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Phytochemistry and Pharmacology of *Coleus Forskohlii*

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Abstract: ***C forskolin is an important medicinal plant native to India. The herbaceous species grows in subtropical warm climates of India, Nepal, Myanmar, and Sri Lanka. In India it grows in the Himalayan Region, extending from Shimla to Kumaon and Garhwal hills at an altitude ranging from 600 to 2300mts. Currently it has been cultivated in some parts of south and central India. It is the member of a mint family and described in Ayurveda for its medicinal properties. The plant has very high medicinal value. In Uttarakhand the plant has been reported to be used by Bhotias of the district Pithoragarh for the treatments of ailments like psoriasis, eczema, and cardiac diseases.***

Keywords: Nutraceutical Coleus, Forskolin, diterpenoid, eye drops, cardio coleus, Anti Diabetic

1. Introduction

Figure 1.1: Picture of Coleus *forskohlii* root raw material

Within the *Lamiaceae* family, *Coleus forskohlii* is a significant medicinal plant that grows wild in subtropical regions of India, Nepal, Bhutan, Thailand, Burma, and Sri Lanka, the roots appear as indicated in Figure 1.1. The species originated in India. [1]. A perennial herb that can grow up to 45–60 cm tall, coleus has four angled stems that branch and have hairy nodes. The thick, fibrous, radially spreading roots have a golden-brown hue [2]. The labdane diterpene forskolin is found to be abundant in the tuberous roots. All of the plant's parts, however, are rich sources of different phytochemicals; the leaves include barbatusin, cyclobarbatusin, methylene quinine, and coleon, the roots also contain coleonol and colisosol. Although practically every portion of the plant contains diterpenoids, the roots are the main source [3]. Numerous other phytochemicals, such as phenolic glycosides, sesquiterpene glycosides, monoterpenes, and terpenoids, are also present in the plant. The plant is used as a diuretic in Egypt and Africa, among other places, to cure a variety of ailments. It is used to treat digestive diseases in Brazil. [1]. The plant is also used for veterinary purposes [4]. The plant's decoction is administered with honey to cure leucorrhea and asthma. For piles, urinary symptoms, and heart complaints, powdered roots are administered.

1.1 Medicinal Uses of *C. forskolin*

Among the phytochemicals that have been extracted from the plant, the diterpenoids are significant components. Forskolin, a significant labdane diterpenoid, is isolated from the plant's roots and has been shown to be hypotensive and cAMP *C. forskolin* has been used in the cosmetics business to create medications and tonics for managing body shape and weight loss because of its ability to stimulate cAMP [5]. High levels of phenols and some diterpenoids with strong antioxidant activity have been found in the plant's stem and leaves, according to HPLC profiling. It has been proposed that *C. forskolin* may be utilized as an antioxidant source. [6]. Several volatile oils having aromatic qualities, such as monoterpenes, sesquiterpenes, and sesquiterpene alcohols, have been isolated from *C. forskolin* and can also be utilized to make perfumes. In South India, *C. forskolin* is used as a tonic. The roots are also used in the treatment of worms. In boils that are festering, the root paste calms the fire. The root is crushed in mustard oil, and the resulting paste is then applied to skin infections and eczema. It is also utilized as a treatment for lung, stomach, and cardiac conditions as well as an antioxidant and anti-aging agent. [7]. The tribal people of Uttarakhand, known as the Bhotias, have utilized it to treat a variety of illnesses, including psoriasis, skin infections, wound healing, stomach and other ulcers, and heart problems.

Forskolin

It was discovered that the primary active ingredient in the roots was forskolin. It is a labdane diterpenoid that is speculated to be produced in the plant's root cork cells through a non-mevalonate mechanism. Blood pressure is lowered by it. The most significant cell-regulating substance, cyclic adenosine monophosphate (cAMP), is increased in cells when forskolin activates the enzyme adenylate cyclase.[8],[9],[10]. When cAMP is activated, platelet activation is inhibited, cardiac muscle contraction force is enhanced, smooth muscle relaxes, insulin production is increased, and thyroid function is increased. The plant's root tubers are often used to extract the chemical.

1.2 Importance of *C. forskolin* as a medicinal plant

The primary diterpene component of *C. forskolin*, forskolin, has therapeutic qualities that help explain why it has become a significant taxon in contemporary medicine. Forskolin is used to treat a variety of conditions, including eczema, asthma, psoriasis, allergies, respiratory issues, cardiovascular disorders, glaucoma, and hypothyroidism. It is also used to treat weight loss. It has been reported recently as a natural treatment for urinary tract infections (UTI) by improving the capacity of antibiotics to eradicate the bacteria responsible for 90% of bladder infections. Typically, a reduced quantity of intracellular cAMP is thought to have a significant role in the progression of the illness. [11]. One of the plant's distinctive features is the presence of yellowish to reddish brown cytoplasmic vesicles in the cork cells of *C. forskolin* tubers. These vesicles store secondary metabolites, such as forskolin, and their decreased intracellular cAMP level is thought to play a significant role in the progression of the disease process. [12].

1.3 Phyto molecule forskolin

The primary active component of the ancient Indian ayurvedic plant *Coleus forskohlii* (*Labatiae*), known for its medicinal properties, is forskolin, a diterpene of the labdane family. Adenylyl cyclase is activated by forskolin, which also raises cAMP levels inside cells. The appropriate biological response of cells to hormones and other extracellular signals depends on cAMP, an essential second messenger. It is necessary for hormone feedback regulation as well as cell communication in the hypothalamus/pituitary gland axis. Protein kinase A and Epac are two examples of cAMP-sensitive pathways that are activated by cyclic AMP. The crystalline solid known as forskolin (C22H34O7, MW 410.5) is off-white in color, with a melting point between 228 and 230 °C and maxima of UV absorbance between 210 and 305 nm. Chromatographic examination of *C. forskohlii* extracts from Brazil, Africa, and India showed that each country's plants generated distinct chemicals in varying amounts, with the discrepancies being ascribed to environmental or genetic causes.[13. When two varieties of *C. forskohlii* were assessed for performance, it was found that, in Tamil Nadu, variety "Maimul" performed much better in terms of establishment percentage and tuber production per plant than variety "Garmai."[14] (Veeraragavathatham et al., 1985). Similarly, many researchers found that there was significant diversity in the morphological and yield parameters across the genotypes of *C. forskohlii*. [15],[16],[17],[18].

1.4 Isolation of the secondary metabolite forskolin

Forskolin has been determined to be the primary active hypotensive component of *Coleus forskohlii* roots based on screening methods.[4]. Using X-ray crystallography, the absolute stereochemistry of forskolin was ascertained. [19]. 1, 9-dideoxy-forskolin, the plant's other most prevalent diterpene, lacked hypotensive properties. Later, a number of closely related diterpenes, including stigmasterol, were extracted from the plant's roots and aerial parts. [20]. Saleem et al. have reported an isolation process that produces 96.9% pure forskolin. [21]. Forskolin has been avidly used as a lead for therapeutic development, leading to the development of numerous analytical techniques for its study. A technique known as gas-liquid chromatography (GLC) was created to measure the amount of forskolin found in dosage forms and plant tissues. [22]. There have also been publications on thin layer and high-performance liquid chromatography (HPLC) techniques. Although the HPLC approach was shown to be faster, the GLC method was proven to be more sensitive. Different germplasms' variations in forskolin content have been tracked using the HPLC technique. To facilitate the affinity separation of forskolin, a monoclonal antibody that is specific for protein has been created. The highly sensitive quantification of forskolin in plant tissues at various stages of development has also been accomplished using the same antibody. [22],[15],[23]. Nuclear magnetic resonance (NMR) and gas chromatography-mass spectral methods have also been published for forskolin and its congeners [24]. Since the plant's low forskolin concentration has hindered its development as a medicinal product, tissue culture techniques have been effectively investigated for forskolin production. Wu et al. recently described the HPLC-ELSD fingerprint of *Coleus forskohlii.* Since forskolin is a biomarker, it is considered for quantification as a quality control criterion for products that contain *Coleus forskohlii* root. [25].

1.5 Mode of action of forskolin

The main way that forskolin lowers blood pressure is by activating adenylate cyclase, which raises the amounts of the second messenger cyclic AMP (cAMP) in cells. [26]. Nearly all hormone-sensitive adenylate cyclases in intact cells, tissues, and even solubilized adenylate cyclase preparations are directly activated by forskolin. [8]. The catalytic subunit of the enzyme or a closely related protein serves as the site of action for forskolin, which makes its activation distinctive. [26]. Forskolin can activate all nine of the human adenylate cyclasr. roye types, with the exception of type IX, which is present in spermatozoa. [27].. It has been suggested that forskolin relaxes a range of smooth muscles by stimulating adenylate cyclase. This forskolin action demonstrated the molecule's potential utility as a therapeutic agent for conditions such as asthma, thrombosis, glaucoma, hypertension, cardiac insufficiency, and metastatic conditions, as well as an invaluable research tool for comprehending cyclic AMP-dependent physiological processes. [28].

2. Extraction of Coleus Roots

Figure 1.2: Coleus *forskohlii* leaves, dry roots and extraction powder

To evaluate different extraction methods, 3 safe solvents were used: water, water-ethanol (9:1) mixture and pure ethanol with Soxhlet, microwave and ultrasonication methods of extraction. For Soxhlet, 5 g of root powder was extracted with 150 ml solvent for 5 h using these safe solvents. For microwave-assisted solvent extraction (MASE), 5 g of sample was mixed with 50 ml of all the 3 solvents separately in beakers. Beakers were placed in the middle of the rotating plate of a microwave oven (LG Electronics, India, model Intello wave) and extracted for 5-, 10- and 20-min. Ultrasound assisted extraction (UASE) was carried out using a sonicator at 20 kHz (Sonics Vibra cell, model: VC505, S/N: 61588AC-02-11). About 5 g of ground powder was mixed with 50 ml of distilled water, ethanol, and water-ethanol (9:1) separately in beakers and extraction was carried out for 5, 10 and 20 min. All the extraction experiments were performed thrice. To separate the liquid extract in the above extraction methods, they were filtered and concentrated using a rotary evaporator. For the analysis the dried extracts were dissolved in 50 ml Acetonitrile and filtered through 0.2 microns membrane filter paper for HPLC analysis. Quantitative estimation of forskolin content was performed as per the method described in literature, using a Shimadzu P series high-performance liquid chromatograph with PDA detector adjusted to 220 nm. 5µm C18 column Shim-Pack (4.6x250mm). Acetonitrile and water were used as a mobile phase A and B respectively. The flow rate was adjusted to 1.8 ml/min and sample volume of 20 µl was injected. Retention time of forskolin sample and total run time was 15.57 min and 45 min, respectively. (29)

Most of the biologically active compounds occurring in plants have been used for commercial application in the manufacture of drugs, flavors, and pesticides because of the presence of antioxidant, antibacterial, antihypertensive, and anti-inflammatory properties [30]. But occurrences of these bioactive compounds in plants are meager. Therefore, it is necessary to select a suitable extraction solvent as well as extraction method to obtain maximum extraction efficiency of a particular compound. Extraction efficiency of bioactive compounds is influenced by the chemical nature of the compound, method of extraction and the solvents used for extraction [31]. Apart from this, the yield of extract also depends on solvent polarity, pH, temperature, and extraction time [32]. Therefore, the present study was carried out to see the effect of solvents and methods of extraction on forskolin content in *C. forskohlii.*

Data pertaining to forskolin content obtained from different solvent extracts. The results indicated that highest forskolin content was obtained from methanol (2.91 %) and ethanol (2.59 %), which are polar in nature while minimum forskolin content was observed in water (0.18 %), since most terpenoid are hydrophobic and difficult to dissolve in water [33]. It is well known that high polarity, low viscosity, surface tension and vapor pressure will play a key role in increasing the terpenoid yield [34] and because of these properties' methanol gave the highest yield of forskolin. Solvents with lower polarity such as n-hexane (0.93 %) and petroleum ether (0.28 %), and intermediate polarity solvents such as ethyl acetate (1.60 %), dichloromethane (0.41 %) and chloroform (0.33 %) were not found to be very effective in extracting forskolin. Cell wall permeability and contact between the solvent and solid is improved by polar solvents which increase the extraction yield.[29]

2.1 Experimental Methods

Forskolin main active ingredients are: diterpenes - Coleonol-D, E, F, coleol, coleonone, barbatusol, plectrin, were isolated from the roots *Coleus forskohlii*. Coleonol and forskolin are stereoisomers. Crocetin dialdehyde, naphthopyrone and 6β-hydroxycarnosol were also isolated from the roots. The molecular structure for forskolin is presented in Fig. 1.2:

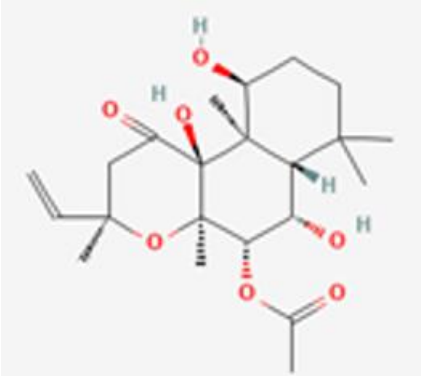

Figure 1.2: Forskolin
Molecular Formula: $C_{22}H_{34}O_7$

IUPAC Name: [(3*R*,4*aR*,5*S*,6*S*,6*aS*,10*S*,10*aR*,10*bS*)-3-ethenyl-6,10,10*b*-trihydroxy-3,4*a*,7,7,10*a*-pentamethyl-1-oxo-5, 6, 6*a*, 8, 9,10-hexahydro-2*H*-benzo[f]chromen-5-yl] acetate

(7β-Acetoxy-8,13, -epoxy-1α,6β,9αtrihydroxy labd-14-en-11-one) Forskolin, the major diterpenoid isolated from the Indian herb, *Coleus forskohlii* is a promising drug for the treatment of glaucoma, congestive cardiomyopathy, and asthma because of its unique adenylate cyclase stimulant activity. It has been shown to be a hypotensive agent with spasmolytic, cardiotonic & platelet aggregation inhibitory activity [8].

a) Method I (by HPLC): Summary: Forskolin in *Coleus forskohlii* extract is separated from its related compounds and other impurities by High Performance Liquid Chromatography (HPLC). The separated compounds are identified with the retention time in comparison with the pure compound and quantified with the corresponding peak area. The results were found to be accurate and reproducible. ANALYSIS: Chromatographic system: High Performance Liquid Chromatographic system equipped with LC8A pump, SPD-M 10Avp Photo Array Detector in combination with Class LC 10A software. Chromatographic conditions: Mobile phase: Acetonitrile: Water 50:50 Column: ODS (Octadecyl silane) C18, 5 µ size, 250 x 4.6 mm (Supelco) Detector: SPD-M 10Avp Photo Array Detector Wavelength: 220 nm Flow rate: 1.6 mL/min Inject volume: 20 µL Standard preparation: Weigh accurately 10 mg of Forskolin in a 25 mL volumetric flask. Dissolve in 15 mL of Acetonitrile and make up to 25 mL with Acetonitrile. Sample preparation: Weigh accurately

250 mg of sample (equivalent to 20 mg of Forskolin). Dissolve 25 mL of Acetonitrile with the aid of heat, filter and make up to 100 mL with Acetonitrile in a volumetric flask.

3. Pharmacological reactions

Cardiovascular disease
Forskolin's benefits in treating cardiovascular diseases are increased by its inhibitory and platelet-aggregating properties. By raising cAMP levels, forskolin has a beneficial inotropic effect on heart tissue. Comprehensive pharmacological investigations demonstrated that forskolin has a positive inotropic impact on the heart muscle and lowers normal or raised blood pressure in a variety of animal species by a vasodilatory effect. Forskolin's benefits in treating cardiovascular diseases are increased by its inhibitory and platelet-aggregating properties. By raising cAMP levels, forskolin has a beneficial inotropic effect on heart tissue. Comprehensive pharmacological investigations demonstrated that forskolin has a positive inotropic impact on the heart muscle and lowers normal or raised blood pressure in a variety of animal species by a vasodilatory effect. [35], [36].

Psoriasis
Four patients receiving forskolin therapy showed improvements in their psoriasis symptoms [37]. It has been demonstrated that forskolin's capacity to control cAMP levels in skin cells has therapeutic advantages for psoriasis patients. Adenylate cyclase is activated by forskolin, a secondary metabolite.

Depression
Although the research is restricted to animal models, forskolin is believed to have antidepressant effects by inhibiting PDE and raising cAMP [38].

Glaucoma
The first description of the impact of forskolin on intraocular pressure and the dynamics of aqueous humour [39]. Topical forskolin application reduced intraocular pressure in healthy human volunteers, rabbits, and monkeys. It was also linked to a decrease in aqueous inflow and no change in outflow facility, suggesting that forskolin may be useful as a therapeutic agent for the treatment of glaucoma. Forskolin did not, however, appear to have any long-term effects on intraocular pressure in glaucoma-affected monkeys [40]. When given topically to the eye, it did not reduce aqueous flow in people [41].

Hypothyroidism
By raising the amount of stimulatory guanine nucleotide-binding proteins, forskolin has been shown to be able to raise thyroid hormone production and stimulate thyroid hormone release [42]. Forskolin may help maintain a normal body weight in part by activating the thyroid to improve metabolism. Forskolin's ability to restore thyroid function to normal may potentially be a factor in its antidepressant properties.

Asthma
Forskolin was investigated as a bronchodilator with the aim of treating asthma [43]. Asthma and bronchitis in guinea pigs are mostly caused by histamine and leukotriene C-4, and it prevented bronchospasm [44]. Leukotriene C 4 and histamine release in human basophils and mast cells were inhibited by forskolin[45]. Human research found that asthmatic individuals could experience bronchodilation by breathing forskolin powder formulations [46]. When administered at the recommended dosage, forskolin appears to be a promising medication for the treatment of asthma, glaucoma, and congestive heart failure [11][4].

Antithrombotic effect
By stimulating adenylate cyclase, forskolin prevents platelet aggregation and enhances prostaglandin effects [47][48]. It has been demonstrated in rabbits to have antithrombotic effects that might be amplified by cerebral vasodilation. Adenosine did not enhance this vasodilation [49]. The use of crude *C. forskohlii* extract as a sensible phytotherapeutic antithrombotic.

Anti-obesity
C. forskohlii does not appear to promote weight loss but may help overweight women avoid gaining weight while posing no adverse effects that appear to be clinically significant [50]. The administration of *C. forskohlii* extracts decreased body weight, food intake, and fat accumulation in those rats, indicating that *C. forskohlii* may be helpful in the treatment of obesity. The antiobesity effects of *C. forskohlii* were studied in ovariectomized rats [51].

Cancer
Melanoma cell line-BF16F10 tumor colonization in the lungs was 70% lessened by forskolin. Forskolin, when combined with rolipram, offers a means of inhibiting the growth and survival of colon cancer cells [52]

Drug Interactions
Forskolin should be avoided when using anticoagulant medicines and antihypertensive treatments together since it may intensify their effects [47]. Because it stimulates lipid release and gluconeogenesis, patients with ulcers, low blood pressure, bleeding disorders, or who are taking blood thinners should use caution when using this medicine. Patients with diabetes should also use caution.

Plant tissue culture of coleus
In vitro propagation is useful for mass multiplication and germplasm conservation of any plant species. *C. forskohlii* being succulent in nature responds well to in vitro propagation and various explants viz., nodal segments, shoot tip, reported that nodal segments as explants on MS medium supplemented with Kn (2.0 mg/l) and IAA (1.0 mg/l) are rooted well, and their plantlets were established successfully under field conditions. Shoot tip explants from 30 days old aseptically germinated seedlings are also used for multiplication using 2 mg/l of 6 benzylaminopurine [53]. Plant establishment protocol from leaf derived callus and found that the in vitro raised plants produce comparable quantities of forskolin with that of wild plants [54]. Complete plantlets of *C. forskohlii* were developed within 35-40 days by culturing shoot tip explants in MS medium containing 0.57 _M IAA and 0.46 _M kinetin through direct multiplication at the rate of 12.5 shoots per explant [55]. The significance of the protocol is the formulation of growth regulators which affected very fast multiplication of the plant in less time, that

is, one-third time less of the hitherto known methods. Leaf explants of *C. forskohlii* induced callusing when cultured on MS media supplemented with 1 mg/L BAP with 2 mg/L NAA. Regeneration of shootlets is observed after 7 weeks of initial culture.

Production of forskolin in vitro:

A study on tissue culture methods for forskolin production was carried out because the relatively modest content of forskolin in the plant has limited its development as a drug (Mukherjee et al., 2000)[56]. Forskolin was identified in shoot differentiating culture, micro propagated plants and root organ suspension by TLC and HPLC *C. forskolin* produced by shoot differentiating. Culture was similar as that of the micro propagated plants whereas root organ suspension showed only traces of forskolin (Sen et al.,1992)[57]. Krombholz et al. (1992)[58] reported that root cultures of *C. forskohlii* initiated from primary callus or IBA-treated suspension cultures and maintained on Gamborg's B5 medium containing 1 mg/l IBA produced forskolin and its derivatives in amounts ranging from 500 to 1300 mg/kg dry weight, corresponding to about 4 to 5 mg/l.Suspension cultures derived from gall calli which were obtained following infection with *Agrobacterium tumefaciens* (C58) were established *in C. forskohlii*. Studies on cell line selection following single cell cloning or cell aggregate cloning were carried out to select cell lines capable of fast growth and for producing high levels of forskolin. A fast-growing cell line (GSO-5/7) was found to accumulate 0.021% forskolin in 42 days. The effect of cultural conditions on cell growth was studied to identify factors influencing biomass yield. Cell growth in suspension was found to be influenced significantly by carbon source, initial cell density and light or dark condition. Optimal cell growth (20-fold increase in biomass in a 42-day period) was obtained when the cells were grown in dark condition in B5O media containing 3% sucrose as sole carbon source with an initial cell density of 1.5 x 105 cells /ml. Forskolin accumulation was maximum (0.021%) in the stationary phase of cell growth. These suspension cultures showed continuous and stable production of forskolin (Mukherjee et al., 2007)[59]. Molecular cloning and functional expression of geranylgeranyl pyrophosphate synthase from *C. forskohli*i have been demonstrated. Engprasert et al. (2004)[60] proposed that forskolin was synthesized from Isopentenyl diphosphate (IPP), a common biosynthetic precursor via a non-mevalonate pathway. GGPP synthase is thought to be involved in the biosynthesis of forskolin, which is primarily synthesized in the leaves and subsequently accumulates in the stems and roots.

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Diseases and its management in coleus

The fusarium wilt in the plant is protected by a chemical emulsion (0.2%) but the protection provided to plants inoculated with biocontrol agents was found to be higher (Boby an Bagyaraj,2003) [61]. Other chemical agents such as halogenated aliphatic hydrocarbons (e.g., 1,3-dichloropropene), methyl isothiocynate mixtures, oxamyl, thionazin and carbofuran have been found effective in the management of nematodes but are not ecofriendly and in the course of time may cause serious threat to the ecological balance. They have been tested and evaluated for their ill effects such as reproductive toxicity and carcinogenesis in mammals. Arbuscular mycorrhizal (AM) fungi are found suppressing the activity of root pathogens (Mohan and Verma, 1996) [62]. Plant growth promoting rhizobacteria *P. fluorescens* can suppress a wide range of plant pathogens including Fusarium (Defago and Hass, 1990) [63]. Some reports clearly indicates that the root-rot/wilt of *C. forskohlii* could be effectively reduced by the application of bio-agents like Trichoderma viride, Pseudomonas fluorescens and AM fungus like *Glomus fasciculatum* and *G. mosesae* (Boby and Bagyaraj, 2003) [61]

FTIR

The FTIR spectra is indicated in Fig. 1.4, have been recorded in KBr pellet, using a: Fourier Transmission Infrared Spectra Make: SHIMADZU.

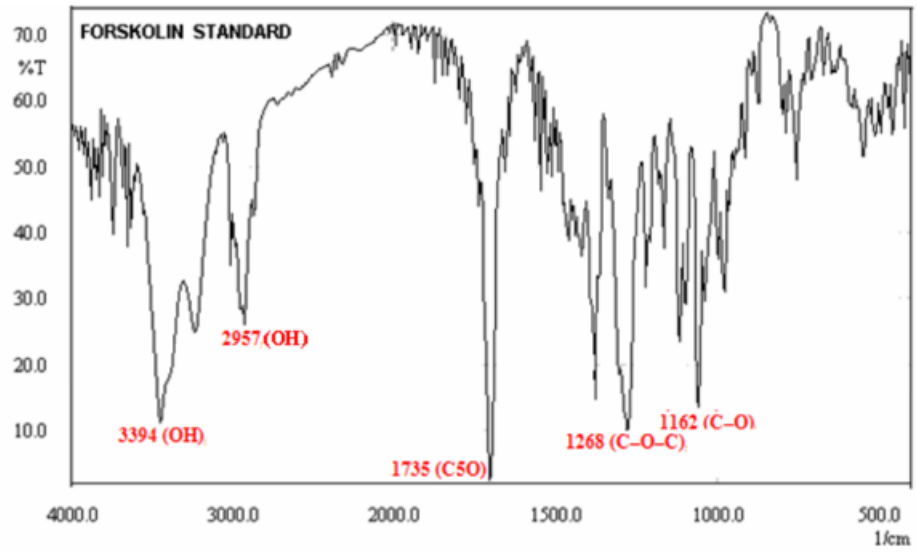

Figure 1.4: FTIR Spectra for Forskolin

Mass Spectra

MASS SPECTRUM Characteristics of Forskolin is indicated in Fig. 1.5

The analysis with Mass Spectroscopy has been made by using an JEOL - JMX-DX303 instrument attached with a JMA-DA5000 Data system.

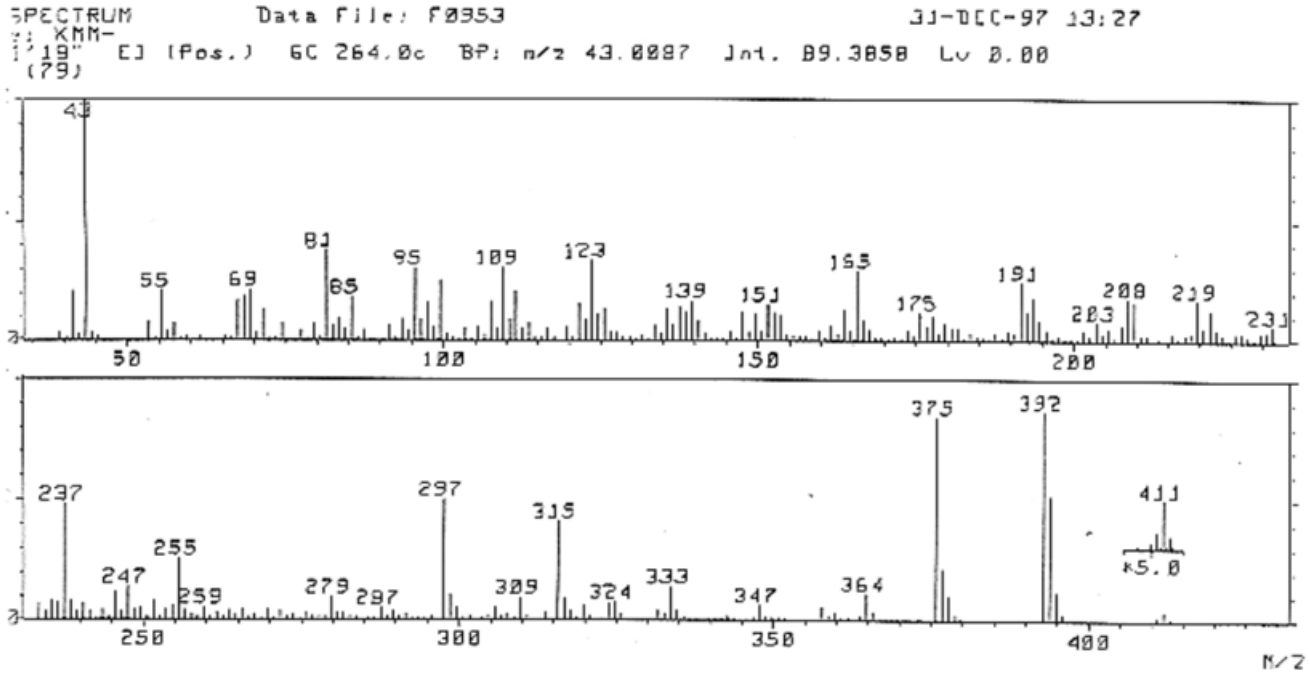

Figure 1.5: Mass spectrum for forskolin

High resolution MS, showed M+ ion at 411 (nearest whole number of Forskolin molecular weight 410.5) corresponding to the molecular formula C22H34O7. Major fragment peaks at m/e 392, 375, 364 etc.

HPLC Analysis of Forskolin

Sample Preparation: (HPLC)

C. forskolin samples are prepared using the Extraction method, this technique for sample preparation ensures selective removal of a component/compound from a solid into another solvent. Isolating a compound from a plant material and dissolving it in a solvent in which it has maximum solubility is an important benefit of extraction. Forskolin sample is weighed and dissolved in approximately 50 ml of acetonitrile and stirred on a magnetic stirrer with a bead for 30-45 minutes, these samples are then filtered using a 0.2 µm syringe filter and injected.

Figure 1.6: Coleus root Powder

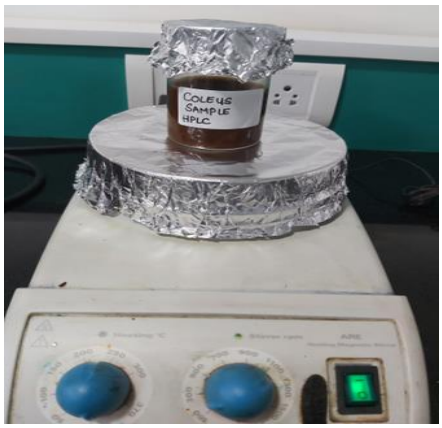

Figure 1.7: Coleus Sample analyzed by HPLC

Chromatogram conditions:

Coleus Consists of Two Mobile phases with a gradient flow, Mobile phase A is Acetonitrile and B is Distilled water. A C18 Shim-Pack Column was used of Dimension (5µm (4.6x250mm). Flow Rate is 1.8 ml/min, with an Injection volume of 20 µL. *C. forskolin* peak was Identified at UV wavelength of 220nm, Retention Time of Forskohlin in sample was 15.57 and total run time was 45 minutes indicated in Fig. 1.8 & 1.9.

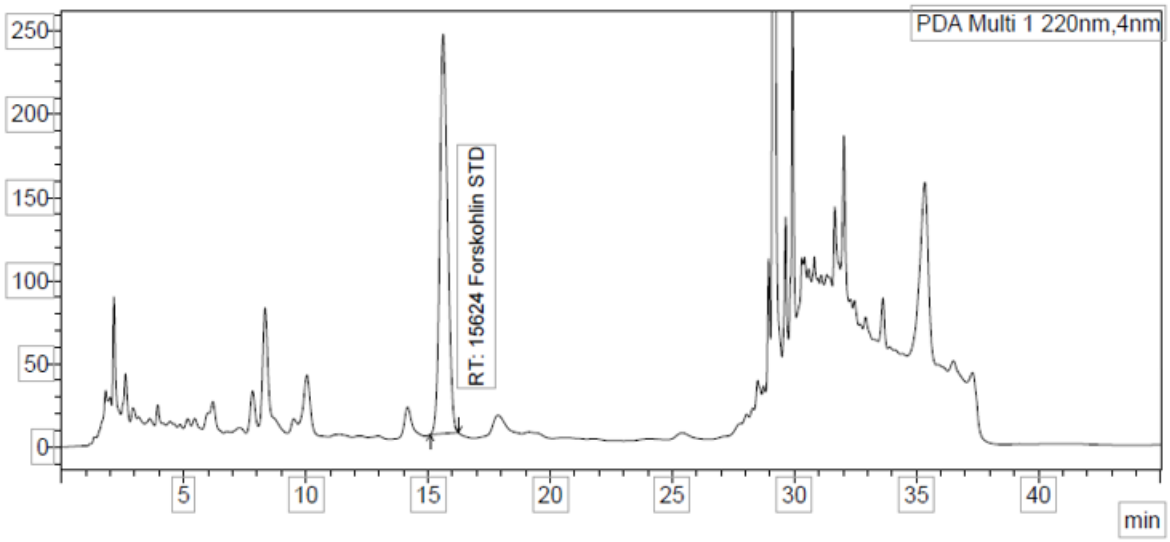

Figure 1.8: HPLC Chromatograph of Coleus root extract standard

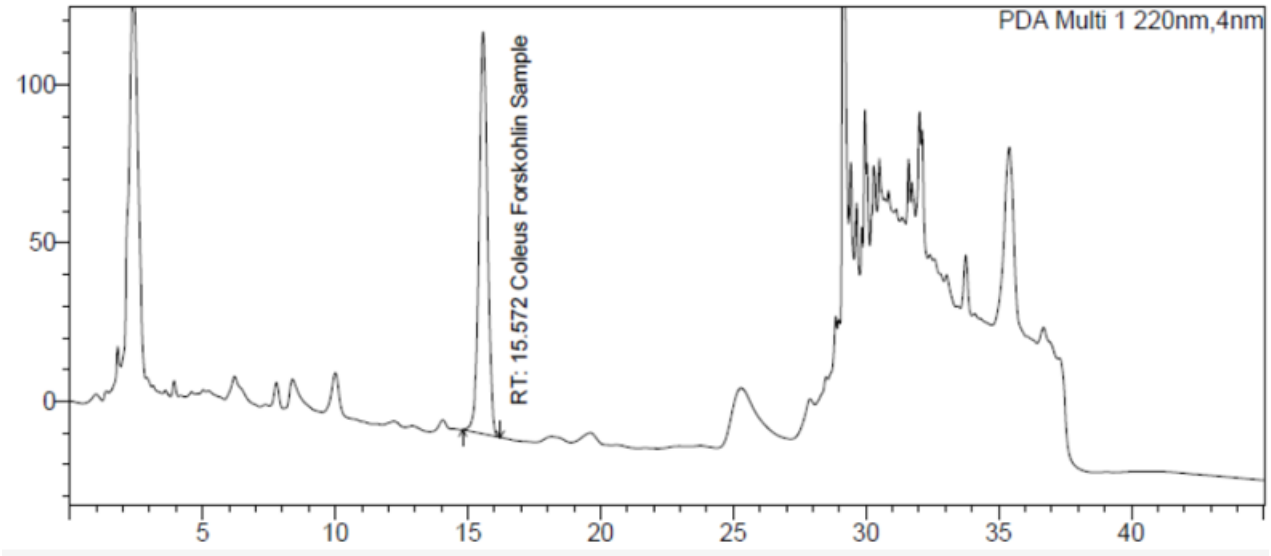

Figure 1.9: HPLC Chromatograph of Coleus root extract sample

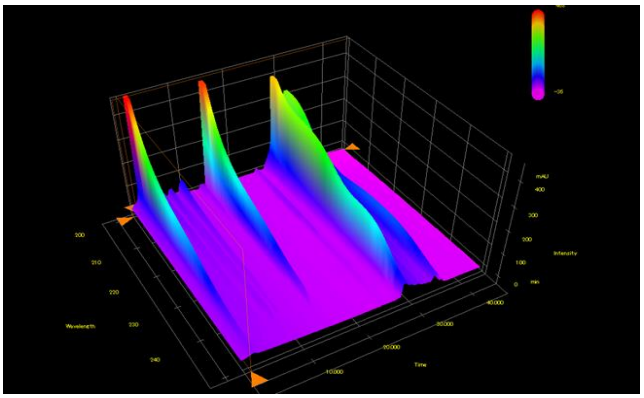

Figure 2.0: 3D Image of Coleus Forskohlin Sample by HPLC

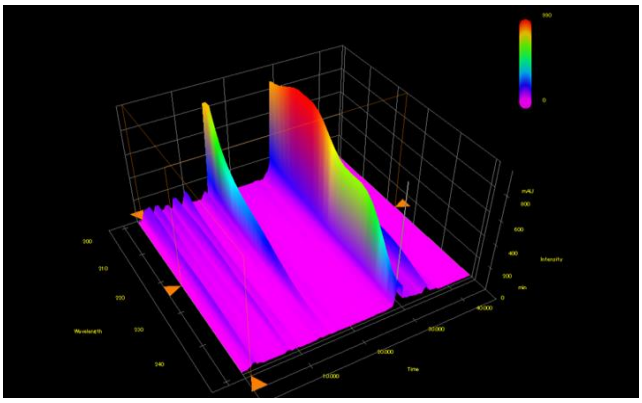

Figure 2.1: 3D Graph of Forskohlin Standard by HPLC:

4. Results

The main active component in Coleus Forskohlii is the diterpene, found in the root of the plant. Coleus root decoction or paste was used in the past in the traditional treatment of eczema, psoriasis, cardiovascular diseases, hypertension, glaucoma, diabetes, etc. To conclude, polar solvents like methanol followed by ethanol extracted highest forskolin content in all the extraction methods employed and Soxhlet

extraction method was found to be the best. The findings of this study could prove to be important for practical pharmacy for better extraction of forskolin. Forskohlin was analyzed and characterized using FTIR, HPLC and eletrospray ionization MS physiochemical methods.

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