SECONDARY METABOLITE COMPOUNDS FROM JATROPHA SPECIES

A Review by Carla W. Sabandar

Several secondary metabolite compounds from some Jatropha species were successfully isolated and identified. Biological activities of some compounds were examined and validated that made *Jatropha* species become interest for researchers and society, recently.

Jatropha curcas Linn.

J. curcas Linn. is a small tree or large shrub, which can reach a height of three to five meters, but under favorable conditions it can attain a height of 8 or 10m. The plant shows articulated growth, with amorphological discontinuity at each increment. The branches contain latex. Normally, five roots are formed from seedlings, one central and four peripheral. A tap root is not usually formed by vegetatively propagated plants. Leaves five to seven lobed, hypostomic and stomata are of paracytic (Rubiaceous) type [1]. The trees are deciduous, shedding the leaves in dry season. Flowering occurs during the wet season an two flowering peaks are often seen, i.e. during summer and autumn. In permanently humid regions, flowering occurs throughout the year. The inflorescence in axillary paniculate polychasial cymes. The plant is monoecious and flowers are unisexual; occasionally hermaphrodite flowers occur [2]. A flower is formed terminally, individually, with female flowers (tricarpellary, syncarpous with trilocular ovary) usually slightly larger and occurs in the hot seasons. In conditions where continous growth occurs, an unbalance of pistillate or staminate flower production results in a higher number of female flowers. Ten staments are arranged in two distinct whorls of five each in a single column in the androecium, and in close proximity to each other. In the gynoecium, the three slender styles are connate to about two-thirds of their length, dilating to massive bifurcate stigma [2]. The rare hermaphrodite flowers can be selfpollinating. The flowers are pollinated by insects especially honey bees. Each inflorescence yields a bunch of approximately 10 or more ovoid fruits. With good rainfall conditions nursery plants may bear fruits after the first rainy season, and directly sown plants after the second rainy season. Three, bivalve cocci is formed after the seeds mature and fleshly exoacarp dries. The seeds mature about 3-4 months afer flowering. The seeds are black and the seed weight per 1000 is about 727g, there are 1375 seeds/kg/in the average [1]. *J. curcas* Linn. is cultivated as a medicinal plant in many tropical and subtropical countries. It is suitable for preventing soil erosion and shifting of sand dunes. Various parts of the plant hold potential for use as a source of oil, animal feed or medicinal preparations. Recently, their seeds were investigated mainly as a potential source of oil that was recognized as an adequate substitute motor fuel [3].

Ethyl acetate extracts of leave of *J. curcas* Linn. contain a complex of 5-hydroxypyrrolidin-2-one and pyrimidine-2,4-dione (uracil) [4]. The seed kernels of *J. curcas* Linn. were rich in crude protein, CP (31-34.5%) and lipid (55-58%). The major fatty acids found in the oil were oleic (41.5-48.8%), linoleic (34.6-44.4%), palmitic (10.5-13.0%), stearic (2.3-2.8%), *cis*-11-eicosenoic and *cis*-11,14-eicosadienoic acids [5]. Seed oil contain 12-deoxy-16-hydroxyphorbol (**1**) belonging to phorbol ester which has tumor-promoting activity [6]. The common diterpene 12-deoxy-16-hydroxyphorbol in six different diterpene esters from the *J. curcas* Linn. oil have determined using HPLC methode which named as *Jatropha factors* C1 to C6 (**2-7**) [7]. From the latex of *J. curcas* Linn., a novel cyclic octapeptide was

isolated and named curcacycline A (**8**) which displays a moderate inhibition of classical pathway activity of human complement and proliferation of human T-cells [8], curcacycline B (**9**) [9], jatrophidin I (**10**) [10] has antifungal activity, and pohlianin A (**78**) [11] has antifungal and antimalarial activity [10]. Diterpene compounds such as tigliane (**11**), jatrophone (**12**) and dinorditerpene (**13**), 3-*O*-acetylaleuritolate acid (**14**), a triterpenoid have been identified from this plant [12]. The roots of *J. curcas* Linn. is a rich source of diterpenes of the daphnane and lathyrane skeletons [13]. From hexane extract of this plant well known jatropholones A (**15**), B (**16**) [14], curculathyrane A (**17**) and B (**18**), and curcusone A-D (**19-22**) [13]. Polar fraction of crude extract of the roots of *J. curcas* Linn. contains propacin (**23**), (+)-jatrophol (**24**), (+)-marmesin (**25**) and jatrophine (**26**) [13]. Two type of lathyrane, 15-*O*-asetil-15-*epi*-(4*E*)-jatrogrossidentadione (**27**) and isojatrogrossidentadione (**28**) and two podacarpanes, 3*β*-acetoxy-12-methoxy-13-methyl-podocarpa-8,11,13-triene-7-one (**20**) and 3*β*,12-hydroxy-13-methyl-podocarpa-8,10,13-triene (**30**) have been isolated and identified from aerial part of *J. curcas* Linn. [15]. Compound 5*α*-stigmastane-3,6-dione (**31**), *β*-sitosterol (**32**), estigmasterol (**33**), taraxasterol (**34**), daucasterol (**35**), nobiletin (**36**), 5-hydroxy-6,7-dimethoxycoumarin (**37**), 6-methoxy-7-hydroxycoumarin (**38**), 3-hydroxy-4-methoxybenzaldehide (**39**), 3-methoxy-4-hydroxybenzoate acid (**40**), glyceride-1, 2S-tetracosanoate acid (**41**) and caniojane (**42**) have been isolated from the roots of *J. curcas* Linn. [14].

Aqueous extracts of leaves of *J. curcas* Linn. were evaluated for antihelmintic activity on adult Indian earthworms *Pheretima poshtuma* that indicated significant activity [16]. Methanolic extract of this plant has shown antiulcer activity on aspirin-induced gastric lesions in Wistar rats [17]. The *in vitro* antimicrobial activity of crude ethanolic, methanolic and water extracts of the stem bark of *J. curcas* Linn. against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Streptococcus faecalis*, *Staphylococcus epidermidis*, *Shigella dysentriae*, *Micrococcus kristinae*, *Klebsiella pneumonia*, *Bacillus cereus*, *Bacillus subtilis*, *Proteus vulgaris* dan *Serratia marcescens* were investigated [18]. Toxicity of seed oil of *J. curcas* Linn. was evaluated against *Callosobruchus maculates* insects dan its parasite, *Dinarmus basalis* [19]. The research of nickel toxicity induced in *J. curcas* Linn. has shown a correlation between responses of antioxidant enzymes as well as PAL activities and nickel concentrations in *J. curcas* Linn. cotyledons. The lower nickel concentrations and higher *superoxide dismutase* (SOD), *peroxidase* (POD), *catalase* (CAT) dan *phenylalanine ammonia lyase* (PAL) activities suggest the tolerance capacity to protect the plant from oxidative damage [20].

Jatropha chevalieri Beille.

Isolation compound of latex of *J. chevalieri* has resulted cyclic peptide, chevalierin A (**43**), B (**44**) and C (**45**) . Compound **43** was evaluated that has antimalarial activity with IC_{50} 8.9 μM [21].

Jatropha elliptica (Pohl) Müll. Arg.

J. elliptica (Pohl) Müll. Arg., a shrub annual herb distributed throughout the North and the West of Brazil and has been reported to possess several medicinal properties [22,23,24]. *J. elliptica* is used in the folk medicine for treatment of neoplasia, inflammation, ulcers and diuretic diseases among others [24]. The ethanolic extract of root has shown molluscicidal activity [12].

A penta-substituted pyridine namely diethyl 4-phenyl-2,6-dimethyl-3,5-pyridinecarboxylate (**46**) was assayed for *in vitro* antibacterial and resistance-modifying activity against strains of *S. aureus* possessing the MsrA and NorA resistance efflux mechanisms. Antibiotic efflux studies indicated that the title compound acts as an inhibitor of the NorA efflux pump and restores the level of intracellular drug concentration [12]. This compound was isolated from rhizomes of *J. elliptica* which has crystal structure was monoclinic ($P12_1/n1$ (no.14), a = 11.204 (5) Å, b = 8.368 (5) Å, c = 18.817 (5) Å, β = 99.366 (5)°, V = 1740.7 Å^3, Z = 4, R_{gt} (F) = 0.054, wRref (F^2) = 0.154, T = 293 K) [25]. Isolation compound of the roots of *J. elliptica* has resulted diterpenoid compound **12**, **14**, **15**, **16**, **23**, pentatriacontanyl ferulate (**47**), fraxetin (**48**) and mixtures of compound **32** and **33** [26]. Compound **12**, extracted from *J. elliptica* inhibited [^{3}H]glutamate binding. These results may indicate a neurochemical parameter possibly related to the antinoceptive activity of these natural compounds [27]. Several biological activities have been reported for **12**, including the molluscicidal effect [24], reaction of biological thiols (inhibition tumor activity) [28], interaction with sRNA from Escherichia coli [29], inhibition of insulin release [30], relaxation effect of induced uterine contraction [31], relaxant action in rat portal vein [32], inhibition of lymphocytes activation, probably through inhibition of the protein kinase C pathway [33], antiprotozoal activity [34], antileishmanial activity [35], antileukemic activity against P-388 lymphocytic leukemia at 27 and 12 mg/kg cytotoxicity (ED_{50}) against KB cell culture at 0.17 μg/ml [36].

Jatropha gaumeri Greenm.

Isolation of secondary metabolite compound from roots extract of *J. gaumeri* was obtained as 2-*epi*-jatrogrossidione (**49**), a rhamnofolane diterpene and 15-*epi*-4*E*-jatrogrossidentadione (**50**), a lathyrane diterpene. Compound **49** has antimicrobial activity and **50** without biological activity. Crude leaf extract of *J. gaumeri* contains compound **32**, **34**, triterpenes α-amyrin (**51**) and β-amyrin (**52**), which responsible for the antioxidant activity.

Jatropha gossypifolia Linn.

J. gossypifolia (synonym: *Adenoropium gossypifolia* Pohl, *J. elegans*) belonging to the family Euphorbiaceae [38] is a shrub herb, height 1.8 meter, gregarious with palmately 3-5 lobed leaves and dark red, crimson or purplish flowers. Leaf margins, petioles and stipules are covered with glandular hairs [39]. *J. gossypifolia* is grows naturally almost entire tropical area in the world [40]. This plant is a native of Brazil, naturalized in many parts of India. It grows on nearly all type of soils within its range. It is common in waste lands, roadsides, poorly tended agricultural fields and river overflow area [41]. Another opinion said that *J. gossypifolia* is native to the Carribean and tropical America but is now widespread throughout the tropical world. It has been listed as a weed in India, Brazil, Jamaica and Trinidad [42]. Flowering in India occurs from February through July. Sometimes both flowers and fruits will be present at the same time on plant. Upon drying, the capsule valves spring open propelling the seeds a few centimeters [41].

J. gossypifolia is reported to be beneficial to dyscrasia, anemia, vertigo and dysphonia [38]. It is an antibiotic, insecticidal and used in toothache and act as blood purifier [43]. The leaves are employed to carbuncles, eczema and itches, act as purgative and swollen. A decoction of the leaves is useful for stomachache, venereal disease and as blood purifier [44]. The leaves, either in decoction or boiled like

spinach, as a purgative remedy for 'dry belly-ache'. It is used to prepare tea for constipation, the part used not being specified but it is probably the leaves [45]. Extracts of the plant are used as a purgative and emetic, and to treat headache, diarrhea, venereal disease, skin sores, mouth sores and cancer [40]. The seed are used to purgative, its oil similar to Castrol oil (Jatropha) [45]. The use of the seeds in herbal medicine is advised against because of their high toxicity [46]. The seed oil is used as an emetic, purgative and stimulant. It is also applied for ulcers and leprosy and is beneficial in adenites and worm infestation [44]. The roots are recommended for leprosy and as an antidote for snake bite [38]. *J. gossypifolia* in many country is used as medicinal plant, variously. In India, it is used to treat diarrhea [47] and the roots are employed to dysentery [48]. Decoction of *J. gossypifolia* in Trinidad are beneficial to treat wound and reduce pain. This beneficial similar to etnoveterinary remedies by certain hunter to treat snakebites, scorpion stings, for injuries and mange of their dogs [49]. Ethnomedicine use in Tobago and Trinidad are to treat snatch wound, sores and swollen [50]. In Ghana, decoction of leaves of *J. gossypifolia*, *Combretum ghaselensis* and the whole part of *Ocimun canum* are used to malarial [51]. In Ekiti, Nigeria, *J. gossypifolia* were cultivated to serve as boundary plants, erosion control and healing of mouth cancer [52]. In Southern Nigeria, the extract from fresh leaf applied with crushed leaf is routinely used by herbalists and local people to stop bleeding from the skin and nose [53,54] and in Suriname, the fruits are used as a purgative [55].

Ogundare *et al*. [39] has been reported the antimicrobial activity of leaves extracts of *J. gossypifolia* against 10 microorganisms (*E. coli*, *B. subtilis*, *Salmonella typhi*, *S. aureus*, *Proteus mirabilis*, *Carynebacterium diptheriae*, *P. aeroginosa*, *S. dysentriae*, *S. pneumonia*, *Candida albicans*), which shown inhibition against *S. typhi*, *S. aureus*, *P. aeroginosa* and *C. albicans*.

Compounds belonging to diterpenoid have been isolated from the whole plant were citlalitrione (**53**) [56] and jatrophenone (**54**) [57]. Compound **54** was found to posses antibacterial activity against *Staphylococcus aureus*. Its activity was comparable to that of the standard compound, penicillin G [57]. A coumarino-lignoid, propacin (**23**) also was obtained [58]. The seed oil of *J. gossypifolia* contains a phorbol ester, **1** was found to posses activity as a tumor-promoter [6]. Two lignans have been isolated from *J. gossypifolia* was gossypidien (**55**) [60] that isolated from its stems and gossypifan (**56**) [61] that isolated from aerial parts of this plant. A coumarino-lignoid, cleomiscosin (**57**) was obtained by soxhletation with hexane and ethyl acetate [62]. Furthermore, two lignins namely isogadain [(+)-savinin or hibalactone] (**58**) [63] and diester jatrodien (**59**) [64]. Catechin [**60**] also isolated from its stems bark. The latex contains cyclogossine B (**61**) [65], a cyclic octapeptide. Cyclogossine A and B was possesed to antimalarial activity [50]. Chemicals composition of lipid extracts of leaves of *J. gossypifolia* (Table 2) have been identified by GC-MS [59]. The roots of *J. gossypifolia* contains **12** [66], **15** and **16** [26]. Biotransformation of **12** by *Aspergillus niger* ATCC (American Type Culture Collection) 16404 afforded the new diterpene 9β-hydroxyisabellione (**62**) [67]. The cytotoxicity of the compounds as IC_{50} values on AGS and lung fibroblasts was 2.4 and 2.8 μM for **12** and 53.1 and 260 μM for **62**, respectively [62]. Chemicals composition of lipid extracts of leaves of *J. gossipifolia* are propanoid acid, glycerol, 2-pentenoic acid, arabitol, 3,7,11,15-tetramethyl-2-hexadecene-1-ol, D-xylofuranose, D-mannitol, hecadecanoid acid, inositol, oleic acid, octadecenoic acid, octacosan, octacosanol, stigmasterol, α-Sitosterol, α-Amyrin, Lup-20(29)-en-3-on and betulin [59].

Jatropha grossidentata Pax et Hoffm.

J. grossidentata Pax et Hoffm. is a shrub known as 'Caniroja' by the Ayoreo Indians living in the central-northern par of the Paraguayan Chaco. The powdered roots are smoked in shamanic practices [68]. The petroleum ether and ethyl acetate extract of *J. grossidentata* roots showed *in vitro* activity against *Trypanosoma cruzi* and *Leishmania* strains at 10 μg/mL. Several diterpenes have been isolated from the roots, the main compound being the rhamnofolane jatrogrossidione (**49**) [69,70]. Compound **49** showed a strong *in vitro* leishmanicidal and trypanocidal activity with IC_{100} of 0.75 and 1.5-5.0 μg/mL, respectively.

Jatropha integerrima Jacq.

J. integerrima Jacq. (syn. *J. pandurifolia* Andr.) is a shrubby tree of which the medicinal properties have not been reported. Its latex is however known to be toxic. The leaves, if accidentally chewed can cause squeamish, stomachalgia and can be very purgative [71]. CH_2Cl_2 extracts of latex of *J. integerrima* contains two new cyclic heptapeptides, integerrimides A (**63**) and B (**64**). Both peptides **63** and **64** at 50 μM inhibited to a certain degree cell proliferation of human ICP-298 melanoma cells, as well as cell, migration of human Capan II pancreatic carcinoma cells, buth both compounds were inactive in HSV-1, antifungal and antimalarial assays [71]. The roots of *J. integerrima* contains rhamnofolane endoperoxide 2-epicaniojane together with caniojane and 1,11-bisepicaniojane (**65**) and integerrimene (**66**), a 8,9-seco-rhamnofolane skeletons and a possible biogenetic precursor [72].

Jatropha multifida Linn.

Latex of *J. multifida* contain a novel non-cyanogenic cyanoglucoside, 1-cyano-3-β-D-glucocyranosyloxy-(Z)-1-methyl-1-propene was named multifidin A (**67**) [73]. Previously, isolation of multifidol (**68**) and its glucoside (**69**) [74), two cyclic peptides, labaditin (**70**) [75], a cyclic decapeptide and biobollein (71) [**76**], a cyclic nonapeptide have been reported.

Jatropha podagrica Hook.

Tetramethylpirazine (TMPZ) [77] is an alkaloid found in *J. podagrica* that causes vasolidation [78] and reduces thrombosit [79]. The roots of *J. podagrica* contains a new aliphatic acid named japodic acid (**72**) with a gem-dimethyl cyclopropane ring [80]. Compound **72** showed mild insect growth inhibition activity against *Helicoverpa zea* and were inactive in the antibacterial assays. Methanolic and chloroform extract of the roots of *J. podagrica* contains fraxidin (**73**) and erythrinasinate (**74**). Both compounds exhibited antibacterial activity against *Bacillus subtilis* [80]. Two peptides, podacycline A (**75**), a cyclic nonapeptide and podacycline B (**76**), a cyclic heptapeptide were isolated from the latex of *J. podagrica* [81]. Podacycline B was found to possess high cytotoxicity against *Dalton's lymphoma ascites* (DLA) and *Ehrlich's ascites carcinoma* (EAC) cell lines with IC_{50} values of 13.2 and 15.5 μM, in addition to moderate anthelmintic activity against earthworms *Megascoplex konkanensis*, *Pontoscotex corethruses* and *Eudrilus* sp. at a dose of 2 mg/mL [82].

Jatropha pohliana Müll. Arg

J. pohliana Müll. Arg. (Syn: *Adenophorum molissimum* Pohl, *Adenophorum luxurians* Pohl, *Jatropha molissimma* (Pohl) Baill., *Jatropha pohliana var. mollissima* (Pohl) Müll. Arg., *Jatropha luxurians* (Pohl) Baill.) known as *Pinhão-bravo* and *pinhão-de-purga* [83].
Three cyclic peptides, pohlianin A (**77**), B (**78**) and C (**79**) was isolated from the latex of *J. pohliana*, which found to posses antimalarial activity with IC_{50} values of 57 μM, 25 μM and 16 μM, respectively. Compound **9** being the more potent [11].

Jatropha tanjorensis J.L. Ellis & Soroja

J. tanjorensis has medium thick stout stem with sparse branching, sparse pigmentation. Leaves alternate, palmately five lobed, light green to dark green with no pigmentation except on very young leaves, margins distantly serrate, long petiole with dense pigmentation. Cymose inflorescence with coinflorescence, monoecious unisexual and bisexual, medium sized green with pale pink tinged flowers, 8 yellow stamens arranged in a single layer, highly sterile pollen. Fruit not seen [84]. *J. tanjorensis* is popular as a natural remedy against malaria infection and hypertension in some parts of Nigeria, however there is dearth in scientific validation of these claims [85]. Edo people in Nigeria consumed the leaves as a vegetable and known as *catholic vegetable* [86]. Phytochemical screening of *J. tanjorensis* leaf revealed that it contains bioactive principles such as alkaloids, flavonoids, tannins, cardiac glycosides, anthraquinones and saponins [87].

Jatropha unicostata Balf.

Relative composition of the leaves of *J. unicostata* were unidentified sterol (0.9%), campesterol (4.9%), stigmasterol (36.5%), sitosterol (56.4%), stigmastanol (1.3%); 76 mg 3-oxo-steroids: campest-4-en-3-one (6.6%), stigmast-4,22-diene-3-one (19.8%), stigmast-4-en-3-one (78.3%); 26 mg dioxosteroids: campest-4-en-3,6-dione (5.6%), stigmast-4,22-diene-3,6-dione (42.2%), stigmast-4-en-3,6-dione (52.2%). The observed ketosteroids might be constituents of the latex from *J. unicostata*. Fraxetin (7,8-dihydroxy-6-methoxy-coumarin) and luteolin (3',4', 5,7-tetrahydroxyflavone) were isolated as main constituents from the ethyl acetate fraction [88].

Jatropha weddelliana

J. weddelliana is a shrub found in calcimorphic and dry soils of the highlands bearing the 'pantanal' of Mato Grosso do Sul, Brazil [89]. Hexane extracts of the roots of *J. weddelliana* contains 14 and 32. A diterpene with type of lathyrane skeletons named jatrowedione (**80**) was isolated from the stems extracts of this plant [90].

References

[1]. A. Kumar and S. Sharma, An evaluation of multipurpose oil seed crop for industrial uses (*Jatropha curcas* L.): A review, *Industrial Crops and Products*, 2008.

[2]. B. Dehgan, and G.L. Webster, Morphology and intrageneric relationships of the genus Jatropha (Euphorbiaceae), vol. 74, University of California Publications in Botany, 1979.
[3]. K. Openshaw, *Biomass Bioenergy*, 2000, **19**, 1-15.
[4]. R. Staubmann, M. Schubert-Zsilavecz, A. Hiermann and T. Kartnig, *Phytochemistry*, 1999, **50**, 337-338.
[5]. J. Martínez-Herrera, P. Siddhuraju, G. Francis, G. Dávila-Ortíz and K. Becker, *Food Chemistry*, 2006, **96**, 80-89.
[6]. M. Hirota, M. Suttajit, H. Suguri, Y. Endo, K. Shudo, V. Wongchai, E. Hecker and H. Fujiki, *Cancer Research*, 1988, **48**, 5800-5804.
[7]. W. Haas, H. Sterk and M. Mittelbach, *J. Nat. Prod*., 2002, **65**, 1334-1440.
[8]. A.J.J. van den Berg, S.F.A.J. Horsten, J.J. Kettenes-van den Bosch, B.H. Kroes, C.J. Beukelman, B.R. Leeflang and R.P. Labadie, *FEBS Lett*., 1995, **358**, 215.
[9]. C. Auvin-Guette, C. Baraguey, A. Blond, F. Lezenven, J.L. Pousset and B. Bodo, *Tetrahedron Lett*. 1997, **38**, 2845.
[10]. W.F. Altei, M.S. Saito, D.G. Picchi, E.M. Cilli, P. Pauletti, D.H.S. Silva, I. Castro-Gamboa, M.J. Giannini, H. Verli and V.S. Bolzani, 1st Brazilian Conference on Natural Products, Brazil, 2007.
[11]. C. Auvin-Guette, C. Baraguey, A. Blond, H.S. Xavier, J.L. Pousset, and B. Bodo, *Tetrahedron*, 1999, **55**, 11495-11510.
[12]. Marquez, L. Neuville, N. Moreau, J.P. Genet, A.F. dos Santos, M.C.C. de Andrade and A.E.G. Sant'Ana, *Phytochemistry*, 2005, **66**, 1804-1811.
[13]. W. Naengchomnong, B. Tarnchompoo, and Y. Thebtaranonth, *J. Sci. Soc. Thailand*, 1994, **20**, 73-83.
[14]. K. Ling-yi, M. Zhi-da, S. Jian-xia and F. Rui, *Acta Botanica Sinica*, 1996, **38(2)**, 161-166.
[15]. N. Ravindranath, M.R. Reddy, C. Ramesh, R. Ramu, A. Prabhakar, B. Jagadeesh and B. Das, *Chem. Pharm. Bull.*, 2004, **52(2)**, 608-611.
[16]. R.A. Ahirrao, S.P. Pawar, L.B. Borse, S.L. Borse, S.G. Desai and A.K. Muthu, *Pharmacologyonline*, 2009, **1**, 276-279.
[17]. N. Kannappan, S. Jaikumar, R. Manavalan and A.K. Muthu, *Pharmacologyonline*, 2008, **1**,279-293.
[18]. O.O. Igbinosa, E.O. Igbinosa and O.A. Aiyegoro, *Afr. J. Pharm. & Pharmacol.*, 2009, **3(2)**, 058-062.
[19]. B.A. Boateng and F. Kusi, *J. Applied Sci. Res.*, 2008, **4(8)**, 945-951.
[20]. R. Yan, S. Gao, W. Yang, M. Cao, S. Wang and F. Chen, *Plant Soil Environ.*, 2008, **54(7)**, 294-300.
[21]. C. Baraguey, C. Auvin-Guette, A. Blond, F. Cavelier, F. Levenzen, J.L. Pousset and B. Bodo, *J. Chem. Soc., Perkin Trans*, 1998, **1**, 3033-3039.
[22]. M.P. Correa and L.A. Penna, Dicionario das Plantas Uteis do Brasil e das Exoticas Cultivadas, Vol. III. Ministerio da Agricultura, Instituto Brasileiro de Desenvolvimento Florestal, RJ Brasil, 1984.
[23]. J.A. Duke, Handbook of Medicinal Herbs, CRC Press, Florida, USA, 1985.
[24]. A.F. dos Santos and A.E.G. Sant'Ana, *Phytother. Res.*, 1999, **13**, 660-664.
[25]. A.F. Silva, C.A. Simone, A.E.G. Sant'Ana, M.A. Pereira and V.R.S. Malta, *Z. Kristallogr. NCS*, 2005, **220**, 611-612.
[26]. M.O.F. Goulart, A.E.G. Sant'Ana, R.A. de Lima and S.H. Cavalcante, *Química Nova*, 1993, **16(2)**, 95-100.
[27]. L.H. Martini, C.R. Souza, P.B. Marques, J.B. Calixto, R.A. Yunes and D.O. Souza, *Neurochemical Research*, 2000, **25(2)**, 211-215.
[28]. J.R. Lillehaug, K. Kleppe, C.W. Sigel, S.M. Kupchan, *Biochim. Biophys. Acta*, 1973, **327**, 92-100.
[29]. M. D'Alagni, M. De Petris, G.B. Marini-Bettolo, P.A. Temussi, *FEBS Lett.*, 1983, **164**, 51-56.
[30]. F.V. Menezes, E.M. Carneiro, E. Delattre, A.C. Boschero, *Braz. J. Med. Biol. Res.*, 1992, **25**, 305-307.
[31]. J.B. Calixto, A.E. Sant'Ana, *Gen. Pharmacol.*, 1990, **21**, 117-122.
[32]. A.M. Silva, R.L. Brum, J.B. Calixto, *Life Sci.*, 1995, **57**, 863-871.
[33]. V.L. Goncalves de Moraes, V.M. Rumjanek, J.B. Calixto, *Eur. J. Pharmacol.*, 1996, **312**, 333-339.
[34]. G. Schmeda-Hirschmann, I. Razmilic, M. Sauvain, C. Moretti, V. Munoz, E. Ruiz, E. Balanza, A. Fournet, *Phytother. Res.*, 1996, **10**, 375-378.
[35]. M.J. Chan-Bacab and L.M. Peña-Rodríguez, *Nat. Prod. Rep.*, 2001, **18**, 674-688.
[36]. G. Goel, H.P.S. Makkar, G. Francis and K. Becker, *International Journal of Toxicology*, 2007, **26**, 279-288.
[37]. R. Can-Aké, G. Erosa-Rejón, F. May-Pat and L.M. Peña-Rodríguez, *Quím. Méx*., 2004, **48**, 11-14.
[38]. K.R. Kirtikar and B.D. Basu, Indian Medicinal Plants, Vol. III, 1980.
[39]. A.O. Ogundare, *Trends In Applied Sciences Research*, 2007, **2(2)**, 145-150.
[40]. H.M. Burkill, The Useful Plants of West Tropical Africa, Vol. 2, Royal Botanic Gardens, Kew, UK, 1994.
[41]. A. Kakade, M. Pawar, K. Wadkar, S. Patil, C.S. Magdum and N.S. Naikwade, *Pharmacognosy Reviews*, 2008, **2(4)**, 2-6.
[42]. S. Csurches and R. Edwards, Potential Environmental Weeds In Australia, The Director of The National Parks and Wildlife, Canberra, 1998.
[43]. W. Balee, Footprints of Forest, Ka'apor Ethnobotany-The Historical Ecology of Plant Utilization by An Amazonian People, Columbia University Press, New York, 1994.
[44]. J. Banerji, B. Das, P. Bose, R. Chakabarti, and A. Chaterjee, Traditional Medicine, Oxford and IBH Publishing Co. Pvt, Ltd, New Dehli, 1993.
[45]. G.F. Asprey and P. Thornton, *West Indian Medicinal Journal*, 2005, **2(3)**, **3(1)**.
[46]. H.A. Lioglier, Plantas Medicinales de Puerto Rico y del Caribe, Iberoamericana de Ediciones, Inc., San Juan, PR, 1990.
[47]. S.K. Dash and S. Padhy, *J. Hum. Ecol.*, 2006, **20(1)**, 59-64.
[48]. R. Dabur, A. Gupta, T.K. Mandal, D.D. Singh, V. Bajpai, A.M. Gurav and G.S. Lavekar, *Afr. J. Trad.*, 2007, **4(3)**, 313-318.

[49]. C. Lans, T. Harper, K. Georges and E. Bridgewater, *BMC Complementary and Alternative Medicine*, 2001, **1**, 10.
[50]. C. Lans, *J. Ethnobiology and Ethnomedicine*, 2007, **3(3)**, 1-12.
[51]. A. Asase, *J. Ethnopharmacology*, 2005, **99**, 273-279.
[52]. J. Kayode and M.A. Omotoyinbo, *Research Journal of Botany*, 2008, **3(3)**, 107-115.
[53]. T. Oduola, O.G. Adeosun, T.A. Oduola, O.G. Avwiroro and M.A. Oyeniyi, *Euro. J. Gen. Med.*, 2005, **2(4)**, 140-143.
[54]. T. Oduola, O.G. Avwiroro and T.B. Ayanniyi, *Afr. J. Biotech.*, 2005, **4(7)**, 679-681.
[55]. T.V. Andel, J. Behari-Ramdas, R. Havinga and S. Groenendijk, *Ethnobotany Research & Applications*, 2007, **5**, 351-372.
[56]. B. Das and B. Venkataiah, *Biochemical Systematics and Ecology*, 1999, **27**, 759-760.
[57]. B. Das, N. Ravindranath, B. Venkataiah, C. Ramesh and P. Jayaprakash, *Chem. Pharm. Bull.*, 2003, **51(7)**, 870-871.
[58]. B. Das and B. Venkataiah, *Biochemical Systematics and Ecology*, 2001, **29**, 213-214.
[59]. O.O. Sonibare, M.A. Sonibare and E. Akharame, *European Journal of Scientific Research*, 2008, **21(1)**, 209-211.
[60]. B. Das and G. Anjani, *Phytochemistry*, 1999, **51**, 115-117.
[61]. B. Das and R. Das, *Phytochemistry*, 1995, **40(10)**, 931-932.
[62]. B. Das, A. Kashinatham, B. Venkataiah, K.V.N.S. Srivinas, G. Mahender and M.R. Reddy, *Biochemical Systematics and Ecology*, 2003, **31**, 1189-1191.
[63]. B. Das, S.P. Rao and K.V.N.S. Srivinas, *Planta Med*., 1996, **62**.
[64]. B. Das, S.P. Rao, K.V.N.S. Srivinas and R. Das, *Phytochemistry*, 1996, **41**, 985.
[65]. C. Auvun-Guette, C. Baraguey, A. Blond, J. L. Pousset and B. Bodo, *J. Nat. Prod*., 1997, **60**, 1155.
[66]. S.M. Kupchan, C.W. Sigel, M.J. Matz and R.F. Bryan, *J. Am. Chem. Soc*., 1970, **92(14)**, 4476.
[67]. M. Pertino, G. Schmeda-Hirschmann, L.S. Santos, J.A. Rodríguez and C. Theoduloz, *Z. Naturforsch*, 2007, **62b**, 275-279.
[68]. G. Schmeda-Hirschmann, *J. Ethnopharmacol.*, 1993, **39**, 105-111.
[69]. J. Jakupovic, M. Grenz and G. Schmeda-Hirschmann, *Phytochemistry*, 1988, **27(9)**, 2997-2998.
[70]. G. Schmeda-Hirschmann, F. Tsichritzis, and J. Jakupovic, *Phytochemistry*, 1992, **31**, 1731-1735.
[71]. W. Mongkolvisut, S. Sutthivaiyakit, H. Leutbecher, S. Mika, I. Klaiber, W. Möller, H. Rösner, U. Beifuss and J. Conrad, *J. Nat. Prod.*, 2006, **69(10)**, 1435-1441.
[72]. S. Sutthivaiyakit, W. Mongkolvisut, P. Ponsitipiboon, S. Prabpai, P. Kongsaeree, S. Ruchirawat and C. Mahidol, *Tetrahedron Letters*, 2003, **44**, 3637-3640.
[73]. A.J.J. Van den Berg, S.F.A.J. Horsten, J.J.K. Bosch, C.J. Beukelman, B.H. Kroes and R.P. Labadie, *Phytochemistry*, 1995, **40(2)**, 597-598.
[74]. S. Kosasi, W.G. Van der Sluis and R.P. Labadie, *Phytochemistry*, 1989, **28**, 2439-2441.
[75]. S. Kosasi, W.G. Van der Sluis, R. Boelens, L.A. 't Hart and R.P. Labadie, *FEBS Letters*, 1989, **256**, 91.
[76]. R.P. Labadie, in *Bioactive Natural Product*, ed. S.M. Colegate and R.J. Molyneux, CRC Press, Boca Raton, Ann Arbor, London, Tokyo, 1993.
[77]. J.A.O. Ojewole and O.O. Odebiyi, *Planta Med*., 1980, **38**, 332.
[78]. X.Z. Dai and R.J. Bache, *J. Cardiovasc. Pharmaeol*., 1985, **7**,841.
[79]. W.J. Wang, *J. Neurol. Psychiat*., 1984, **17**, 121.
[80]. O.O. Aiyelaagbe and J.B. Gloer, *Rec. Nat. Prod.*, 2008, **2(4)**, 100-106.
[81]. A.J.J. Van den Berg, S.F.A.J. Horsten, J.J.K. Bosch, C.J. Beukelman, B.H. Kroes, B.R. Leeflang and R.P. Labadie, *Phytochemistry*, 1996, **42(1)**, 129-133.
[82]. R. Dahiya, *J. Iran. Chem. Soc.*, 2008, **5(3)**, 445-452.
[83]. C.K.A. Leal and M.F. Agra, *Acta Farm. Bonaerense*, 2005, **24(1)**, 5-13.
[84]. A.J. Prabakaran and M. Sujatha, *Genetic Resources and Crop Evolution*, 1999, **46**, 213-218.
[85]. E.S. Orhue, M. Idu, J.E. Ataman and L.E. Ebite, *Asian J. Biol. Sci.*, 2008.
[86]. J.K. Mensah, R.I. Okoli, J.O. Ohaju-Obodo and K. Eifediyi, *Afr. J. Biotech.*, 2008, **7(14)**, 2304-2309.
[87]. S.O. Ehimwenma and A.U. Osagie, *Plant Arch.*, 2007, **7**, 509-516.
[88]. K. Franke, A.K. Nasher , and J. Schmidt, *Biochemical Systematics and Ecology*, 2004, **32**, 219-220.
[89]. A. Pott and V.J. Pott, Plantas do Pantanal, EMBRAPA, Corumbá, Brasil, 1994.
[90]. R.L. Brum, N.K. Honda, S.M. Mazarin, S.C. Hess, A.J. Cavalheiro and F.D. Monache, *Phytochemistry*, 1998, **48(7)**, 1225-1227.

Notification: Structures described separately and downloadable in The Structures of Secondary Metabolites of Jatropha Species.

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