

Exploring the potential of herbal drugs for the treatment of hair loss

Shivam A. Bartere ¹, Lochana L. Malode ¹, Gunjan P. Malode ², Minakshee G. Nimbalwar ², Chaitanya A. Gulhane ², Jagdish V. Manwar ^{1,*} and Ravindra L. Bakal ²

¹ IBSS's Dr. Rajendra Gode College of Pharmacy, Mardi Road, Amravati-444 602, MS, India.

² IBSS's Dr. Rajendra Gode Institute of Pharmacy, Mardi Road, Amravati-444 602, MS, India.

GSC Biological and Pharmaceutical Sciences, 2021, 16(02), 212–223

Publication history: Received on 03 July 2021; revised on 19 August 2021; accepted on 21 August 2021

Article DOI: <https://doi.org/10.30574/gscbps.2021.16.2.0225>

Abstract

Hair loss can be recognized as a life-threatening disorder. It is a health condition during which hair is lost from some or all areas of the body, usually from the scalp. However, it has a great harm to a person's self-respect, mental health, and entirety quality of life. Balding can be caused because of various reasons, like genetic tendencies, environmental triggers, exposure to chemicals, medicines, nutritional deficiency, extreme stress or long illness etc. In present article, we have covered information about loss of hair loss, types of alopecia, causes and various medicinal plants and parts they're of used in treatment prophylaxis or treatment of hair loss.

Keywords: Hairs; Alopecia; Medicinal plant; Herbal formulation.

Graphical Abstract



1. Introduction

Hair is one of the fundamental pieces of the body got from ectoderm of the skin, is defensive enhancement on the body and considered adornment design of the integument alongside sebaceous organs, sweat organs and nails [1]. As per Ayurveda, pitta dosha is the essential driver of going bald. Ayurvedic medicine for hair loss contains herbs which will arrest hair fall and improve hair development. There are various causes for hair loss and therefore the phenomenon remains not fully understood. Plants have been generally utilized for hair development advancement since past as reported in Ayurveda, Chinese and Unani systems of drugs [2].

* Corresponding author: Jagdish V Manwar

IBSS's Dr. Rajendra Gode College of Pharmacy, Mardi road, Amravati-444 602, MS, India.

2. Alopecia (Hair loss)

Alopecia is a dermatological issue that has been seen for more than 2000 years and besides, it has been typical issue in beautifiers similarly as fundamental clinical benefits practice. It is a synonym of baldness, involves absence or loss of hair, especially of the top. Alopecia is typical all through the world and has been evaluated to impact between 0.2 % and 2% of the absolute people [3]. Alopecia is perhaps the most widely recognized trichinosis in clinical, which brings about a huge effect on human soul and psychology. Over past years, the rate of alopecia has been expanded. The occurrence of alopecia is due to the nutritional imbalance caused by a combination of environmental pollution, stress, frequent dyeing and perm, drinking, smoking, diet and so on [4-5].

The age of patients with hair loss tends to be younger. 40% of patients suffered from alopecia require relevant treatment [6-7]. Alopecia has likewise been seen as significant symptom of anticancer medications, immunosuppressant and numerous other medication therapies. Mental stun, enthusiastic strain, central disease, mistakes of refraction, endocrine aggravation, neurocirculation unsteadiness and hereditary inclination are additionally the known reason for alopecia [8].

There are numerous medicines for alopecia, including hair relocate, beautifying agents and prescription. Clinical treatment shows an extraordinary impact on improving hair development. A lot of medications that prevents alopecia by repressing the male hormone. The two famous agents, Finasteride (a synthetic 5- α -reductase inhibitor) and minoxidil (a vasodilator), are used to treat alopecia by suppressing male hormone [9-10]. Nevertheless, the use of these two drugs is limited due to their severe side effects [11]

3. Composition and Hair Growth Cycle

Hairs can be characterized as - "improved epithelial construction framed because of keratinization of germinative cells," hairs are the outgrowths from the follicles existing on the skin. Hair is composed of keratin with chemical constituents such as Carbon(C), Nitrogen (N), Sulphur (S), & Oxygen (O). Hair development fluctuates from one individual to another but on average hair grows about 15-30 mm/ month. It is also called as epidermal subsidiaries as they begin from the epidermis during embryological advancement [12-13]. Every hair falls in following three cyclic stages [14]

3.1. Anagen (Growth stage)

The anagen stage can be short as 2 years to up to 8 years. Around 80 % of hair is generally in anagen stage. On a solid scalp, there are around 1,000,000 hair and 90% of the follicles are constantly in the anagen period of hair development.

3.2. Catagen (Involution phase)

In the catagen stage, the development action increments and hair moves to the following stage, catagen stage is between 10-14 days.

3.3. Telogen (Resting phase)

The telogen stage is a state at which the hairs move into resting state. This stage goes on for 90-100 days. All in all, 50-100 hair at irregular is shed each day. An increment of in excess of 100 hair for each 6-constituents a condition of going bald or alopecia, but it very well may be brief [15-16].

4. Types of Hair Loss

There are various types of hair loss as discussed below [17-19].

4.1. As per Ayurveda

Ayurveda, a 5000-year-old back traditional system of medicine developed in India. It has classified hair loss under three categories viz.

- Khalitya (loss of hairs)
- Palitya (Premature hair graying)
- Indralupta (Alopecia areata ortotalis)

4.2. As per Anglo-Indian medicine system

4.2.1. Alopecia Areata (Primary stage)

Alopecia areata is a typical immune system illness that outcomes in the deficiency of hair on the scalp and somewhere else. It as a rule begins with at least one little, round, non-scarring smooth patches.

4.2.2. Mild Brief Alopecia Areata

Patient with repeated transient alopecia areata yet never changes over into alopecia totalis or universalis. 25% of alopecia cases are record by the dermatologists and it is perhaps the most widespread types of alopecia.

4.2.3. Mild Transient Alopecia Areata

Patient with repeated transient alopecia areata yet never changes over into alopecia totalis or universalis.

4.2.4. Transient Alopecia Areata

Patient with Alopecia areata in progressive stage and some of them changes over into Alopecia totalis /Alopecia universalis.

4.2.5. Temporary Alopecia Areata

Patient with Alopecia areata in advanced phase and few of them converts into Alopecia totalis/Alopecia universalis.

4.2.6. Ophiasis Alopecia Areata

Ophiasis kind of alopecia areata shows a band like going bald. It happens generally in the transient or the occipital area of the scalp, and subsequently it is harder to treat, as most medicines have a delayed action on these regions.

4.2.7. Alopecia Totalis

Loss of hair from the entire Scalp.

4.2.8. Alopecia Universalis

Loss of hair from whole body including eyebrows and eyelashes.

4.2.9. Scarring Alopecia

Any provocative interaction (consumes, bacterial diseases, ringworm, injury) adequate to cause permanent loss of follicles, influenced region referred as scarring alopecia.

4.2.10. Tricotilomania

This kind of hair loss is referred as compulsive pulling or repetitive self-pulling by a patient himself/herself.

4.2.11. Traction Alopecia

Hair style that ties hairs so tight can cause much traction at the root of hairs, and can develop traction alopecia.

4.2.12. Chemotherapy and hair loss

Chemotherapy is elite therapy for malignant growth patients yet it influences typical cells and hair follicles as well. This causes going bald and known as anagen effluvium type of alopecia.

4.2.13. Diffuse Alopecia

Excessive Loss of hair everywhere on the scalp without creating a patch. Hair loss due to adverse effect of the cosmetic treatments like hair colors, dye, straightening, softening, rebounding, perming etc., which contains harsh chemicals can trigger hair loss for certain people. Telogen effluvium (TE) and chronic telogen effluvium- (CTE) Dietary lacks, Crash dieting High grade fever, Anemia, Blood loss, Hormonal imbalance and pregnancy etc. can cause telogen effluvium type of hair loss telogen word is known for latent phase of the hair and fluvium means.

4.2.14. Androgenetic alopecia

Androgenetic alopecia is the most common form of hair loss in both men and women and is characterized by the loss of hairs in defined pattern. When it affects women, it results in diffuse alopecia over the mid-frontal scalp (female pattern hair loss).

In men however the pattern of hair loss usually starts with a retreating hairline which then advances to thin the top of the head [20-21].

The effect of androgenetic alopecia is overwhelmingly mental. While men expect age-related going bald, similar interaction in ladies is typically unexpected and unwelcome at any time [22].

Male Pattern Baldness

Hair loss resulting in thinning is referred as alopecia. When it's associated with hormones (androgens) and genetics, it's referred to as androgenetic alopecia. When androgenetic alopecia exposes a space of the scalp it is called baldness. Male pattern bald is described by a subsiding hairline or potentially going bald on the top and front of the head.

Male pattern hair loss is an inherited condition, caused by a genetically determined sensitivity to the consequences of dihydrotestosterone, or DHT in some areas of the scalp. DHT is believed to shorten the expansion, or anagen, phase of the hair cycle, from a usual duration of 3–6 years to only weeks or months. This happens along with miniaturization of the follicles, and progressively produces less and better hairs. The creation of DHT is regulated by an enzyme called 5-alpha reductase. A few qualities are included, representing contrasting time of beginning, movement, pattern and severity of hair loss in relatives. The susceptibility genes are acquired from both mother and father. At this time, genetic testing for prediction of balding is unreliable (Fig. 1).

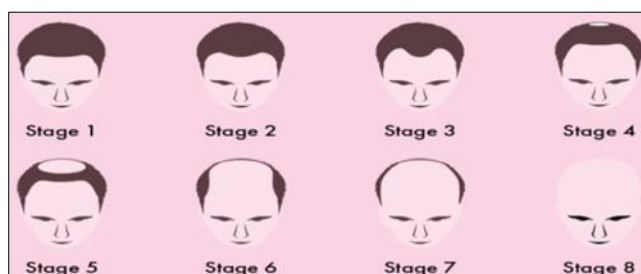


Figure 1 Stages of male pattern baldness

Female Pattern Baldness

The most widely recognized type of going bald found in ladies is androgenetic alopecia, also referred as female pattern alopecia or baldness. This is viewed as hair thinning predominantly over the highest and sides of the top. It affects approximately one-third of all susceptible women, but is most ordinarily seen after menopause, although it's going to begin as early as puberty (Fig. 2).

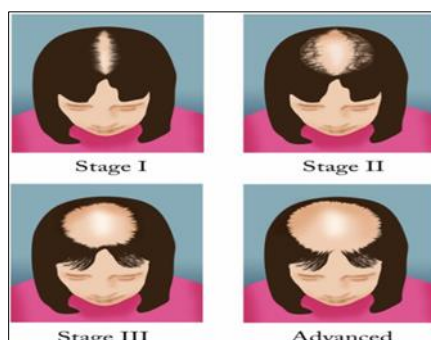


Figure 2 Stages of female pattern baldness

Ordinary hair fall is roughly 100-125 hairs each day. Luckily, these hairs are replaced. Genuine balding happens when lost hairs are not regrown or when the day-by-day hair shed surpasses 125 hairs. Hereditarily, hair loss can come from either parent's side of the family [23].

4.3. Causes of Hair Loss

There are several factors that are responsible for the hair loss. These factors includes acute illness, poisons, autoimmune disorders, poor blood circulation, chemicals (hair dyes), poor diet or malnutrition, chemotherapeutic agents, prescription drugs, diabetes, psychological, radiation exposure, etc [24].

5. Medicinal plants used in hair loss

5.1. Ginkgo biloba

The drug is known to improves cerebral microcirculation and hence increases oxygen supply. Ginkgo biloba leaf extract promote hair regrowth through combined effects on proliferation and apoptosis of the cells within the follicle, thus recommending potential as a hair dressing (Fig. 3) [25].

5.1.1. Part used

Leaves

5.1.2. Chemical constituents

Lactones (6%): Diterpenoids, Ginkgolides A, B, C, J, M, Bilobalide-A, Flavanols (24%). Kaempferol, Quercetin, Isorhamnetin, bio-Flavin, sitosterol and anthocyanins.

5.1.3. Mode of Application

The drug is separated in coconut oil and is massaged for a minimum of 2 minutes.

5.2. Allium cepa L.

It has also been found essential in patchy baldness. The affected part should be rubbed with onion juice morning and evening till it's red. It should be rubbed with honey afterwards. It contain Zinc that helps to secrete the scalp with much needed oil and avoid dandruff which will cause hair loss. Iron is involved within the oxygenation of your body's red blood cells. It is essential for normal hair growth and maintaining healthy hair (Fig. 3) [26].

5.2.1. Parts used

Onion Juice

5.2.2. Chemical Constituents

Protein (albumin), allyl propyl disulphide, diallyl sulphide, alliin, allicin. It also Contains some mineral like potassium, zinc, calcium, magnesium and traces of chromium.

5.3. Asiasari radix

Asiasari radix extract has hair growth promoting potential, and this effect may be due to its regulatory effects on both cell growth factor gene expressions (Fig. 3) [27].

5.3.1. Parts used

Roots & Rhizomes

5.3.2. Chemical constituents

Safrole (18.4%), Methyl eugenol (18%), methoxytoluenes& 3-benzodioxole derivatives.

5.4. Eclipta alba (L) Hassak

Eclipta alba is a component in various polyherbal formulations for hair growth promotion. Methanolic extract has been shown potential as a hair growth promoter. It is also reported that the petroleum ether extract of *E. alba* promotes follicular enlargement and prolongation of anagen phase (Fig. 3) [28-30].

5.4.1. Part used

Whole plant

5.4.2. Chemical constituents

Flavonoids & iso-flavonoids: Wedelolactone, Desmethylwedelolactone, Triterpene, Glycosides & Saponins: Eclalbasaponins I-VI, -amyrin.

5.5. Hibiscus rosa-sinensis Linn

Leaf extract of *Hibiscus rosa-sinensis* increases hair length and the anagen/telogen ratio of hair follicles in mice [66]. Formulation containing *Eclipta alba* Hassk, *Hibiscus rosa sinensis* Linn, *Nardostachys jatamansi* have excellent hair growth promoting activity, they mainly act by an enlargement of follicular size and a prolongation of the anagen phase (Fig. 3) [31].

5.5.1. Parts used

Leaves & Flowers

5.5.2. Chemical constituents

Flavonoids; Anthocyanins and Cyaniding-3, 5-diglucoside, Cyaniding-3-sophoroside-5- glucoside, Quercetin-3,7-diglucoside, Quercetin-3-diglucoside.

5.6. Phyllanthus embelica

Iron is involved within the oxygenation of your body's red blood cells. It is necessary for normal hair growth and maintaining healthy hair. If the amount of iron cannot be replaced with food intake, iron deficiency will cause hair loss because of oxygen deficiency. Its polyherbal ointment and herbal hair oil have hair growth promoting activity (Fig. 3).

Herbal Formulation containing *Tridax procumbens* (Linn.), *Hibiscus rosa sinensis* (Linn.), *Trigonella foenum graecum* (Linn.), and *E. officinalis* (Linn.) showed synergistic effects by significant increase in hair growth activity [32].

5.6.1. Part used

Fruits

5.6.2. Chemical Constituents

Vitamin C, Phyllembin, tannin, phosphorous, iron, calcium.

5.6.3. Mode of Application

Indian gooseberry oil, prepared by boiling dry pieces of Indian gooseberry in coconutoil, is viewed as a significant hair tonic for advancing hair development. A mixture of ansame quantity of fresh Indian gooseberry juice and lime juice, used as a shampoo also stimulates hair growth and prevents hair loss.

5.7. Rosmarinus officinalis

The essential oils enter your system through the olfactory system (inhalation) and/or through your skin and reach your circulatory system (the blood) where they bind to receptors and change the chemical composition. For local herbal therapy stimulates hair follicles and it is proved as safest way to cope up with different type of hair loss (alopecia), however perfect pharmacological actions of these herbs and oils are still not known (Fig. 3) [33].

5.7.1. Chemical Constituents

Angustifolia Miller (Labiatae) Rosmary constitutes 1-2% volatile oil containing 0.8-6% of esters and 8-20% of alcohols, The principal constituents are 1, 8- cineole, borneol, camphor, bornyl acetate and monoterpene hydrocarbons. The major components of lavender oil are Lavandulol, linalyl acetate, linalol, lavendulyl acetate, terpineol and cineol.

5.7.2. Mode of Application

These oils were massaged into the scalp for a minimum of two minutes daily for seven months.

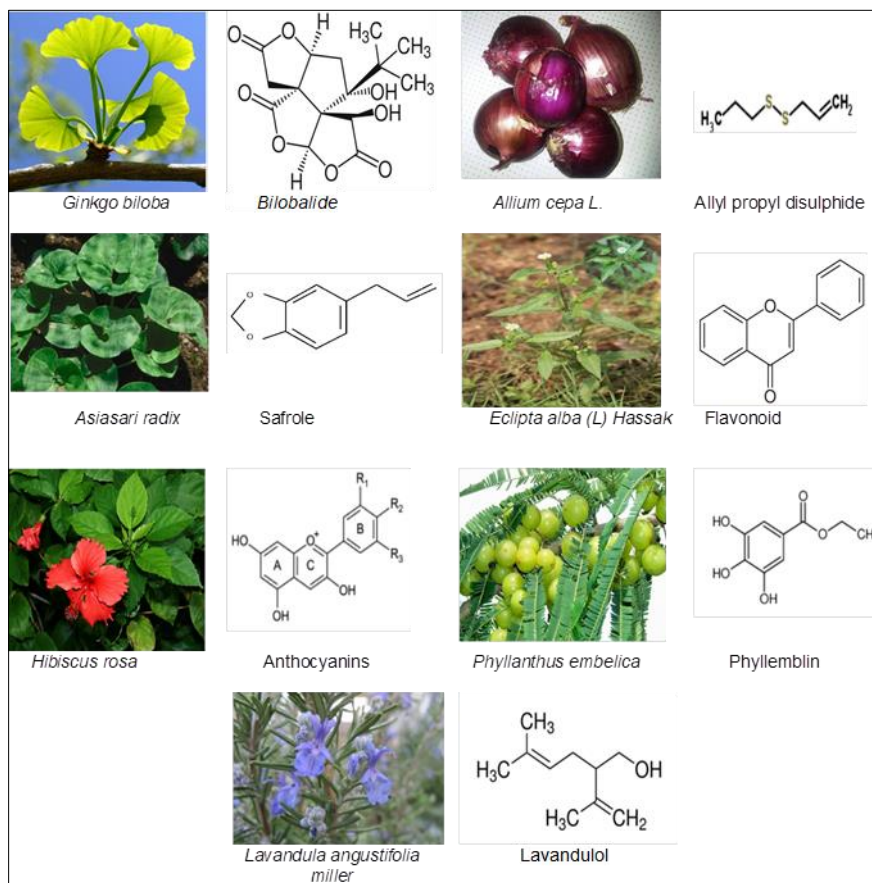


Figure 3 Herbal drugs and main chemical constituent

6. Analysis of herbal drugs

Herbal drugs wholly or parts or extracts or their formulations are analyzed by routine quality control methods. These includes high performance thin layer chromatography, high performance liquid chromatography, Uv-spectrophotometry, gas chromatography, etc [34-95].

7. Future Prospective

Although many natural drugs have been discovered, it is still necessary to search for novel hair promotion agents with more effective and less toxicity. Furthermore, the underlying mechanisms of many compounds with hair-growth promotion activity have not been studied or explained in detail.

Even though some effective hair-growth promotion drugs are developed from botanical sources, there still remains an untapped resource in herbal medicines.

8. Conclusion

Thus, herbal drugs provide a new revolution for hair development having potency for curing alopecia with no sides effect. These herbal extracts having numerous phytoconstituents can treat alopecia either by supplying nutritional supplements. There are also some natural treasures having essential oil active constituents which may be used as aromatherapy for treating alopecia by improving scalp blood circulation.

Compliance with ethical standards

Acknowledgments

We express our sincere thanks to Shri. Yogendraji Gode and Dr. Yogeshji Gode, IBSS's Dr. Rajendra Gode College of Pharmacy, Amravati and Dr. Rajendra Gode Institute of Pharmacy, Amravati.

Disclosure of conflict of interest

The author declares no conflict of interest.

References

- [1] Hillmer AM, et al. Genetic variation in the human androgen receptor gene is the major determinant of common early-onset androgenetic alopecia. *The American Journal of Human Genetics*. 2005; 77(1): 140-148.
- [2] Ebling FJ. The biology of hair. *Dermatol Clin*. 1987; 5(3): 467-81.
- [3] Hordinsky M, Junqueira AL. Alopecia areata update. *Semin Cutan Med Surg*. 2015; 34(2): 72-5.
- [4] Jadhav P, Zawar V. Interesting patchy alopecia. *Int J Trichol* 2015; 7(2): 74-6.
- [5] Hmid AB, et al. FOXP3 transcription is enhanced in lesional and perilesional skin of patients with focal Alopecia areata. *International journal of dermatology*. 2015; 54(8): e319-21.
- [6] Hu R, et al. Combined treatment with oral finasteride and topical minoxidil in male androgenetic alopecia: a randomized and comparative study in Chinese patients. *Dermatologic therapy*. 2015 Sep; 28(5): 303-8.
- [7] Ponniacamy G, et al. A Simple Siddha Remedy for Puzhuvettu (Alopecia areata)- A Pilot Study. *J.R.A.S*. 1989; 10(1-2): 87-92.
- [8] Pallarès M, et al. Finasteride administration potentiates the disruption of prepulse inhibition induced by forced swim stress. *Behavioural brain research*. 2015; 289: 55-60.
- [9] Moore TJ. Finasteride and the uncertainties of establishing harms. *JAMA dermatology*. 2015; 151(6): 585-6.
- [10] O'Leary M. By the way, doctor. Finasteride has been prescribed for my BPH. I think that the most frequent side effect is erectile dysfunction or loss of sexual desire. Would Levitra or a similar drug (like Viagra or Cialis) overcome the side effects of finasteride? *Harvard health letter*. 2009;34(8): 8.
- [11] Sastri S, Madhavanidanam (Chukamba Publications, Varanasi). 2003; 202-205.
- [12] Cash TF. The psychology of hair loss and its implications for patient care. *Clinics in dermatology*. 2001; 19(2): 161-166.
- [13] Messenger AG. Medical management of male pattern hair loss. *International journal of dermatology*. 2000; 39(8): 585-6.
- [14] Stough D, Stenn K, Haber R, Parsley WM, Vogel JE, Whiting DA, Washenik K. Psychological effect, pathophysiology, and management of androgenetic alopecia in men. In *Mayo Clinic Proceedings*. 1 Oct 2005; 80(10): 1316-1322.
- [15] Paus R, Cotsarelis G. The biology of hair follicles. *New England journal of medicine*. 1999; 341(7): 491-497.
- [16] Bhalerao SS, Solanki NH. Therapeutic approaches to the management of common baldness. *Indian drugs*. 2002; 39(11): 567-73.
- [17] Gupta KA, Astangahridayam. Chukamba Publications, Varanasi. 2003; 534-535.
- [18] Stenn KS, Paus R. Controls of hair follicle cycling. *Physiological reviews*. 2001; 81(1), 449–494.

- [19] Camacho FM, García-Hernández MJ. Psychological features of androgenetic alopecia 1. *Journal of the European Academy of Dermatology and Venereology*. 2002; 16(5): 476-80.
- [20] Norwood OT. Incidence of female androgenetic alopecia (female pattern alopecia). *Dermatologic Surgery*. 2001; 27(1): 53-4.
- [21] Sinclair R, Patel M, Dawson Jr TL, Yazdabadi A, Yip L, Perez A, Rufaut NW. Hair loss in women: medical and cosmetic approaches to increase scalp hair fullness. *British Journal of Dermatology*. 2011; 165: 12-8.
- [22] Nusbaum AG, Tosti A. Commentary on a randomized placebo-controlled, double-blind, half-head study to assess the efficacy of platelet-rich plasma on the treatment of androgenetic alopecia. *Dermatologic Surgery*. 2016; 42(4): 498-9.
- [23] Singh K, Saeed F, Ahmad Z, Ahsan F, Shakya P. Alopecia: introduction and overview of herbal treatment. *Journal of Chemical and Pharmaceutical Research*. 2016; 8(8): 59-64.
- [24] Pundkar AS, Murkute PM, Wani S, Tathe M. A review: Herbal therapy used in hair loss *Pharmaceutical Resonance*. 2020; 3(1):44-50.d
- [25] Kobayashi N, Suzuki R, Koide C, Suzuki T, Matsuda H, Kubo M. Effect of leaves of Ginkgo biloba on hair regrowth in C3H strain mice. *YakugakuZasshi*. 1993; 113: 718-24.
- [26] Rho SR, Park JS, Hwang SL, et al. The hair growth promoting effect of Asiasari radix extract and its molecular regulation. *J Dermatol Sci*. 2005; 38: 89-97.
- [27] Sharma AK, Agarwal V, Kumar R, Kaushik K, Bhardwaj P, Chaurasia H. Development and evaluation of herbal formulation for hair growth. *Int J Curr Trends Sci Tech*. 2010; 1: 147-51.
- [28] Jain R, Jain NK, Singh N, et al. Development and evaluation of Polyherbal ointment for hair growth activity. *Int J Pharm Pharma Sci*. 2011; 3: 180-2.
- [29] Datta K, Singh AT, Mukherjee A, et al. Eclipta alba extract with potential for hair growth promoting activity. *J Ethnopharmacol*. 2009; 124: 450-6.
- [30] Singh DK, Luqman S, Mathur AK, Lawsoniainermis L. *Ind Crops Prod*. 2015; 65: 269-86.
- [31] Adhirajan N, Kumar TR, Shanmugasundaram N, Mary B. *In vivo* and *in vitro* evaluation of hair growth potential of Hibiscus rosa-sinensis Linn. *J Ethnopharmacol*. 2003; 88: 235-9.
- [32] Banerjee PS, Sharma M, Nema RK. Preparation, evaluation and hair growth stimulating activity of herbal hair oil. *J Chem Pharma Res*. 2009; 1: 261-67.
- [33] Ishida H, Inaoka Y, Okada M, et al. Studies of the active substances in herbs used for hair treatment III Isolation of hair-regrowth substances from Polygara senega var. latifolia TORR et GRAY. *Biol Pharma Bull*. 1999; 22: 1249-50.
- [34] Khadatkar SN, et al. Preparations and evaluation of microcapsules of capsaicin. *International Journal of Chemical Sciences*. 2007; 5(5): 2333-2341.
- [35] Manmode R, et al. Effect of preparation method on antioxidant activity of ayurvedic formulation kumaryasava. *J Homeop Ayurv Med*. 2012; 1: 114.
- [36] Manwar J, et al. Isolation, biochemical and genetic characterizations of alcohol-producing yeasts from the flowers of Woodfordia fruticosa. *J Young Pharm*. 2013; 5(4): 191-194.
- [37] Khadatkar SN, et al. *In-vitro* anthelmintic activity of root of Clitoria ternatea linn. 2008; 4(13): 148-150.
- [38] Sahare AY, et al. Antimicrobial activity of Pseudarthria viscida roots. *Asian Journal of Microbiology Biotechnology & Environmental Sciences*. 2008; 10(1): 135-136.
- [39] Gudalwar BR, et al. Allium sativum, a potential phytopharmacological source of natural medicine for better health. *GSC Advanced Research and Reviews*. 2021; 06(03): 220–232.
- [40] Shubham Garibe, et al. Bioequivalence study of test formulations T1 and T2 Nadolol tablets USP with reference formulation in healthy adult, human subjects under fed conditions. *Ijppr.Human*. 2021; 20(2): 20-28.
- [41] Chaudhari KD, et al. Comprehensive review on characterizations and application of gastro-retentive floating drug delivery system. *GSC Advanced Research and Reviews*. 2021; 07(01): 035-044.

- [42] Chaudhari KD, et al. Floating drug delivery system: An update of preparation and classification of formulation. *Ijppr.Human*. 2021; 21(1): 207-220.
- [43] Malode GP, et al. Formulation and evaluation of a novel floating in situ gel system for the treatment of peptic ulcer. *World Journal of Pharmacy and Pharmaceutical Sciences*. 2021; 10(4): 416-1433.
- [44] Jain CM, et al. Review on approaches for development and evaluation of extended-release tablets. Review on approaches for development and evaluation of extended-release tablets. *World Journal of Pharmacy and Pharmaceutical Sciences*. 2021;10(4): 542-554.
- [45] Nimbawar MG, et al. A brief review on principle, preparation and properties of proniosomes: A provesicular drug delivery system. *World J Pharm Sci*. 2021; 9(5): 149-162.
- [46] Vaidya VM, et al. Design and in vitro evaluation of mucoadhesive buccal tablets of terbutaline sulphate. *Int J PharmTech Res*. 2009; 1(3): 588-597.
- [47] Dhamankar AK, et al. The novel formulation design of O/of ketoprofen for improving transdermal absorption. *Int J of Pharm Tech Res*. 2009; 4(1Suppl): 1449-1457.
- [48] Manwar JV, et al. Diclofenac Sodium Loaded Nanosized Ethosomes: An Investigation on Z-Average, Polydispersity and Stability. *J Pharm Res*. 2017; 1(3): 000115.
- [49] Patil SS, et al. Ultrasound-Assisted Facile Synthesis of Nanostructured Hybrid Vesicle for the Nasal Delivery of Indomethacin: Response Surface Optimization, Microstructure, and Stability. *AAPS PharmSciTech*. 2019; 20(3): 97.
- [50] Parbat AY, et al. Ethnopharmacological review of traditional medicinal plants as immunomodulator. *World Journal of Biology Pharmacy and Health Sciences*. 2021; 06(02): 043–055.
- [51] Nimbawar MG, et al. Fabrication and evaluation of ritonavir proniosomal transdermal gel as a vesicular drug delivery system. *Pharmacophore*. 2016; 7(2): 82-95.
- [52] Pophalkar PB, et al. Development and evaluation of ondansetron medicated jelly. *World Journal of Pharmaceutical Research*. 2018; 7(19): 1252-1263.
- [53] Suroshe RS, et al. Development and characterization of osmotic drug delivery system of model drug. *World Journal of Pharmaceutical Research*. 2018; 7(18): 1158-1171.
- [54] Kadam CY, et al. Design and *In vitro* characterization of phase transition system using rivastigmine tartrate for nasal drug delivery system. *World Journal of Pharmaceutical Research*. 2018; 8(1): 815-829.
- [55] Nimbawar MG, Panchale WA, Nimbokar SW, Gudalwar BR, ManwarJV, Bakal RL. A brief review on principle, preparation and properties of proniosomes: A provesicular drug delivery system. *World J Pharm Sci*. 2021; 9(5): 149-162.
- [56] Nimbawar MG, Gudalwar BR, Panchale WA, WadekarAB, Manwar JV, Bakal RL. An overview of characterizations and applications of proniosomal drug delivery system. *GSC Advanced Research and Reviews*. 2021; 07(02): 025–034.
- [57] Sabhadinde AF, et al. Novel RP-HPLC method for simultaneous analysis of chlorthalidone and telmisartan from combined dosage form. *Ijppr.Human*. 2020; 20(1): 491-502.
- [58] Panchale WA, et al. RP-HPLC method for simultaneous determination of escitalopram oxalate and flupentixol HCl in tablet dosage form. *GSC Biological and Pharmaceutical Sciences*. 2021; 14(01): 169-174.
- [59] Nimbokar SW, et al. Development and validation of RP-HPLC method for determination of zonisamide from tablet formulation. *World Journal of Pharmaceutical and Medical Research*. 2021; 7(2): 196-200.
- [60] Panchale WA, et al. RP-HPLC method for simultaneous determination of metformin hydrochloride and linagliptine in pharmaceutical dosage form. *World Journal of Pharmaceutical and Medical Research*. 2021; 7(5): 234- 238.
- [61] Manwar JV, et al. Development of newer RP-HPLC method for simultaneous estimation of cefixime and linezolid in bulk drugs and combined dosage form. *International Journal of Pharmacy and Life Sciences*. 2021; 12(1): 26-31.
- [62] Panchale WA, Gulhane CA, Manwar JV, Bakal RL. Simultaneous estimation of salbutamol sulphate and ambroxol HCl from their combined dosage form by UV-Vis spectroscopy using simultaneous equation method. *GSC Biological and Pharmaceutical Sciences*. 2020; 13(03): 127-134.

- [63] Bakal RL, et al. Spectrophotometric estimation of amitriptyline HCl and chlordiazepoxide in tablet dosage form. *International Journal of Chemical Sciences*. 2007; 5(1): 360–364.
- [64] Panchale WA, Bakal RL. First-order derivative spectrophotometric estimation of gemifloxacin mesylate and ambroxol HCl in tablet dosage form. *GSC Biological and Pharmaceutical Sciences*. 2021; 14(2): 029-036.
- [65] Gulhane CA, et al. Liquid chromatographic method for simultaneous estimation of thicolchicoside and etoricoxib from tablet formulation. *Asian Journal of Pharmaceutical Analysis*. 2021; 11(2): 118-122.
- [66] Panchale WA, et al. Chromatographic analysis of famotidine, paracetamol and ibuprofen from tablet formulation. *Research Journal of Pharmacy and Technology*. 2019; 12: 231-263.
- [67] Manwar JV, et al. Application of simultaneous equation method for the determination of azithromycin and cefixime trihydrate in tablet formulation. *Research Journal of Pharmacy and Technology*. 2017; 10(1): 108-112.
- [68] Manwar JV, et al. Response surface based optimization of system variables for liquid chromatographic analysis of candesartan cilexetil. *Journal of Taibah University for Science*. 2017; 11: 159–172.
- [69] Manwar J, Mahadik K, Paradkar A, et al. Gas chromatography method for the determination of non-ethanol volatile compounds in herbal formulation. *International Journal of Analytical and Bioanalytical Chemistry*. 2013; 3(1): 12-17.
- [70] Badukale NA, et al. Phytochemistry, pharmacology and botanical aspects of *Madhuca indica*: A review. *Journal of Pharmacognosy and Phytochemistry*. 2021; 10(2): 1280-1286.
- [71] Panchale WA, et al. Concurrent analysis of ambroxol HCl and salbutamol sulphate from tablet formulation by RP-HPLC. *GSC Biological and Pharmaceutical Sciences*. 2020; 13(03): 197-202.
- [72] Padgilwar S, et al. Traditional uses, phytochemistry and pharmacology of *Oroxylum Indicum*: A Review. *International Journal of Pharmaceutical and Phytopharmacological Research*. 2014; 3(6): 483-486.
- [73] Wadekar AB, et al. Morphology, phytochemistry and pharmacological aspects of *Carica papaya*, an review. *GSC Biological and Pharmaceutical Sciences*. 2020; 14(03): 234-248.
- [74] Gudalwar BR, et al. *Allium sativum*, a potential phytopharmacological source of natural medicine for better health. *GSC Advanced Research and Reviews*. 2021; 06(03): 220–232.
- [75] Manwar JV, et al. Experimental design approach for chromatographic determination of ketorolac tromethamine from bulk drug and tablet formulation. *Global Journal of Pharmacy & Pharmaceutical Sciences*. 2017; 3(2): 38-47.
- [76] Malode GP, et al. Phytochemistry, pharmacology and botanical aspects of *Murraya Koenigii* in the search for molecules with bioactive potential - A review. *GSC Advanced Research and Reviews*. 2021; 06(03): 143–155.
- [77] Manmode RS, et al. Stability indicating HPLC method for simultaneous determination of methocarbamol and nimesulide from tablet matrix. *Der Chemica Sinica*. 2011; 2(4): 81-85.
- [78] Bagade SB, et al. Simultaneous high performance thin layer chromatographic estimation of methocarbamol and nimesulide in combined dose tablet. *Journal of Pharmaceutical Research*. 2006; 5(4): 137-140.
- [79] Gulhane CA, et al. UV- Visible Spectrophotometric estimation of azithromycin and cefixime from tablet formulation by area under curve method. *World Journal of Pharmaceutical Sciences*. 2021; 9(6): 163-168.
- [80] Bijewar AH, et al. Overture in development, properties and clinical aspects of biosurfactants: A review. *International Journal of Medical, Pharmaceutical and Biological Sciences*. 2021; 1(1): 1-12.
- [81] Nikhare AM, et al. Morphological, phytochemical and pharmacological aspects of *Sygium cumini*. *International Journal of Medical, Pharmaceutical and Biological Sciences*. 2021; 1(1): 1-11.
- [82] Malode LL, et al. Potential of medicinal plants in management of diabetes: An updates. *GSC Advanced Research and Reviews*. 2021; 08(01): 149-159.
- [83] Manwar JV, et al. Comparative antioxidant potential of *Withania somnifera* based herbal formulation prepared by traditional and non-traditional fermentation processes. *Integr Med Res*. 2013; 2: 56-61.
- [84] Manwar JV, et al. Determination of withanolides from root and herbal formulation of *Withania somnifera* by HPLC coupled with DAD and ELSD detector. *Der Pharmacia Sinica*. 2012; 3 (1): 41-46.
- [85] Manwar JV, et al. Rapid RP-HPLC method for estimation of zidovudine from tablet dosage form. *Der Chemica Sinica*. 2011; 2(5): 152-156.

- [86] Dongare PN, Motule AS, et al. Recent development in novel drug delivery systems for delivery of herbal drugs: An updates. GSC Advanced Research and Reviews. 2021; 8(08):008-018.
- [87] Nimbawar MG, et al. Pharmacognostic and nootropic aspects of withania somnifera: A Potential herbal drug as memory enhancer. IJRASET. 2021; 9(VIII): 1075-1081.
- [88] Mankar SS, Motule AS, et al. Progress in development of herbal cosmeceuticals: An current status and prospects. International Journal of Medical, Pharmaceutical and Biological Sciences. 2021; 1(2): 1-11.
- [89] Motule, AS, et al. Favipiravir: A critical review of pharmacology, pre-clinical data, and emerging clinical uses in COVID-19. IJRASET. 2021; 9(VIII).
- [90] More, MP, et al. Pharmacognosy, Phytochemistry, Pharmacology and Clinical Application of *Ginkgo Biloba*. GSC Biological and Pharmaceutical Sciences, 2021; 16(2).
- [91] Motule, AS, et al. Ethnopharmacological relevances of herbal plants used in cosmetics and toiletries preparations. GSC Biological and Pharmaceutical Sciences, 2021; 16(2).
- [92] Motule, AS, et al. Development and physicochemical evaluation of bilayered transdermal patches of ondansetron hydrochloride. Journal of Innovations in Pharmaceutical and Biological Sciences. 2021; 8(3): 17-23.
- [93] Gulhane CA, Motule AS, et al. An overview on nail drug delivery system: A Promising application for various diseases. European Journal of Biomedical and Pharmaceutical Sciences. 2021;8(2):104-110.
- [94] More MP, Dongare PN, Patinge PA, Bakal RL, Motule AS. An overview on phytoconstitute and utilisation of *Lepidium sativum* linn (Garden Cress). World Journal of Pharmacy and Pharmaceutical Science. 2021; 10(1):710-719.
- [95] Dongare PN, Motule AS, et al. An Overview on anticancer drugs from marine source. World Journal of Pharmaceutical Research. 2021; 10(1): 950-956.