins which also work much similar to proteases.[42] The constituents of latex are well known in some plant families for their phytotoxic, insecticidal, cytotoxic, antibacterial, and antifungal activities.

CONCLUSION

It is clear from various studies that plant latex contains deterrent chemicals which elicit the feeding behavior in insects. These latex-based pure compounds are quite effective and might have potential uses in agriculture mainly for termite control. These inhibit feeding in first to third instar larvae; inhibit its growth and molting. These effectively inhibit embryonic and post-embryonic development in insects. Plant latex contains highly active bio-organic components mainly glycosides, hydrolytic active proteins protease inhibitors, sterols, phenylpropanoids, monoterpenes, and furanocoumarins and Lactucin (*Lactuca sativa*), myristicin, are antagonist of nicotinic acetylcholine receptors found in insects. Most of them are hemotoxic, cytotoxic, and neurotoxic to insects. Among them, proteases can be used as potential pesticides in place of synthetic insecticides. Lignan glycoside, isolated from the latex of *C. gigantea,* shows insecticidal activity. Both latex and its derived formulations cause significant mortality in termites. These natural formulations put no deleterious effect on non-targeted biotic and abiotic factors of environment. These easily biodegrade in the medium and show no residual effect and non-harmful to food chain. These formulations can be used as dust, spray, and in form poison baits to control termite population in field garden and vegetation, particularly in semi-arid ecosystems.

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CONFLICTS OF INTEREST

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