



Formulation And Evaluation Of Hairserum From Leaves Extract Of Piper Betel And Ixora Coccinea

Dr.J .Nandhakumar¹ Sreekanth S Kaithavalappil², Anusha Shajan³, Anu T.J⁴, Bijitha Krishna
T.V⁵, Fathima Jalal⁶

¹Principal and professor ,Indira Gandhi institute of Pharmaceutical Sciences, Ernakulam.

²Head of Department of Pharmaceutics, Indira Gandhi institute of Pharmaceutical Sciences, Ernakulam.

^{3,4,5,6} Students of Indira Gandhi institute of Pharmaceutical Sciences, Ernakulam .

Corresponding Author : Sreekanth S Kaithavalappil²

ABSTRACT:

The present study aims to formulate and evaluate a herbal hair serum using leaf extracts of Piper betel and Ixora coccinea, plants traditionally recognized for their antimicrobial, antioxidant, and hair growth-promoting properties. The leaves were collected, authenticated, shade-dried, and subjected to extraction using appropriate solvents. Preliminary phytochemical screening confirmed the presence of bioactive constituents such as flavonoids, tannins, phenolic compounds, terpenoids, and glycosides. The herbal hair serum was formulated incorporating natural excipients including aloe vera gel, vitamin E, lavender oil, rose water, Tween 80, and sodium benzoate. The prepared formulations were evaluated for physicochemical characteristics such as appearance, homogeneity, spreadability, transparency, pH, and antifungal activity. The pH of the formulation was found to be within the acceptable range for scalp application. Antifungal activity assessed by the well diffusion method demonstrated significant inhibitory effects against fungal strains. Among the formulations developed, the optimized formulation exhibited satisfactory stability, smooth texture, and effective antifungal activity. The findings of the study indicate that the formulated herbal hair serum is safe effective, and suitable for improving scalp health, reducing dandruff, and enhancing overall hair quality.

KEYWORDS: Hairserum, formulation, safety, efficacy, daily use, Anti- fungal activity

INTRODUCTION

Cosmetics are products typically used on the skin to enhance its beauty and clarity. "Cosmetics" comes from the Greek word "Kosmesticos," which signifies "to embellish." Since that time, the word "cosmetics" has been utilized to denote items that enhance appearance or adorn the skin. Herbal cosmetics aim to enhance people's appearance and beauty. Numerous people apply makeup every day, and the need for it is increasing each day. Herbal cosmetics are commonly used due to their minimal side effects and offer extra safe options for various loss concerns. They also seek methods to encourage growth and assist in loss. Hair is a complicated structure made of keratin and acts as a protective layer for the body. Hair is vital for shielding the scalp, maintaining body temperature, and affecting a person's looks. The composition of hair differs due to genetic, environmental, and health influences. Proper hair maintenance is essential to keep hair healthy and protect it from outside damage. Hair care products are applied to enhance its look, and it is a cyclical medium with hair shaft conflation, extension, and shedding. Hair is constituted of anagen, catagen, and telogen phase follicles, and a root, shaft, and tip. Anti-ringlet parcels also support to make it smoother. Hair serum adds natural glow while protecting hair from external or heat damage with its rich moisturizing properties. Hair is said to become healthier and less brittle by being moisturised and sealed with moisture by serums, which also cause it to be smoother. Anti-frizz effects of hair serum also help to enhance its smoothness. Hair is primarily made up of two main parts: the hair shaft, which is the visible part, and the hair follicle, which is embedded in the skin. Consequently, hair has a very important function to protect the scalp, maintains body temperature, and adds to the appearance of an individual. The structure of hair differs due to genetic, environmental, and health factors. Properly caring for hair is important for maintaining healthy hair and preventing external damage.¹

➤ HAIR STRUCTURE

The Shaft of hair : a portion of hair that grows above the skin surface. It consists of three layers: Cuticle, Cortex, and Medulla. Cuticle is the outer layer which composed of covered scale protecting the inner layers and are responsible for the elasticity of the hair. Cortex is the medium layer most hair proteins and determines color, strength and flexibility and Medulla is the most interior layer present in some hair type but may be absent or less renowned in others.

Hair Follicle : Hair Follicle is the design where hair grows. Hair follicle lives inside the skin and it has Several layers, including external root shay, internal origin, sheath and hair bulb. There are cells in the hair bulb to promote hair growth and pigment.

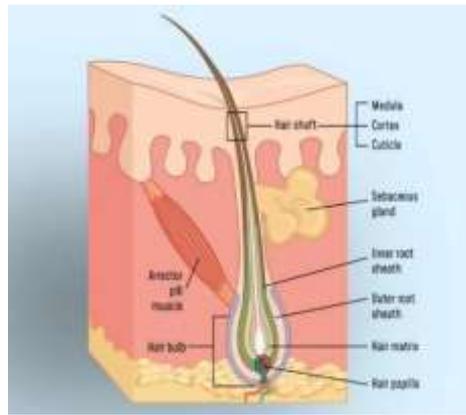


Fig no : 01 Structure of hair

➤ HAIR GROWTH PHASE

1. Anagen Phase:

First stage of hair growth cycle & approximately 1,000 days. It begins in papilla & can last from two-six years. Eighty to ninety percent of all human scalp hair in anagen stage. Period of growth when cell around the Follicle rapidly dividing of depositing materials within the hair. The hair with capability to grow 1 meter, the genetic determination of hair growth; the cells in papilla divide to produce new hair fibers and follicle buries itself in a dermal layer of skin for nourishment of strand.

2. Catagens phase:

At the end of anagen, phase hair enters catagen phase. It is a short transitional phase, generally lasts about 10 days. First sign of catagen is stoppage of melanin production in hair bulb & apoptosis of follicular melanocytes. It is also known as transitional phase. Follicle renew itself two weeks hair follicle shrinks. Due to disintegration and papilla detaches or rest. Cutting hair strand off from its nourishing blood supply. Hair not grows during this phase, length of terminal fibre increases follicle pushes them upward.

3. Telogen phase:

The final stage of hair growth. During this phase, hair follicle is dormant/ resting & hair easily lost 10-18% hair in telogen phase. Follicle then remain inactive for 3 months. The epidermal cells lining follicle channel continue to grow and accumulate around base of hair. The follicle will this means that within two weeks, the new hair shaft will begin to grow, signaling the completion of the telogen phase. This is also called shedding phase.

4. Exogen phase:

For long hair shedding function has been assumed to be part of telogen phase, but now it has been shedding actually occurs as distinct phase termed as exogen phase. The shedding of hair fibre highly controlled active process. The process different from quiescence normally found during hair follicle cycling. The process of has two steps: After telogen the follicle base cells receive signal initiate exogen. Turn on effectors of shedding.

5. Kenogen phase:

The empty hair follicle noticed after shedding of hair fibre. Kenogen means hair follicle remains empty after telogen & before new anagen hair reappears. If the growth cycle becomes disrupted then hair loss, hair thinning & problems with hair growth will result.⁴



Fig no: 02 Hair growth phases

➤ HAIR SERUM

Serums for hair are light hair treatment products meant to enhance hair texture, manageability, and protection from the elements. They create a protective layer on the hair shaft that locks in moisture and shields it from outer damage. There are various types of hair serums for various hair purposes. It is essentially a hair care product in liquid form, its density thicker than water. The hair serums contain natural oils and plant extracts to provide extra treatment benefits and nourishment. Hair serum is one of the decorative products with veritably high focus of active ingredient in their recipe for providing ferocious nutrition to the lower skin subcaste and non- greasy finish product which appropriate for skin. Hair serums are liquid medication having slightly thicker thickness the water. Hair serums adds natural luster while protecting hair from environmental or heat- associated damage with its rich moisturizing properties. hair serum prevents humidity and conditions the hair. Hair serum's anti- ringlet parcels also support to make its smoothness greater.

➤ ADVANTAGES

Hair serum provides natural shine while protecting hair against environmental or heat damage with its dense moisturising properties. Hair has been proven to become healthier and less prone to brittleness through being moisturized and sealed in moisturiser by serums, which also cause it to feel smoother and look healthier. Hair serum's ability to reduce frizz also helps to boost its smoothness.

➤ DISADVANTAGES

Regular use and overuse can harm hair. Once it is used regularly for a couple of days, this accumulates and causes weight to hair, making it extremely flat and lifeless-looking. Serum use on scalp leads to Inflammation.

➤ TYPES OF HAIR SERUM

There are different types of herbal hair serums, each with the goal of improving blood circulation to the scalp and managing specific hair issues and desires. Common types of herbal hair serums are the following.

- Moisturizing serum

Such serums are targeted towards delivering moisture to brittle and dry hair. Herbal ingredients usually consist of nourishing components like argan oil, shea butter, coconut oil, and aloe vera, which provide hydration and feed hair strands, leading to smooth, silky hair that can be handled more easily.

- Growth-enhancing serum

The ingredients in these serums are mainly to enhance hair density and promote growth. Ingredients such as biotin, promote hair growth ginseng extract, and fenugreek extract could be included in them; these are believed to stimulate the follicles.

- Strengthening serum

To reduce breakage and make hair look healthier, strengthening serums are designed to strengthen weak, broken strands. They usually contain vitamins, minerals, and antioxidant-rich herbs that strengthen hair and make it more resilient, like horsetail extract, nettle leaf extract, and rosemary oil.

- Anti-dandruff serum

Anti-dandruff serums are formulated to address scalp problems, such as flaking, itching, and dandruff. These products usually contain herbal elements like tea tree oil, neem oil, and peppermint oil, which have anti-inflammatory and antimicrobial properties. These ingredients calm the scalp and minimize the bacteria that cause dandruff.

- Repair serum

Chemical processing, heat styling, and exposure to environmental aggressors can be compensated for using repairing serums. Herbal extracts such as keratin, avocado oil, and bamboo extract are common in these serums and play the role of closing the hair cuticle, taming frizz, and regaining shine.

- Soothing serum

Calming serums are formulated to soothe the scalp, which has the effect of reducing inflammation and irritation. They can contain herbal elements that are anti-inflammatory and calming in nature, such as calendula extract, lavender oil, and chamomile extract, to soothe scalp irritation.

- Shine serum

Shine serums are created to add shine and brightness to dull hair. In order to increase shine without leaving hair weighed down, they typically consist of light-reflecting particles or oils like coconut or jojoba oil.

➤ **BENEFITS OF HAIR SERUM**

Before finishing the product, it is important to know about the benefits of hair serum. The primary benefits of a hair serum are as mentioned below.

1) **Multi-Purpose:** A hair serum solves several hair issues instead of a single one. It is known as a one-stop solution to all your hair issues for a reason. An untidy day for your hair can be made into a good one with hair serum. Your hair will have a different feel and look after only a few drops.

2) **Hair Protection:** A protective layer of hair serum is applied on the hair strands. Therefore, it gives excellent protection against pollution, dust, heat, and sun damage. It prevents damage to your hair. That is why, applying a heat-protecting serum before using hot styling tools is advisable.

3) **Gives Shine to the Hair:** The layer that hair serum creates reflects light, giving your hair a glossy, glossy appearance. Amino acids found in hair serums shield chemically treated and colored hair.

4) **Prevents Hair Fall From Breaking:** Due to the wear and tear required to detangle tangled hair, we experience a significant loss of hair strands. Hair serum serves as a lubricant and facilitates entangling. And there is less hair loss that results.

5) **Conditions Hair and Makes It Easy to Style:** Hair serums condition damaged and fragile hair by plugging follicular cracks. Hair serum makes hair more manageable by making it simpler to style. patience, time, and effort. Everything has been retained.⁴

AIM AND OBJECTIVES

- Hair serums based on herbs can perfectly smoothen, soften, and turn hair silky.
- Serums are excellent hair protectants, guarding against heat damage, sun damage, dust, dirt, and pollution.
- They impart luster to the hair, prevent hair loss because of breakage, works well on dry hair, as a hair conditioner.
- To prepare the hair serum preparation
- Improve Hair Condition and Texture
- To evaluate herbal hair serum.
- To determine its ability to combat dandruff and scalp infection.
- To check the pH level balance for the serum so it does not cause irritation to the skin.
- For maintaining the freshness and potency of the serum

MATERIALS AND METHODS

➤ PIPER BETLE



Fig no: 03 Betel leaves

SYNONYM	Vettila (Malayalam), Paan (Hindi), Vettilai(Tamil), Tambula (Sanskrit)
FAMILY	Piperaceae
BIOLOGICAL SOURCE	Fresh or dried leaves of Piper betle Linn
KINGDOM ORDER	Plantae Piperales
GENUS	Piper
CHEMICAL CONSTITUENTS	Hydroxychavicol ,Caryophyllene,Chavicol, Eugenol,

USES

Antimicrobial,
anti-inflammatory,
antioxidant, treats scalp
infections, reduces hair
fall, and prevents dandruff.

➤ IXORA COCCINEA

Fig no :04 Ixora coccinea leaves

SYNONYM	Jungle Geranium, Vetchi (Tamil), Rugmini(Hindi), Techhi (Malayalam)
FAMILY	Rubiaceae
BIOLOGICAL SOURCE	dried or fresh flowers, leaves, and roots of the plant <i>Ixora coccinea</i> Linn.
KINGDOM	Plantae
ORDER	Gentianales
GENUS	<i>Ixora</i>

CHEMICAL CONSTITUENTS anthocyanins flavonoids tannins, and saponins. Oleanolic acid, aromatic acids, and sterols like sitosterol, Triterpenoids, phenolic compounds.

USES Scalp Health & Anti-Dandruff, Stimulates Hair Growth, Antioxidant Protection, Provide conditioning and Shine.

➤ ALOE VERA GEL



Fig no :05 Aloe vera gel

SYNONYM	<i>Aloe barbadensis</i> Mill., <i>Aloe indica</i> Royle, <i>Aloe vulgaris</i> Lam.
FAMILY	Liliaceae
BIOLOGICAL SOURCE	dried juice or fresh gel obtained from the leaves of <i>Aloe vera</i> Linn.
KINGDOM	Plantae

ORDER	Asparagales
GENUS	Aloe
CHEMICAL	Anthraquinones: Aloin and emodin
CONSTITUENTS	Polysaccharides: Vitamins & Minerals: Vitamins A, C, E B12, Folic Acid, and Zinc. Salicylic acid Saponins
USES	Improves blood circulation to the scalp, Dandruff Control, Hair Growth, Moisturizer, Acts as a natural conditioner .

➤ TWEEN 80



Fig no :06 Tween 80

It is a surface-active compound. Its nature is non-ionic. It acts as a solubilizer, stabilizer, and emulsifier. In pharmaceuticals, it is Tween80. Also known as Polysorbate 80.⁹

➤ SODIUM BENZOATE



Fig no :07 Sodium benzoate

Sodium benzoate has a crystalline white powder formulation which is soluble in water to get a colorless and transparent solution. The chemical compound is primarily used as a cosmetic raw material in cosmetic formulation. Its main role as a cosmetic preservative is to inhibit fungus growth in cosmetic formulations. Its antibacterial efficiency is low but can be used as such. Sodium benzoate is its efficiency as a product stabilizer.¹

➤ ROSE WATER



Fig no :08 Rose water

Rose water is also used as a moisturizer and has applications as a cosmetic toner and cream. Additionally used as a fragrance and moisturizer. Rosewater exerts moderate astringency, which may work in reducing the oily sensation and dandruff. It has anti-inflammatory properties which could help in addressing scalp problems. Curly-haired women can attest to the efficacy of rose water used in reducing frizz and increasing gloss. It is also used in perfume.⁹

➤ VITAMIN E



Fig no :09 Vitamin E

A good oil high in vitamin E helps replenish shine by rebuilding the protective layer. Overall, oil helps seal in and protect the hair from moisture, minimize breakage, and protect the hair from harm. Vitamin E can help maintain a healthy crown and hair since it contains natural antioxidants that may aid in hair growth. Vitamins and antioxidants can reduce the amount of oxidative stress and free radicals responsible

for it implies the decay of hair follicle cells of one's crown. Its also known as Tocopherol.

➤ LAVENDER OIL



Fig no :10 Lavender oil

The components of lavender oil (LO) are linalyl acetate, linalool, and geraniol., linalool exhibits antifungal offer a basis for development of treatments for hair loss., In order to achieve this, the hair growth- stimulating activity.

METHODOLOGY

1. Collection and Authentication

The leaves of Piper betel and Ixora coccinea were gathered from the roadside of Cherukunnam. and both leaves were authenticated by Dr.Shintu P.V ,HOD Department of Botany,Sree Sankara College kalady,Ernakulam,Kerala.

2. Preparation of Herbal extract

➤ Extraction of betel leaves

The betel leaves were dried in the shade for seven days and ground into powder. Extraction was performed using a heating mantle, where 30 grams of powdered extract is boiled in 900ml of water at 50°C for 4 hours. The extract was filtered.⁷



Fig no: 11 Dried betel leaves



Fig no :12 Fine powder



Fig no : 13 Decotion of betel leaves



Fig no :14 Extract

➤ Extraction of *Ixora coccinea* leaves

The fresh leaves of *ixora coccinea* were washed thoroughly with double distilled water. 10 grams of the leaves were grind with the mortar and the pestle was then extracted with a mixture of 50ml of distilled water. The solution was filtered with Whatmann filter paper, and the total volume was then made up to 100ml.¹¹

Fig no : 15 Fresh leaves of *Ixora coccinea* Fig no : 16 Maceration of leaves



Fig no :17 Extract of leaves

3. Phytochemical Test

➤ Chemical test for betel leaves

SL. NO	PHYTOCONSTITUENT	CHEMICAL TEST	OBSERVATION
1	Flavonoids	Alkaline reagent test	Dark blue disappear by the addition of NaOH
2	Tannins	Ferric chloride test	Greenish-black colour
3	Phenols	Ferric chloride test	Yellow colour

➤ Chemical test for ixora coccinea leaves

SL. NO	PHYTOCONSTITUENT	CHEMICAL TEST	OBSERVATION
1	Phenols	Ferric chloride test	Green colour
2	Terpenoids	Salkowski test	Reddish-brown colour
3	Tannins	Ferric chloride test	Greenish-black colour
4	Glycosides	Keller-killiani test	Reddish-brown ring at the junction

4. Procedure for hairserum

Procedure for preparation 25 ml hair serum

- preparation of herbal extract
- preparation of gel base
- Add herbal extract to gel base
- Add Lavender oil
- Enrichment with Vitamin E
- Add Rose water
- Mix until a smooth homogeneous formulation obtained
- Final formulation¹

5. Hair serum formulation

SL.NO	INGREDIENTS	WORKING FORMULA (30ML)			USES
		(F1)	(F2)	(F3)	
1	Betel leaf extract	2ml	2ml	2ml	Plant extract
2	Ixora coccinea leaf extract	3ml	3ml	3ml	Plant extract
3	Aloe vera gel	1.4g	1.4g	1.4g	Hydration
4	Vitamin E	400mg	400mg	400mg	Antioxidant
5	Sodium benzoate	0.24g	0.24g	0.24g	Preservative
6	Lavender oil	0.1ml	0.1ml	0.1ml	Fragrance
7	Tween 80	0.25ml	0.25ml	0.25ml	Emulsifier
8	Rosewater	q.s	q.s	q.s	Soothing

6. Evaluation of hair serum

The following parameters are used to evaluate hairserum.

➤ Physical Appearance:

Physical appearance was assessed by observation of the texture, color, and smell of the cosmetic serum thus formulated.

➤ pH :

The pH test will be determined by using Digital pH meter. Digital pH dipper will be deep into the sample

of serum formulation and the pH value will be recorded. The pH of the formulation should be at acidic pH as the Skin has an acidic pH, which is approximately 4.5 –5.5.

➤ **Homogeneity Test:**

A clean and dry object glass was smeared with the hair serum was added, and a cover glass was sealed. The appearance under the light of some coarse particle/homogeneity was studied. Herbal Hair serum was subjected to a visual check for homogeneity, and tested for any lumps. It means either to flocculate or aggregate.

➤ **Spreadability:**

specifically, one gram of hair serum was placed between two vertical plates, each of which was 20 cm x 20cm with an applied weight of 125 grams. The spread periphery was recorded for one minute. The spreadability is calculated by:

$$S = (M \times L) / T$$

S - spreadability

M -weight placed on top of the upper plate. L - distance covered by glass slide

T -time taken in seconds to completely separate the plate.¹

➤ **Anti fungal activity study:**

WELL DIFFUSION METHOD

The well diffusion technique was the standard technique for performing the antimicrobial test using 100 µl of a suspension containing 10⁶ spores/ml of fungal organisms spreading on Potato dextrose agar medium. 14 Petri plates with 20 ml potato dextrose agar medium were inoculated with a 72 hr. culture of a different fungal strain. The wells were created at the size of 8mm and varying concentrations of test sample polyherbal formulation.

The plates were incubated by inverting at 37°C for 72 hours. The antifungal activity was determined by measuring the diameter of the inhibition zone formed around the wells and mean and SD were calculated.¹⁰



Fig no :18 Antifungal activity against candida albicans

7. Result and discussion

➤ Physical appearance:

The physical appearance, odour, texture of hairserum are visually tested.⁵

Parameter	F1	F2	F3
Color	light yellowish brown	yellowish brown	yellowish brown
Odour	Aromatic, pleasant	Aromatic, pleasant	Aromatic, pleasant
Texture	Smooth	smooth	smooth

➤ Homogeneity, Ph, Spreadability, Transparency :

Parameter	F1	F2	F3
Homogeneity	Excellent	Good	Average
PH	5	5	5.56
Spreadability	Easily spreadable	Easily spreadable	Easily spreadable
Transparency	Translucent	Translucent	Translucent

8. Conclusion

In this research, the herbal hair serum was formulated by Piper betel and ixora coccinea extract. The main objective of the current study is to evaluate the characteristics of the cosmetic serum in order to identify the best formulation. Three different formulations of serum were developed, namely F1, F2, and F3, with varying concentrations of excipients. Various tests of evaluation were performed, including physical appearance, pH values, homogeneity, and antifungal properties. Among the three formulations, F1

proved to be the best one and successfully cleared all the tests of evaluation. Moreover, F1 possessed antifungal properties against the candida albicans, as revealed by the results obtained from the well diffusion method.

ACKNOWLEDGEMENT

We are grateful to have the chance to work on this project, and we would like to sincerely thank our mentor, Dr Sreekanth S Kaithavalappil., for all of his help, support, and encouragement. We want to express our gratitude to everyone who contributed, either directly or indirectly, to the completion of this project. We would like to express our appreciation to Dr. J Nandhakumar, our principal, for his invaluable support and approval of the project work. Finally, we thank God, our parents, and our friends for their unwavering support.

Reference

1. Mrudali U.Kathane,Sakshi G.Bisen,Devendra S.Borkar,Rani T.Bhagat,Tulsidas P.Nimbekar, Formulation and evaluation of herbal hair serum,Technology and history journal,2025,volume 25,issue 4,96-135
2. Mrunal K.Shirsat,Avinash V.Dhobale,Aaditi P.Jadhav,Pratiksha S.Karwande,Parwati Kumawat,Formulation and evaluation of herbal hair serum from leaves extract of Alternanthera sessilis linn,International journal of creative research thoughts(IJCRT), May 2024,volume 12,issue 5,58-69
3. Anusha R.,Akhila N.,Nikhitha J.,Harish K.,Abdull Rajjak Shaikh ,Formulation and evaluation of herbal hair serum-a review, International journal of basic and clinical pharmacology,September-october 2023,volume 12,issue 5,759-765
4. RuchiTiwari, GauravTiwari, AjeetYadav, Vadivelan ramachandran, Development and evaluation of herbal hair serum: a traditional way to improve hair quality, The open dermatology journal, April 2021,volume 15,52-58
5. Harshada D. Shende, Ujwalkumar P. Patil, Vishwajit V. Jadhav ,Om A. Gonde Formulation and evaluation of herbal hair serum using rosemary leaves, World journal of pharmaceutical research, March 2024,volume 13,issue 6,652-662
6. S M Shahidulla,Zehra unnisa, Sayyada hajira, Herbal hair serum:an updated review, International Journal of Research and Analytical Reviews (IJRAR),June 2025,volume 12,issue 2,260-268
7. Neelam Joshi,Kalpana Patidar, Rakesh Solanki,Vandana Mahawar, Preparation and evaluation of herbal hair growth promoting shampoo formulation containing Piper betle and Psidium guajava leaves extract, International Journal of Green Pharmacy ,October-December 2018, volume12,issue 4, S835-S839
8. Chandra Vikash,Tripathi Shalini,Verma N.K, Singh D.P, Chaudhary S.K, Roshan Asha, Piper betel: phytochemistry, traditional use and pharmacological activity-a review, International Journal of

9. Priyanka M. Khadasare, Shruti A Shinde, Shruti S Londe, Simaran A Inamdar, Shubham J Kharat, Formulation & Evaluation of Hair Growth Serum from Hibiscus Flowers and Leaves, September-October 2024, Volume 2, Issue 5, 203-211

10. Sharmila Devi Veeraswamy, Raju I, Mohan S. An Approach to Antifungal Efficacy through Well Diffusion Analysis and Molecular Interaction Profile of Polyherbal Formulation. Biomedical & Pharmacology Journal. December 2022, Volume 15, Issue 4, 2069-84.

11. Ratnasooriya WD, Deraniyagala SA, Galhena G, Liyanage SSP, Bathige SDNK, Jayakody JRAC. Anti-inflammatory Activity of the Aqueous Leaf Extract of *Ixora coccinea*. Pharmaceutical Biology. 2005 January, Volume 43, Issue 2, 147-152.

