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A Scientific Update on *Passiflora foetida*

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Authors' contributions

This work was carried out in collaboration between all authors. Author ASP designed the study. Author BDL performed literature survey, data collection, wrote the first draft of the manuscript, referencing and author HMP rechecked manuscript, assist in referencing. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: This review describes the importance of medicinal plant *Passiflora foetida* in the modern world. Between 190 countries, approximately 85% have dependency of traditional systems of Ayurveda, Homeopathy and Unani that have contributed for exploring remedial plants. *Passiflora* is a prominent medicinal plant with major phyto-constituents such as flavonoids, glycosides, alkaloids, phenolic and volatile constituents those are potent for potential therapeutic practice.
Aim: This article focus, specifically on *Passiflora foetida* describing its distribution taxonomic, morphology, remedial uses, photo-constituents and clinical applications.
Study Design: Comprehensive literature survey, including national and international journals for assembly of the pharmacological aspects of medicinal *P. foetida* has been done.
Results: *P. foetida* extracts have potential tendency against anxiety, insomnia, sexual dysfunction, inflammation and cancer. They are rich in fiber content, used in paper production industries. In various, countries *Passiflora* fruits are farmed for making cold drink, ice cream, flavor thus best source for economic earning.

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Conclusion: Current review form package of pharmacological importance of *P. foetida* that will assist a researcher for identification of bioactive compounds. Information regarding medicinal and phytochemical are discussed that would be beneficial in research design. This plant carries a large number of bioactive phyto-constituents that may be effectively raised for drug in pharmaceutical industry.

Keywords: Passiflora foetida; secondary metabolites; phytochemical; phenylpropanoid pathway.

1. INTRODUCTION

Earth is a best source for numerous medicinal plants. The global market for medicinal plants and herbal medicines is estimated to be worth of US$ 80 billion per year. International export trade in curative plants from India is 32600 tons/year [1]. According to World Health Organization [2] healing plants have neutral side effects, greater specificity and efficacy [3] thus, worlds 70 percentages of countries depend on a conventional health care system [4]. About 85 percentages of traditional medicines in India are prepared from extracts of leaf, stem, root and flower. Human have advanced to next age were indiscriminate deforestation, industrialization, urbanization and uncontrolled population have resulted in disappearing of numerous medicinal plants in alarming rate. Thus, many scientific researchers have extracted active component and formulate drugs from the natural available plant sources thus several developing countries such as Bangladesh (90%), Myanmar (85%). India (80%), Nepal (75%), Sri Lanka (65%), Indonesia (60%) and few other south east asian countries have deliberately focused research on medicinal plants [4]. therapeutic plants are the best source for treatment of varied minor to harsh human diseases such as cough, temperature, skin burns, fungal infection, inflammation, Diabetes mellitus and rheumatoid arthritis [5].

2. *Passiflora foetida* INFORMATION

Passiflora foetida Linnaeus, 1753 annual vine climber grows 1-6 m tall with eye catcher beautiful flower, that has been previously in 15th century noted for the Passion of Christ, and named as passionflower [6]. This plant has woody roots, solid stem, tendrils, and leaves carry distinctive hairs all over plants that secrete an odorous chemical and thus specific named stinking passion flower [7]. There are about 600 species of this plant reported in several places in Asia. Including India, Thailand, Myanmar, Indonesia, Singapore and many more that are occurred in tropical and sub tropical part of the world [8,9].

2.1 Taxonomic Tree

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledone
Order: Violales
Family: Passifloraceae
Genus: Passiflora
Species: *Passiflora foetida* [10].

3. DATA BASE CONTENT

Data base content Useful data base for *P. foetida* information.

1. http://www.threewa.co.uk/passion/
2. http://www.media-public.de/passiflora
3. www.biosecurity.qld.gov.au [11]
4. http://www.passionflow.co.uk/
5. http://www.passiflorasociety.org/
6. http://passiflora.org/
7. http://www.marinespecies.org
8. http://www.nlm.nih.gov

4. TRADITIONAL USES

This plant is used for traditional purposes and there are numerous herbal products prepared from *Passiflora foetida* that are accepted in India, America, France, Brazil, Vietnam and European nations. In India, this plant is used for forming lotions for skin disease & for preparation of medicinal powder for digestive problems. In Brazil, this plant is used to formulate lotions for skin diseases with inflammation. In Vietnam, leaves are used for tea making for vanishing sleeping and nervous disorders.

5. MEDICINAL USES

Passiflora foetida is well known for its used in medicinal purpose it is used as surface covering for smothering weed and to enhance organic matter production. The leaves are employed in baths for skin affections [12]. Raw fruits are directly eaten in Thailand [13] Fruits are used for

preparation of refreshment in Venezuela [14]. Common disease in chickens such as Newcastle disease is treated with different preparations of the fruits, leaves, stem and seeds [15]. *Passiflora foetida* organ's parts have various medicinal values for treating chronic pain, cough, asthma, insomnia, hysteria, emmenagogue, biliousness, digestive problems, including dyspepsia [16]. *P. foetida* shows fungicidal activity [17] Leaf extracts of *P. foetida* show antibacterial properties against four human pathogenic bacteria, *i.e. Pseudomonas putida, Vibrio cholerae, Shigella flexneri* and *Streptococcus pyogenes* [18]. Leaf extracted in methanol shows fungicidal and against bacteria with presence of cyclopropane, triterpene and glycoside compounds [19]. Expectorant for nervous conditions, spasms and [20] anti inflammatory activity was observed in mice study [21]. A research by [22] suggests that *P. foetida* extracts possess antidepressant effects that could be used in the treatment of patients with depressive disorders. Vitexin could be anti-inflammatory and Kaempferol, Apigenin and luteolin may lead to anti-allergic drug development for compensation of excessive steroidal drugs usage has been observed by [23]. [24] confirmed anti-ulcer and antioxidant activity of *P. foetida* in gastric tissue of ulcer rat's models and concluded antiulcerogenic effect is related to antioxidant activity.

6. *Passiflora foetida* STATUS IN INDIA

In India *P. foetida* grown as runner plant occurred mostly in wet places associated in spiky trees and grows over the surface of land if support is unavailable. It is normally seen as a decorative plant because of its flower. Life stages of *P. foetida* are represented in Fig. 1.

7. *Passiflora foetida* STATUS IN FOREIGN COUNTRIES

In several nations, *P. foetida* grows as annual climbing herb produced from seed that may be survived, germinated in warm and moist soil. This plant is seen in moist lands, marshy, neglected places, riverbanks and lake side. *P. foetida* favors are grown on soaked areas, dry conditions and tolerate in arid conditions [13]. In Guam, wild Passiflora was seen in both volcanic and limestone soils and is grown in waste land [25]. *P foetida* usually sited along a spiky tree that serves as support for growth of the plant. However, if this support is unviable, then *P. foetida* grows in a form of mat over surface area. In Hawaiai, *P. foetida* are observed in large groups growing over a long lava flow, road sides. *P. foetida* forms an impact on other plants by growing as mat covering in the absence of support and inhibiting other plants from growing. It is a common weed in several countries, including Australia, Bolivia and Argentina [20].

8. NATIVE PLACE

Natural community of this plant was observed in river, lakes, costal mountain ranged in Central America, Africa, South-East Asia, Pacific region and in the state of Parana and Brazil South America [26].

9. GEOGRAPHICAL DISTRIBUTION

P. foetida plant is widely distributed in South America, American Samoa, Cocos Islands, Commonwealth of the Northern Mariana Islands, Cook Islands, Federated States of Micronesia, Fiji, French, Galapagos Islands, Guam, Hawaiai, Kiribati, Marshall Islands, New Caledonia, Solomon Islands, Tonga, Vanuatu, Wake Island, Wallis and Futuna Islands, Poland, Finland, European countries, Japan, Malaysia, Thailand, Kenya, Nigeria, south Africa, Singapore, China, Hong Kong, India, including Assam, Amravati, Nagpur and Tamil Nadu. Table 1 clearly represent the language and common name for *Passiflora foetida* in India and Table 2 indicates *P. foetida* distribution around the world with their origin and called name.

10. HABITAT

This plant found usually in association with spike plants or shrubs and grows on, moist marshy places, dry, arid, river side, lake side and few reports for long side of lava. It is a weed plant in many places of Pacific and Atlantic were found along road side vegetation. However, it is grown for a decorative and gardening purpose in India and Poland.

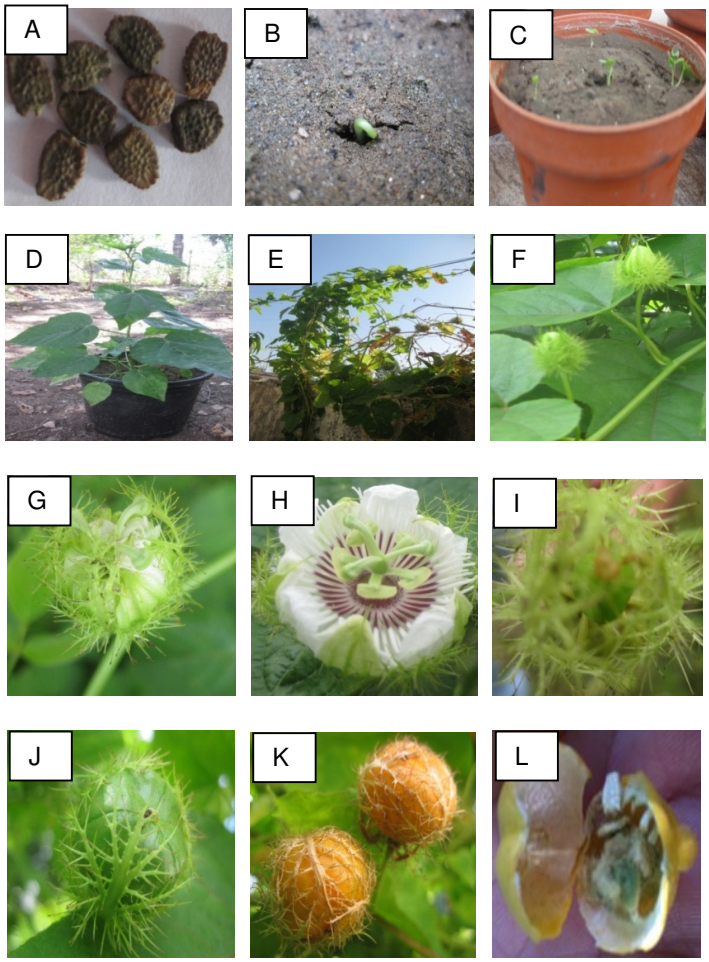

Fig. 1. The photo shows pictures of various life stages of *Passiflora foetida*.
A: Seeds, B: Germinating seed, C: Partial developed plant, D: Maturing plant, E: Matured plant. F: Flower bud. G: opening of a flower. H: Mature flowers. I: Closing of a flower. & fruit formation of a closed flowers. J: developing fruit. K: Fully developed fruit. L: Seed bursting

Table 1. Represents the language and common name for *Passiflora foetida* in India

Sl no	Language	Country	Commonly known	References
1	English	India	love in a mist, Stinking passion flower, Smelling flower	[27]
2	Hindi	India	Rakhi flower, krishnna kamal, Jhumka lata,	*
3	Bengali	India	Jhumka lota	*
4	Manipuri	India	Lam Radhikanachom	*
5	Marathi	India	Vel ghani	*
6	Kannada	India	Kukkibali	*
7	Malayalam	India	Chirranchantiya, Poochapalam	[27]
8	Tamil	India	Siruppunaikkali, Chiru punai k kali, Mapparisavalli	
9	Telugu	India	Tellajumiki	[27]

*Note: * Local sources*

Table 2. Presentation of origin, occurrence, common name, invasive and country for *Passiflora foetida*

Sr no	Country	Origin	Commonly known	Invasive	References
ASIA					
1	Cambodia	-	-	-	[28]
2	China	-	long zhu guo	-	[28,17,29]
3	Hong Kong	-	-	-	[17]
4	Christmas Island (Indian ocean)	-	-	-	-
5	India	Native	banchathail, mukkopeera, Krishna kamal, rakhi flower.	Non invasive	[28,17,30]
6	Maharashtra	-	Krishna kamal, rakhi flower.	-	[31]
7	Japan	-	kusa-tokeiso	-	[28]
8	Lebanon	-	-		[28]
9	Malaysia	-	pokok lang bulu, timun dendang	-	[28,32]
10	Sarawak	Native	-	-	[33]
11	Myanmar	-	-		[32]
12	Philippines		kurunggut, lupok-lupok, masaflora, melon meleonan, pasionariang-mabaho, prutas taungan	-	[17,34,32]
14	Singapore	-	timun dendang, timun hutan, timun padang	-	[35,32,27]
15	Sri Lanka	-	wal wel dodam or padawal, dalbattu, kodimathulai, madahalu, udahalu	-	[36,28,17,37]
AFRICA					
16	Congo	-	-	-	[28,17,38]
17	Ghana	-	-	-	[17]
18	Kenya	-	-	-	[28]
19	Madagascar	-	Tsipopoka	-	[28]
20	Nigeria	-	-	-	[17]
21	South Africa	-	running pop	-	[39]
North America					
22	Mexico	Native	clavellín blanco, granadilla, jujito peludo, jujo	Non invasive	[28, 26]
23	USA	-	-	-	[17]
24	Arizonan	Native	-	Not invasive	[26]
25	Hawaii	-	scarlet fruited passion flower	-	[40,28,17]
Central America and Caribbean					
26	Bahamas	Native	-	Not invasive	[26]
27	Barbados	Native	-	Not invasive	[26]
28	Belize	Native	-	Not invasive	[26]
29	British virgin island	Native	-	Not invasive	[26]
30	Costa Rica	Native	-	Not invasive	[26]
31	Cuba	Native	-	Not invasive	[28,26]
32	Curacao	Native	-	Not invasive	[26]
33	Dominica	Native	-	Not invasive	[26]
34	Dominican Republic	Native	caguazo, mariballa	Not invasive	[28,17,26]
35	Elsalvador	Native	-	Not invasive	[41,17, 26]
36	Guadeloupe	Native	-	Not invasive	[26]
37	Guatemala	Native		Not invasive	[26]
38	Haiti	Native	-	Not invasive	[26]
39	Honduras	Native	-	Not invasive	[28,17,26]
40	Jamaica	Native	granadilla, love in a mist, sweet cup	Not invasive	[28,17,26]
41	Martinique	Native	-	Not invasive	[26]
42	Montserrat	Native	-	Not invasive	[26]
43	Nicaraqua	Native	-	Not invasive	[28,17,26]
44	Panama	Native	-	Not invasive	[28,17,26]
45	Puerto Rico	Native	flor de pasion sylvestre, silvestre, tagua tagua	Not invasive	[28,17,26]

46	Saint Kitts and Nevis	Native	-	Not invasive	[26]
47	Saint Vincent and the Genadines	Native	-	Not invasive	[26]
48	Trinidad and Tabaqo	Native	-	Not invasive	[17,26]
South America					
49	Argentina	Native	ataco, corona de Cristo, granadilla,	Not invasive	[42,26]
50	Bolivia	Native	Pendon	Not invasive	[43,26]
51	Brazil	Native	Maracujazinho (San Luis Island), maracujá catinga, maracujá de cheiro, maracujá de cobra, maracujá de estalo, maracujá de lagartinho, maracujá fedorento, maracuja-da-petra	Not invasive	[44,28,26]
52	Chile	Native	-	Not invasive	[42,26]
53	Colombia	Native	bejuco canastilla, chulupa de loma, cinco llagas, cocorilla, curubo, flor de la pasión, gulupo	Not invasive	[28,17,26]
54	Ecuador	Native	Love in a mist	Not invasive	[26]
55	Galapaqos island	Native	-	Not invasive	[45,26]
56	French Guiana	Native	passiflore fétide	Not invasive	[26,37]
57	Guyana	Native	-	Not invasive	[26]
58	Paraguay	Native	-	Not invasive	[26]
59	Peru	Native	bolsa mullaca, granadilla, granadilla cimarrona, puru-puru	Not invasive	[28,17,26]
60	Suriname	Native	-	Not invasive	[17,26]
61	Uruquay	Native	-	Not invasive	[42]
62	Venezuela	Native	cojón de gato, parchita de culebra, parchita de Montana	Not invasive	[41,28,26]
Oceania					
63	American Samoa	-	pasio vao	-	[32]
64	Australia	-	mossy passion flower	-	[28,46]
65	Australian northern tertiary	-	-	-	[47,28]
66	New South Wales	-	-	-	[47,28,46]
67	Queensland	Introduced	-	-	[47,28,46]
68	South Australia		-	-	[28,46]
69	Western Australia	-	-	-	[28]
70	Cooks island	-	-	-	[32]
71	Fiji	-	Wild Passion Fruit	-	[28,17,48]
72	Tonqan	-	vaine ‘ae kumā, vaine ‘initia	-	[29]
73	Vanuatu	-	-	-	[28]
74	Wallis and Futuna islant	-	-	-	[28]

Note: This table is prepared from the information given on web site [44] and assembled from website (CAB International: www.cabi.org/isc) on dated 2 January 2014

11. PROPAGATION AND SEED GERMINATION

Passiflora foetida is propagated from seed and by planting branch of stem in soil. Seed sowed germinates within two weeks after sowing.

12. MORPHOLOGY

Love-in-a-mist is a perennial vine climber [9] sometime surface coverer, which has a trifoliate leaf, an edible fruit and has beautiful eye catching flower. Fig. 1E shows complete morphology of *the P. foetida* climbers. It is to be notated that when a support is present *P. foetida* grows faster and spread over the surface in no time.

- Seed Ripped seeds are blackish to brown in color, flattened and wedge in shape of 3-4mm in size [7] seeds are as shown in Fig. 1A.
- Leaves are shown in Fig. 1D they are three lobed with spiked viscid hairy leaves 3-parted; segments-apices acute; leaf based

cordate; both sides hispid-hirsute; blades 3, 5-10cm long, 4-12cm wide; petiole 2-6cm long; with prominent veins.

- Steam The stems are1-6m long, branched, thin, wiry and woody, covered with sticky yellow hairs with tendrils [7]
- Tendril Tendrils are spring like coiled in nature and grasped support present around and helps the plant to grow faster.
- The flower the flowers are erected at axis white color outer side and dark pink to violet to inner circular side with figure like projection outward from flower. A flower is about 5-6 cm in diameter with13-15 petals and 8-11 sepals. The stamens arising from the top middle of flower with three styles. Peduncle 3-5 cm long and a bract 2-4 cm long. The flower is displayed in Fig. 1H, Fig. 1G show opening of flower and 1, I show closing of a flower. This species has unique opening and closing pattern of flowering.
- Seedling germinates from soil with hypocotyl 4-12 mm long green in color, two juvenile leaves ovate in shape. The temperature range 19-29℃ is good for seedlings [49]. Seedling can be seen in Fig. 1B was small green color hypocotyl is coming out from the soil.
- Special features
  A) The bract of this plant trap insect and exude a digestive enzyme. The larvae heliconii butterflies of family nymphalidae grow on this plant.
  B) Unique flower opening and closing *P. foetida* produces flowers in september and december in India. It has a unique pattern of opening it is usually open in morning 5 am and closed around 11 am on a same day, alike is followed for next three days. Later, flowers closed to form fruit. *P. foetida* produces flowers and fruits between october and february in Brazil [44] and throughout the year, mainly from september to may in Argentina [42].

13. PHYTOCHEMICALS OF *P. foetida*

The important phytochemicals of this plant are alkaloids, phenols, glycoside, flavonoids, cyanogen compounds [5,18]. Other constituents are C-glycosyl flavonoids based on apigenin and luteolin. Chrysoeriol, kaempferol, isoschaftoside, isovitexin and vitexin are some of the other phytochemicals found in *P. foetida* [50,7]. Aromatic metabolites such as coumarin, phenolic volatiles and ester-related compounds show antimicrobial activitie, which are induced up on mechanical wounding [34]. Vitexin exhibited anti-inflammatory and anti-spasmodic properties. Cyanohydrin glycoside tetraphyllin A, tetraphyllin B, tetraphyllin B sulphate, deidaclin, volkenin, fatty acids, linoleic acid, alpha-pyrone named passifloricin are some of the other phytoconstutents reported in *P. foetida* [16]. In recent vitexin and isovitexin show inhibition of formation of advanced glycation end products (AGEs) that are found to be implicated in diabetic complications [13].

14. BIOSYNTHESIS OF PHYTOCONSTITUENTS OF *P. foetida* THROUGH PHENYLPROPANOID PATHWAY

Plant usually produced secondary metabolites to overcome biotic and abiotic stress [51] by activating phenylpropanoid pathway producing diverse metabolites such as lignin, alkaloids, flavonoid, iso flavonoid, phlobaphene [25]. First most enzyme phenylalanine ammonia-lyase (PAL) greatly increased its activity after wounding was observed by [52]. Phenylalanine ammonia-lyase is converted to cinnamic acid further through subsequent oxygenases, transferesas and reductase reaction p- Coumaryl CoA is generated [19], which is a precursor for other secondary metabolites produced through diverse pathway route. The Fig. 2 shows a complete pathway for production of secondary metabolites. In recent, some other aromatic metabolites like coumarin, phenolic volatiles and ester-related compounds are also found to be produced against a stress response. There may be the chance of obtaining some unique antimicrobial and microbial compounds that are produced on wound stress which may not be produced in (un-wounded) healthy plant [12].

Phenylpropanoid Metabolic Pathway [52] [26]

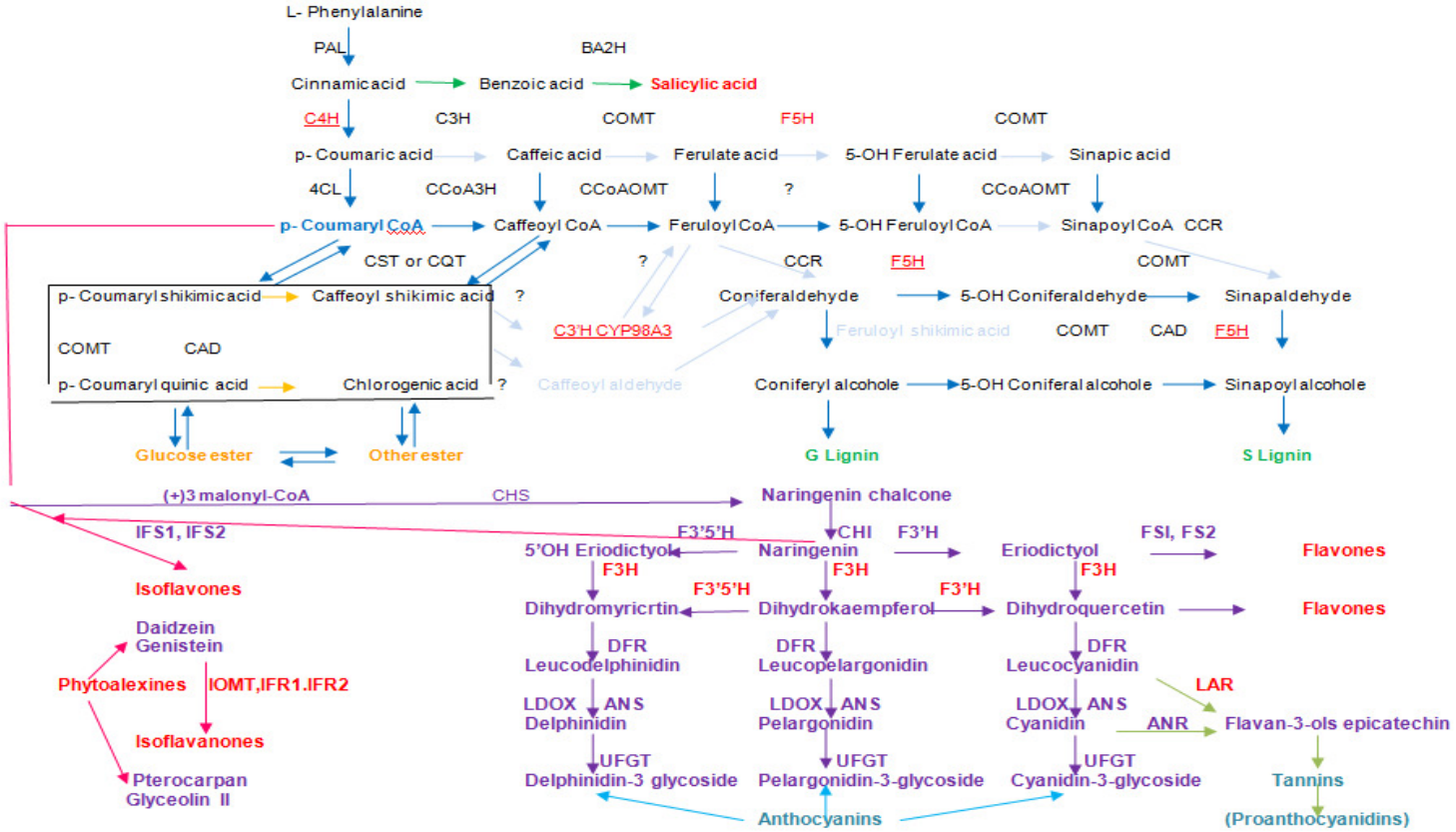

Fig. 2. Phenylpropanoid metabolic pathway: this pathway has been grafted using information available from paper cited above. Enzyme are denoted in uppercase, following are enzyme listed below, Phenylalanine ammonia lyase (PAL), Cinnamic acid 4-hydroxylase(C4H) 4-coumarate:CoA ligase (4CL), Hydroxycinnamoyltransferases (HCT) [18], p-Coumarate 3- hydroxylase (C3H), Caffeoyl CoA O-methyltransferase (CCoAOMT), Cinnamoyl CoA reductase (CCR), Ferulate 5-Hydroxylase (F5H) (Aguade., 2001), Caffeic acid O-methyltransferase (COMT), Cinnamyl alcohol dehydrogenase (CAD). (CHS) Chalcone synthase: (CHI), Chalcone isomerase: (IFS), Isoflavone synthase: (F3'H), flavonoids 3' hydroxylase (F3',F5'), flavonoid ', 5' hydroxylase: (DFR), dihydroflavonol-4- reductase: (ANS), anthocyanidin synthase: (UFGT), UDP- flavonoid glucosyl transferase: (BA2H), benzoic acid 2- hydroxylase [52] [26] and metabolites are Tannins, Proanthocyanidins, Anthocyanins, Isoflavanones, Phytoalexines, Isoflavones, Glucose ester, other ester , G Lignin, S Lignin, Salicylic acid, p- Coumaric acid , Caffeic acid, Ferulate acid, 5-OH Ferulate acid and Sinapic acid

15. ECONOMIC IMPORTANCE

The studies performed by [53] suggest that *P. foetida* is rich in fiber content, about 17.7% and shall be economic for various paper production industries. It has been reported that all parts of *P. foetida* such as leaf, root, stem fruit has tremendous medicinal properties, making plant hot spot for new drug discovery in pharmaceutical industry [44]. In various, countries Passiflora fruits are farmed for making cold drink; ice cream flavor thus *P. foetida* farming could be the best source for economic earning.

16. FUTURE PROSPECTS

P. foetida traditional and medicinal uses would be crucial for treatments of several diseases. The complete understanding of phyto constituents of *P. foetida* would be beneficial for designing a drug with better efficiency and efficacy. This paper would help researchers for understanding physiology and various secondary compounds that are produced upon abiotic or biotic stimuli. Phenylpropainoid pathway understanding would clear the puzzle of biosynthesis of those compounds. This will help in studies of phenylpropanoid pathways in related and distance species, for production of novel compounds. The well-known research on P. *foetida* is not up to the mark; very few works have been done in India. Some paper indicated *P. foetida* for sedative, hypnotic, sleep aids and herbal products with solid support for clinical cases.

17. CONCLUSION

Medicinal plants have significantly provided the discovery of novel drugs that are safe with improved efficiency and efficacy. In this review, a complete information package is provided specifically of *P. foetida* that would be helpful for sketching of research work and identification of viable bioactive compounds. *P. foetida,* distribution, medicinal uses, habitat, morphology, phytochemical are discussed that would be useful in research design. This plant carries large numbers of bioactive phytoconstituents that may be effectively raised for drug in pharmaceutical industry. This paper would boost in research information with working on *P. foetida.*

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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