Qualitative Phytochemical Screening and FTIR Spectroscopic Analysis of *Thunbergia coccinea* leaves extract

Gayathri. P[1*] and Dr. D. Chandra Prabha[2]

[1]Research Scholar, Department of Biochemistry, Sri Ramakrishna College of Arts and Science for Women, Coimbatore.

Email- gayathrip021996@gmail.com

[2]Associate Professor, Department of Biochemistry, Sri Ramakrishna College of Arts and Science for Women, Coimbatore.

Email- chandrabio@srcw.ac.in

ABSTRACT

Plants have an inherent ability to treat various aliments which gained interest towards medicinal plants for curing debilitating conditions. *Thunbergia coccinea* is an ethnomedicinal plant used as a therapeutic for anti-inflammatory, hepatoprotective, antipyretic and detoxicants by the rural community. Based on this knowledge present study was carried out to investigate presence of phytochemical constituents and Fourier transform infrared spectroscopy to characterize the chemical structure of bioactive compounds and presence of functional group in the hydroethanolic leaves extract of *Thunbergia coccinea*. Phytochemical analysis in leaves extract shows evidently that extract contains phytoconstituents such as Alkaloids, reducing sugar, saponins, steroids, phytosterols, flavonoids, tannins, phenol and cardiac glycoside. Fourier transform infrared spectroscopy in this extract explores presence of various functional groups such as carboxylic acid, alkane, aldehyde, alkynes, aliphatic amines etc. Our findings exhibit that hydroethanolic leaves extract of *Thunbergia coccinea* have medicinally important bioactive constituents with different functional groups and it justifies its use as a traditional medicine for the cure of various manifestations.

KEYWORDS : *Thunbergia coccinea*, Phytochemical, Fourier transform infrared spectroscopy, Traditional medicine.

DOI Number: 10.14704/nq.2022.20.9.NQ44292 **Neuro Quantology 2022; 20(9):2493-2499**

INTRODUCTION

Plant serves as an incredible source for human and thus plays a predominant role in the global population[1]. Plants have earned a great source of interest in the formulation of medicines in pharmaceutical industries and treatment of various ailments. Ability of a plant to synthesis aromatic compounds mainly a secondary metabolite provides an insight for the development of new drugs. Primary benefit of a plant derived medicines are mainly because they are relatively safer than the synthetic drugs, provides therapeutic benefits and cost-effective treatments for numerous diseases. The naturally derived plant products such as secondary metabolites played a vital role in the formation of bioactive molecules for potential preventive and therapeutic agent against neurodegenerative disorders[2].

Among the major neurodegenerative disorders, Alzheimer's are a huge socioeconomic burden. Alzheimer's is a progressive neurodegenerative disorder characterized by cognitive dysfunction and behavioural deficit. Potential therapeutic target in Alzheimer's based on biological mechanism include inflammatory mechanism, preventing formation or deposition of β amyloid protein and neurofibrillary tangles, amending cholinergic transmission etc. Research investigations on leaf extract of *Ginkgo biloba* have shown efficacy to prevent the pathological symptoms of Alzheimer's disease[3]. Plants can be

authentic source of novel bioactive compound for the evolution of therapeutic targets for Alzheimer's disease.

Thunbergia is a genus of flowering plant belong to the family of Acanthaceae. It constitutes about 100- 150 species[4] of robust annual or perennial vines which grows almost 2-8 m long. It is widely distributed as a shrub or climbers commonly used as an ornamental plant and possess medicinal properties. *Thunbergia coccinea* is a perennial twinning climber with dark green leaves and vines which bears bright red colour tubular flowers found hanging as a cluster. This is plant is rare in cultivation since it grows and blooms mostly in late winter and early spring, thus it is naturally found in subtropical regions and some tropical monsoon regions of India. *Thunbergia coccinea* is extensively used by karbis, tribal society of Assam (India) as a medicine for numerous ailments[5]. Literature on medicinal plant of Assam reported that juice extract from the root is used to treat sterility, stomach infection, aphrodisiac, pain, fever and against dysentery[6,7]. Study on leaves of *Thunbergia coccinea* have been reported for its potential anti-inflammatory, analgesic, and antipyretic properties[8]. Few research evidence reported that this plant parts are traditionally used to treat fresh wounds, cuts and stomach infections[9,10,11]. In the present study an attempt is made to explore the phytochemicals in different extracts and functional groups in the potent extract of *Thunbergia coccinea* leaves.

MATERIALS AND METHODS

Collection and Identification of Plant material

The plant material was collected from Kothagiri, Nilgiri Dt, Tamilnadu. The plant specimen was authenticated by Botanical survey of India, Southern Regional Centre, Coimbatore by referring the deposited specimen. The voucher number of the specimen is BSI/SRC/5/23/2017/Tech.

Preparation of Extract

Collected leaves were washed and shade dried then coarsely powdered using an electrical blender. Active components present in 25g of *Thunbergia coccinea* leaves were extracted using 100 ml of each solvents like hydroethanol, hexane, petroleum ether, ethyl acetate and chloroform using Soxhlet extraction. The solution was filtered using Whatman No.1 filter paper and the filtrate was lyophilized and stored at 4^0 C for analysis.

Qualitative Phytochemical Screening

The different extracts of *Thunbergia coccinea* leaves was analysed for the presence of alkaloids, reducing sugar, saponins, steroids, phytosterols, flavonoids, amino acids, tannins, phenol and cardiac glycosides according to the standard methods[12, 13].

Test for Alkaloids

To the 1 ml of extract of *Thunbergia coccinea* leaves were added with few drops of Mayer's reagent. Formation of pale or white precipitate indicates the presence of alkaloids.

Test for Reducing sugar

To the 0.5 ml of leaves extract added 1 ml of water and 5-8 drops of Fehling's solution. The test was kept in a boiling water bath and observed for the formation of brick red precipitate which shows presence of reducing sugar in the leaves extract.

Test for Saponins

1ml of extract was dissolved in 10ml of distilled water in a test tube and shaken vigorously. Formation of froth, which is stable for 5-10 minutes indicates the presence of saponin in the leaves extract.

Test for Steroids

To the 2 ml of leaves extract added 2 ml of chloroform and 2 ml of concentrated sulphuric acid then shaken well. Red colour produced in the lower layer indicate the presence of steroids.

Test for Phytosterols

The test was conducted by adding a few drops of concentrated sulphuric acid with hydroethanolic extract. Formation of brown ring indicates the presence of phytosterols in the leaves extract.

Test for Flavonoids

Using an alkaline reagent test, a few drops of sodium hydroxide solution was added with hydroethanolic leaves extract. Formation of an intense yellow colour which become colourless on the further addition of few drops of 1% dilute hydrochloric acid, which indicate the presence of flavonoids.

Test for Amino acids

Ninhydrin test was carried out by adding 5 drops of ninhydrin reagent with 1 ml of leaves extract. Which is further kept in a boiling water bath for 3-5 minutes. Formation of purple colour indicate the presence of amino acid in the leaves extract.

Test for Tannins

In ferric chloride test, 2 ml of leaves extract were stirred with 2 ml of distilled water and few drops of ferric chloride solution was added with it. Formation of dark green precipitate indicates the presence of tannins

Test for Phenol

The leaves extract was dissolved in 2 ml of distilled water. To this added few drops of 5% ferric chloride solution. A dark green colour indicates the presence of phenol in the extract.

Test for Cardiac glycoside

For the confirmation of cardiac glycoside 5 ml of leaves extract was added with 1 ml of glacial acetic acid. Then few drops of 2% ferric chloride solution were mixed with 1 ml of concentrated sulphuric acid. Brown ring indicates the presence of cardiac glycoside.

Fourier Transform Infrared Spectroscopic analysis

Fourier transform infrared spectrophotometer is feasibly the most powerful tool for identifying the type of functional group (chemical bond) present in the extract[14]. The wavelength of the light absorbed is characteristics of chemical bond. By interpreting the infrared spectrum, the functional groups in a molecule can be determined[15]. Dried powder of hydroethanolic extract of *Thunbergia coccinea* leaves were used for the analysis. 10 mg of dried extract powder were encapsulated in 100 mg of KBr pellet to prepare translucent disc. The powdered sample were loaded in FTIR spectrophotometer with the resolution ranging from 400 – 4000 cm^{-1}.

RESULTS AND DISCUSSION

Traditional medicines are considered as a prime resource for rural people since it contributes on treating various ailments. Medicinal plants have been referred as a backbone of traditional medicine and their therapeutic properties are mainly due to the presence of chemical agents in plant which serves as a secondary metabolite[16]. This gained an interest over years for the development of potential drugs from plants to treat various diseases. The research was focused on understanding the presence of bioactive chemicals and their functional groups, their role in the prevention and cure for diseases. Result of the phytochemical screening are depicted in table -1.

Table-1: Phytochemical screening of *Thunbergia coccinea* leaves

S.No.	Phytochemicals	Hydroethanol	Hexane	Petroleum ether	Ethyl acetate	Chloroform
1	Alkaloids	+++	+++	++	-	++
2	Reducing sugar	+++	++	+	++	+
3	Saponins	+++	-	-	-	+
4	Steroids	+++	+	-	++	++
5	Phytosterols	+	-	-	+	++
6	Flavonoids	++	+	-	++	++
7	Amino Acids	-	-	-	-	-
8	Tannins	+++	+	+	++	+
9	Phenol	+++	+	+	++	+
10	Cardiac glycosides	+++	+++	+	-	-

+++ - Present

++ - Moderately present

+ - Traces

⁻ - Absent

Preliminary phytochemical screening

In the present study exploration of phytochemical screening with different extracts of *Thunbergia coccinea* leaves revealed the presence of alkaloids, reducing sugar, saponins, phytosterols, flavonoids, tannin, phenol and cardiac glycoside. Therefore, these leaves extract can be used pharmacologically for the development of new drugs for numerous diseases.

From the use of traditional plants as a cure for diseases by the ancient society shows evidently that phytochemicals have a potency to aid the role of immune system, reduce inflammation, conserve DNA and cells against damage. One among the best plant containing organic compound is alkaloids and it bears quit diverse medicinal properties such as anaesthetic, cardio protective, anti-inflammatory agent[17]. Reducing sugar is one of the bioactive molecules found in plants, fruits and vegetables. It has a wide role on significantly reducing obesity, development, and disease resistance[18]. Saponin is a naturally occurring bioorganic molecule which has a vital role in human health hence it considered as pharmaceutical and nutraceutical agent[19]. Various studies shows that saponins exhibits numerous biological and medicinal properties such as anti-inflammatory, antibacterial, antifungal, antiviral and anticancer etc[20]. Steroids are distinctive class of bioactive compound which are found distinctly among plants and animals. Plant steroids displays several biological such as development, growth, maintain sex hormones etc. Pharmacological properties possess anti-inflammatory, immunosuppressive, antihelminthic and cytotoxic activity etc[21]. Plant sterols are otherwise known as phytosterols which are naturally occurring bioactive molecule. They are present in plant cell membrane and enriched in cereals, vegetables, fruits and berries. Various studies revealed that phytosterols have antibacterial, antiulcerative and antitumor properties[22,23,24]. Phytosterols also gained attention on reducing heart disease and cholesterol level[25,26,27]. Flavonoids have extensive biological properties which plays a significant role in enhancing human health and reduces the risk of diseases[28]. Numerous studies on flavonoids and bioactive molecules evidently found that flavonoids derived from medicinal plants are responsible for preventing oxidation of fat, cardiovascular disease, cancer, diabetes and cognitive impairments etc. Therapeutic uses of amino acids present ethnomedicinal plant with a great therapeutic option. Some of the prominent pharmaceutical applications of amino acids are used for the treatment of imbalance in neurotransmission and synaptic functions. Other area of therapeutics of amino acids are such as gastrointestinal health, immune function and also applicable in cardiovascular disorders[29]. Tannins are water soluble polyphenol commonly present in plants and plant based materials. They exert various pharmacological roles such as free radical scavenger, antimicrobial and anticancer properties etc[30]. Phenols are ubiquitous in nature hence they are found in most of the terrestrial plants. Its an organic compound act as an antioxidant, antiproliferative, anti-inflammatory and plays a vital role in other defence mechanism[31]. Cardiac glycoside is a unique secondary metabolite which are found in many plants, they are considered as one of the most useful components in the therapeutics. They are reportedly used for the treatment of atrial fibrillation, atrial flutters and they also possess anti proliferative property[32].

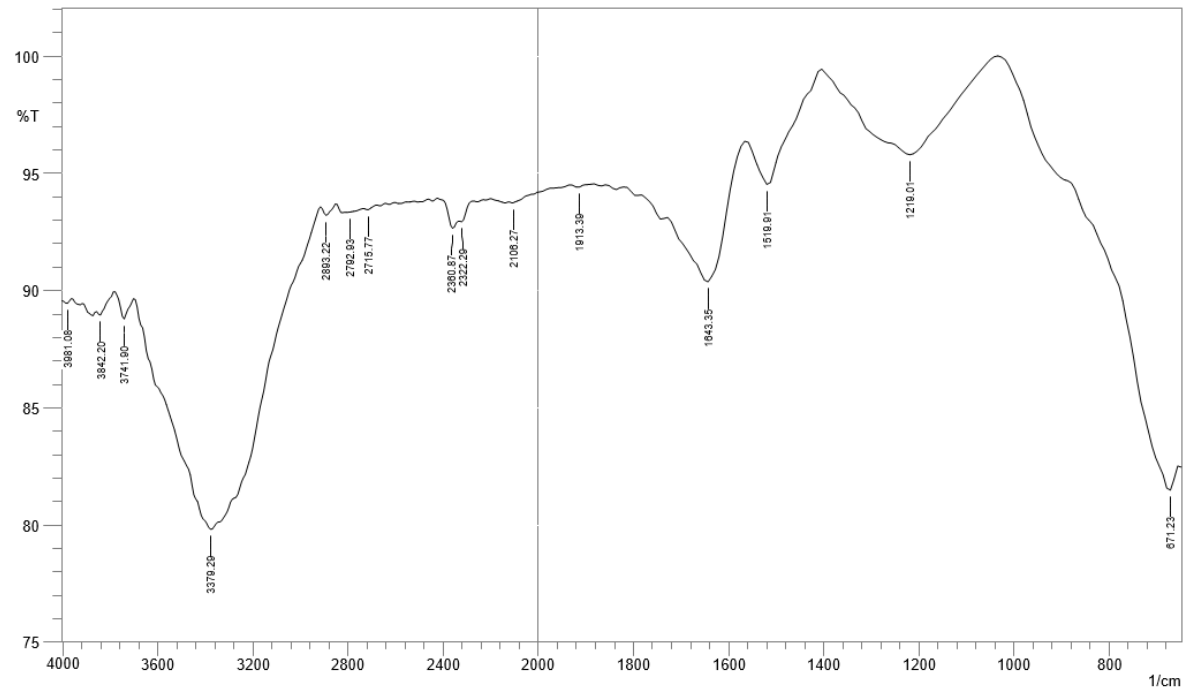
In the present study, hydroethanolic extract of *Thunbergia coccinea* was found to have high content of alkaloids, reducing sugar, saponins, steroids, tannins, phenols and cardiac glycosides, moderate number of flavonoids and trace amount of phytosterols. Hexane extract was found to have good number of alkaloids, cardiac glycosides, moderate amount of reducing sugar and trace number of steroids, flavonoids, tannins and phenol. Determination with petroleum ether reveals the moderate number of alkaloids and only few traces of reducing sugar, tannins, phenol, cardiac glycosides. Whereas ethyl acetate shows presence of reducing sugar, steroids, flavonoids, tannins and phenols and a trace of phytosterols. Alkaloids, steroids, phytosterols, flavonoids were observed in moderately whereas reducing sugar, saponins, tannins and phenols were only found in traces in chloroform extract. This represents most of the polar constituents were extracted in hydroethanol when compared to other solvents such as hexane, petroleum ether, ethyl acetate

and chloroform. Hence hydroethanolic extract of *Thunbergia coccinea* was used for detecting functional group present in this plant by using Fourier transform infrared spectroscopy analysis.

Fourier Transform Infrared Spectrophotometer

Plants are major source for the pharmaceutical industry since it possesses large functional groups, which has a great influence on the drug-like properties. FTIR spectrum was used to identify the presence of functional group of active components in the plant extract. FTIR is a high-resolution analytical technique which help to identify important chemical constituents in plant and elucidate the structural components[33, 34]. The result of FTIR analysis confirm the presence of various chemical constituents such as hydroxyl group, carboxylic acid, alkane, aldehyde, nitriles, alkyne, isothiocyanate, alkene, nitro compound, aliphatic amines, halogen compound in hydroethanolic leaves extract of *Thunbergia coccinea*.

(Figure 1) demonstrates the presence of 15 functional groups identified from the hydroethanolic extract of *Thunbergia coccinea* leaves. 3981.08 cm^{-1}, 3842.20 cm^{-1} and 3741.90 cm^{-1} were corresponding to the functional group of hydroxyl group (non-bonded, O-H stretching). The strong and wide peak was observed at 3379.29 cm^{-1} and 671.23 cm^{-1} which are assigned as carboxylic acid (O-H stretching) and halogen compound (C-Br stretching) respectively. The moderate peaks were observed at 1643.35 cm-1, 1519.91 cm-1 and 1219.01 cm^{-1} were assigned as Alkene (C=C stretching), Nitro compound (N-O asymmetric stretch), Aliphatic amines (C-N stretching) respectively. The peak at 2893.22 cm^{-1}, 2106.27 cm^{-1} and 1913.39 cm^{-1} refer to the presence of functional group such as alkane (C-H stretching), Alkyne (C≡C Stretch), Isothiocyanate (N=C=S stretch) respectively. The peaks at 2792.93 cm^{-1}, 2715.77 cm^{-1} represents the functional group aldehyde (C-H stretching). Peak obtained in 2360.87 cm^{-1}, 2322.29 cm^{-1} determines the presence of Nitriles (C=N stretch) as a functional group.



CONCLUSION

The present work has been carried out to establish the various phytoconstituents in different extracts and FTIR parameters in the potent hydroethanolic leaves extract of *Thunbergia coccinea*, which could serve as an important and commercial interest in pharmaceutical industries and research for the innovation of drugs. This preliminary study has been an insight for conducting further study on this plant to resolve their efficacy by *in vivo* studies.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCE

1. Sen, T., & Samanta, S. K. (2015). Medicinal plants, human health and biodiversity: a broad review. Advances in biochemical engineering/biotechnology, 147, 59–110. https://doi.org/10.1007/10_2014_273.
2. Sharifi-Rad, M., Lankatillake, C., Dias, D. A., Docea, A. O., Mahomoodally, M. F., Lobine, D., Chazot, P. L., Kurt, B., Tumer, T. B., Moreira, A. C., Sharopov, F., Martorell, M., Martins, N., Cho, W. C., Calina, D., & Sharifi-Rad, J. (2020). Impact of Natural Compounds on Neurodegenerative Disorders: From Preclinical to Pharmacotherapeutics. *Journal of clinical medicine*, *9*(4), 1061. https://doi.org/10.3390/jcm9041061.
3. Sierpina, V. S., Wollschlaeger, B., & Blumenthal, M. (2003). Gingko biloba. *American family physician*, *68*(5), 923-926.
4. Borg, A. J., McDade, L. & Schönenberger, J. (2008). Molecular phylogenetics and morphological evolution of Thunbergioideae (Acanthaceae). *Taxon* 57: 811 – 822.
5. B., Mahesh & Shekar, Kokila & Kenganora, Mruthunjaya. (2020). EXPLORATION OF BIOACTIVE COMPONENTS OF THUNBERGIA COCCINEA, ITS PHARMACOGNOSTIC, ANTIOXIDANT, GCMS AND ANTIHYPERGLYCEMIC STUDIES. International Journal of Pharmacy and Pharmaceutical Sciences. 12. 37290. 10.22159/ijpps.2020v12i6.37290.
6. Ghosh, Debosree & Parida, Pratap. (2015). Medicinal Plants of Assam, India : A Mini Review. International Journal of Pharmacology and Pharmaceutical Sciences.
7. Sarma, J. (2006). Medicinal and aromatic plants of Assam with special reference to Karbi Anglong, Published by Silviculture Division, Department of Forest, Diphu.
8. Victoria, S & Das, S & Lalhlenmawia, H & Shantabi, Longjam & Sarda, S. (2014). ANTIOXIDANT ACTIVITIES OF THE LEAVES OF THUNBERGIA COCCINEA WALL.
9. Borah P. Various ethno-medicinal plants used for treatment of reproductive health problems by morans of Tinsukia district, Assam. Int. J. New Technol. Res. 2017;3:38–40. [Google Scholar]
10. Taid TC, Rajkhowa RC, Kalita JC. A study on the medicinal plants used by the local traditional healers of Dhemaji district, Assam, India for curing reproductive health related disorders. Adv. Appl. Sci. Res. 2014;5:296–301. [Google Scholar]
11. Sultana, K. W., Das, S., Chandra, I., & Roy, A. (2022). Efficient micropropagation of Thunbergia coccinea Wall. and genetic homogeneity assessment through RAPD and ISSR markers. *Scientific reports*, *12*(1), 1683. https://doi.org/10.1038/s41598-022-05787-7.
12. Evans WC, Trease. 3rd ed. Text Book of Pharmacognosy. ELBS, London 1994; 177-179.
13. Harborne JB. 3rd ed. Phytochemical methods. A guide to modern techniques of plant analysis. Chapman and Hall Int. Ed. New York.1998.
14. Pakkirisamy M, Kalakandan SK and Ravichandran K. Phytochemical Screening, GC-MS, FT-IR Analysis of Methanolic Extract of Curcuma caesia Roxb (Black Turmeric). Pharmacog J. 2017;9(6):952-6.
15. Sahayaraj, P. & J.Gowri, & Dharmalingam, V. & R.Shobana, & Prema, A.Angelin. (2015). Phytochemical screening by FTIR spectroscopic analysis of leaf and stem Extracts of wedelia biflora. International Journal of Nano Corrosion Science and Engineering. 2(5).
16. Abukakar, M. & Ukwuani-Kwaja, Angela & Shehu, Rriskuwa. (2008). Phytochemical Screening and Antibacterial Activity of Tamarindus Indica Pulp Extract. Asian Journal of Biochemistry. 3. 134-138. 10.3923/ajb.2008.134.138.
17. Heinrich, M., Mah, J., & Amirkia, V. (2021). Alkaloids Used as Medicines: Structural Phytochemistry Meets Biodiversity-An Update and Forward Look. *Molecules (Basel, Switzerland)*, *26*(7), 1836. https://doi.org/10.3390/molecules26071836.
18. Khatri, D., & Chhetri, S. (2020). Reducing Sugar, Total Phenolic Content, and Antioxidant Potential of Nepalese Plants. *BioMed research international*, *2020*, 7296859. https://doi.org/10.1155/2020/7296859.
19. Rao, A.V., Gurfinkel, D.M. (2000). Dietary Saponins and Human Health. In: Oleszek, W., Marston, A. (eds) Saponins in Food, Feedstuffs and Medicinal Plants. Proceedings

of the Phythochemical Society of Europe, vol 45. Springer, Dordrecht. https://doi.org/10.1007/978-94-015-9339-7_26.

20. El Aziz MMA, Ashour AS, Melad ASG. A review on saponins from medicinal plants: chemistry, isolation, and determination. J Nanomed Res. 2019;8(1):282-288. DOI: 10.15406/jnmr.2019.07.00199.
21. Raju, Renjith & Prakash, Toms & Rahul, Ramachandran & Poonangadu, Sruthi & Kumar, Siranjeevi & Sonaimuthu, Prasanth & Jinky, Marie & Chua, Jinky Marie & Capili, Julius. (2021). Phytochemical Analysis of Three Common Medicinal Plants (Gliricidia sepium, Melothria pendula, and Pithecellobium dulce) in the Philippines. portal Libraries and the Academy. 9. 84-88. 10.36347/sajb.2021.v09i03.004.
22. Arisawa, M.; Kinghorn, D.A.; Cordell, G.A.; Phoebe, C.H.; Farnsworth, R.N. (1985) Plant anticancer agents XXXVI, Schottenol glucoside from Baccharis cordifolia and Ipomopsis aggregata. Planta Medica, 6: 544–545. doi: 10.1055/s-2007-969601.
23. Akihisa, T.; Yasukawa, K.; Yamaura, M.; Ukiya, M.; Kimura, Y.; Shimizu, N.; Arai, K. (2000) Triterpene alcohol and sterol ferulates from rice bran and their anti-inflammatory effects. Journal Agricultural Food Chemical, 48 (6): 2313–2319. doi:10.1021/jf000135o.
24. Berger, A.; Jones, P.J.; Abumweis, S.S. (2004) Plant sterols: factors affecting their efficacy and safety as functional food ingredients. Lipids Health Diseases, 3: 5. doi: 10.1186/1476-511X-3-5.
25. Jones, P.J.H.; MacDougall, D.E.; Ntanios, F.; Vanstone, C.A. (1997) Dietary phytosterols as cholesterol-lowering agents in humans. Canada Journal Physiological Pharmacology, 75: 217–227. doi: 10.1139/y97-011.
26. Hicks, K.B.; Moreau, R.A. (2001) Phytosterols and phytostanols: functional food cholesterol busters. Food Technology, 55: 63–67.
27. Uddin MS, Sahena Ferdosh, Md. Jahurul Haque Akanda, Kashif Ghafoor, Rukshana A.H., Md. Eaqub Ali, B. Y. Kamaruzzaman, Fauzi M. B., Hadijah S., Sharifudin Shaarani & Md. Zaidul Islam Sarker (2018) Techniques for the extraction of phytosterols and their benefits in human health: a review, Separation Science and Technology, 53:14, 2206-2223, DOI: 10.1080/01496395.2018.1454472.
28. Sushil, C. T. & Nisreen, H. (2017). Biological Activities and Roles of Flavonoids in Human Health- A Review. Indian Journal of Scientific Research, 12 (2): 193-196.
29. Dr. Chris D. Meletis and Jason E. Barker.Alternative and Complementary Therapies.Feb 2005.24-28.http://doi.org/10.1089/act.2005.11.24
30. Smeriglio, A., Barreca, D., Bellocco, E., and Trombetta, D. (2017) Proanthocyanidins and hydrolysable tannins: occurrence, dietary intake and pharmacological effects. *British Journal of Pharmacology*, 174: 1244– 1262. doi: 10.1111/bph.13630.
31. Lin, D., Xiao, M., Zhao, J., Li, Z., Xing, B., Li, X., Kong, M., Li, L., Zhang, Q., Liu, Y., Chen, H., Qin, W., Wu, H., & Chen, S. (2016). An Overview of Plant Phenolic Compounds and Their Importance in Human Nutrition and Management of Type 2 Diabetes. *Molecules (Basel, Switzerland)*, *21*(10), 1374. https://doi.org/10.3390/molecules21101374.
32. Škubník, J., Pavlíčková, V., & Rimpelová, S. (2021). Cardiac Glycosides as Immune System Modulators. Biomolecules, 11(5), 659. https://doi.org/10.3390/biom11050659.
33. Aysal P, Ambrus AD, Lehotay SJ, Cannavan A. Validation of an efficient method for the determination of pesticide residues in fruits and vegetables using ethyl acetate for extraction. J. Environ. Sci. Heal. 2007; 42:481-90.
34. Ibrahim M, Hameed AJ, Jalbout A. Molecular Spectroscopic Study of River Nile Sediment in the Greater Cairo Region. Applied Spectroscopy. 2008; 62(3):306-11.