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Development and evaluation of VCO based herbal hair tonic

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Abstract

Loss of hair or alopecia is a universal problem that has been estimated to affect between 0.2 and 2% of the world's population. Various synthetic formulations available for treatment of alopecia exhibit severe side effects and also do not cure the condition permanently while natural products are getting more popular mainly due to their fewer side effects. It is therefore necessary to discover natural remedies of plant origin having hair growth promoting potential to replace the synthetic one for the treatment of alopecia.

People in the tropical countries have effectively used coconut oil to promote hair growth and development as a traditional hair grooming practice. Virgin coconut oil is the purest form of coconut oil which retains most of its functional components. The aim of present study involves development of herbal hair oil from virgin coconut oil extracts of a mix of nine herbs which is beneficial as a hair tonic. The various herbs used in the formulation are amla, hibiscus, curry leaf, Aloe vera, henna, bhringraj, tulsi, small onion and neela amari in varying concentration. Mixtures of these herbs are extracted in a definite proportion in virgin coconut oil and lavender oil is added for fragrance. The formula is finalised in such a way that the combination of ingredients provides essential nutrients such as protein, antioxidant vitamins and minerals which complement the normal function and nourishment of hair. The poly herbal hair oil developed was analysed for organoleptic properties and various physical and biological properties. Parameters such as moisture content, pH, specific gravity, viscosity, acid value, saponification value etc., were evaluated and irritation test and sensitivity test were conducted and recorded. It was observed that all the parameters were within the permissible limits. Herbal hair oil formulation showed the best result in hair growth having a cooling effect with no side effects.

Keywords: Virgin coconut oil, herbal hair oil, amla, hibiscus, bhringraj, Aloe vera

Introduction

Hair is one of the most important and noticeable features that improve the overall appearance of an individual. It sets the tone for a person's entire look and enhances one's personality, glamour, self-esteem and confidence. A good hair style requires shiny and voluminous hair. However, loss of hair or alopecia is a universal problem that has been estimated to affect between 0.2 and 2% of the world's population (Semalty *et al.*, 2011) [59]. It is a source of significant psychological and physical distress affecting both sexes irrespective of age (Kelly *et al.*, 2016) [33].

The major problems associated with hair grooming are reduced pigmentation and greying, split ends, dandruff and falling of hair (Adhirajan *et al.*, 2001) [1] leading to premature balding. Multiple factors including genetic predisposition, hormones, environmental exposure, medications, and nutrition predominantly contribute to hair loss (Hosking *et al.*, 2018) [28]. Certain pathological conditions, use of chemotherapeutic agents and dermatological disorders can also cause hair fall (Madnani and Khan 2013) [38].

Various synthetic formulations such as Finasteride and Minoxidil, a vasodilator medication known for its ability to slow or stop hair loss and promote hair regrowth are widely used for treatment of alopecia but do not cure the condition permanently. Pharmacological approaches based on such drugs have limited potential considering the side effects such as allergic reactions associated with them (Satish *et al.*, 2015) [58]. For this reason, the attention has been recently focused on the discovery of new and safer remedies, often exhibited by natural products. It is therefore necessary to discover natural remedies with hair growth promoting potential to replace the synthetic one with hair tonics of plant origin for the treatment of alopecia.

Applying oil to the scalp and hair before bath is a regular practice in India to enhance lubrication and maintain hair health. Fregonesi *et al.* (2009) [24] analysed oils derived from various natural sources and observed that oil treatment reduced the combing force percentage and the formation of split ends in the hair.

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Hair oils also facilitate scalp treatments and control of alopecia (Maria, 2015) [42]. A large portfolio of products from different brands are available in the market competing each other to grab a higher market share in the hair care segment mostly through advertisement rather than their effectiveness. Most of these hair oils include mineral oil as a component in their formulations because it is cheaper compared to vegetable oils and it is non-greasy in nature. However, in a comparative study by Rele and Mohile (2003) [53] on the effectiveness of mineral oil, coconut oil and sunflower oil, it was concluded that coconut oil only could compensate the protein loss for both undamaged and damaged hair. Mineral oil, being a hydrocarbon, has no affinity for hair proteins and therefore is not able to penetrate and yield better results. Similarly, on a comparative study by Keis *et al.*, (2005) [32] on the effectiveness of coconut oil, olive oil, sunflower oil and mineral oil, it was observed that coconut oil leave a thin layer on the scalp surface and has a higher penetration level and is well absorbed by the fibre compared to mineral oil and other vegetable oils tried.

People in the tropical countries have effectively used coconut oil to promote hair growth and development as a traditional hair grooming practice for centuries. Unlike mineral oil, fatty acids present in the coconut (particularly lauric acid) have been found to have antiseptic properties (Kumar *et al.*, 2012) [37] and is more efficient and safer. Virgin coconut oil is the purest form of coconut oil with natural distinctive coconut taste and smell. Nutritionally, VCO has more beneficial effect than copra oil because it retains most of its functional components. VCO is unique among all the other vegetable oils because of its high lauric acid content. VCO contains 92 percent medium chain fatty acids consisting of 48 to 53 percent lauric acid (Mansor *et al.*, 2012) [41].

Hair is a protein filament that grows from follicles found in the dermis (Begum *et al.*, 2017) [12]. Due to low molecular weight and straight linear chain, lauric acid has high affinity for hair proteins and is able to penetrate into hair shaft and promote hair growth. Lauric acid is the most active antimicrobial fatty acid. VCO exhibits antibacterial, antiviral and antifungal activity (Gerard *et al.*, 2016) [27]. A natural product with antiseptic effects has higher consumer appeal in the market. So VCO can be viewed as an ingenious and safe replacement for mineral and petroleum-based oils because of its appreciable contents of hair grooming principles.

VCO has multiple benefits that include moisture retention and hydration, softening, smoothing and protecting the hair (Pandiselvam *et al.*, 2019) [46]. The presence of fatty acids, vitamins and minerals in VCO nourish and restore the hair naturally and prevent premature greying (Mahajan *et al.*, 2017) [39]. The studies show that the VCO can be used as protective medium against hair damage by blocking about 20% of the sun's ultraviolet rays.

The various hair growth promoting and curative properties of VCO thus makes it an incredible base for the development of a hair tonic. Hair tonics are the hair care formulations effective in the treatment of hair disorders such as baldness, greying of hairs, hair falling, and dryness of hairs. To qualify with the status of a hair tonic, the formulation requires fortification with herbal extracts in Virgin coconut oil as base. Since ages, herbs and natural products are being used to treat hair loss or other hair related problems worldwide (Jain *et al.*, 2016) [29]. India is a good repository of medicinal herbs (Sanju *et al.*, 2006) [57] and a number of plants and herbal formulations are reported for hair growth promotion as well as improvement of quality of hair in Indigenous system of

medicine (Ayurveda). Hair tonics enriched with herbs are used regularly by Indian women from time immemorial as a hair care practice. Natural products involving herbal formulations available in the market are used as hair growth promoter, hair conditioner, hair-cleansing agent, antidandruff agents, as well as for the treatment of alopecia, dandruff and lice infection (Adhirajan *et al.*, 2003) [2]. A number of herbal products have been acclaimed with hair growth promoting activity and the use of some of the herbal oils is also reported to reduce the hair fall (Dulal *et al.*, 2014) [21].

Amla, Indian gooseberry or Phyllanthus emblica

Linn. is one of the richest sources of vitamin-C, amino acids and minerals. Amla fruit is widely used in the Indian system of medicine alone or in combination with other herbs as a tonic. It is considered as a rasayana (rejuvenator) useful against degenerative and senescence related processes. Amla is reported to have antioxidant, anti-inflammatory, analgesic, antipyretic, refrigerant, diuretic, laxative and restorative properties (Baliga and Dsouza, 2011) [7]. It contains several chemical constituents like tannins, alkaloids, phenols, amino acids and minerals such as phosphorus, iron and calcium which provides nutrition to hair and also improves darkening of hair.

Amla powder and the fixed oil from amla are used traditionally in Ayurvedic applications for the treatment of scalp. Amla oil is usually extracted by boiling dried and powdered amla fruits in coconut oil. This is a very effective conditioner which strengthens and promotes hair growth and pigmentation and prevents balding. Massaging the head with amla oil induces sound sleep, prevents premature greying of hair, and is useful in curing dandruff, alopecia and insomnia.

Amla has antibacterial and antioxidant properties that can help promote the growth of healthy and lustrous hair (Turner, 1996) [66]. The fruit extract is useful for hair growth and reduce hair loss (Dhanukar and Thatte, 2000) [18]. Amla maintains the hair colour and prevents premature greying and strengthens the hair follicles (Singh *et al.*, 2011) [61]. *Phyllanthus emblica* L. is a potent inhibitor of 5 α -reductase, which promotes the growth of the hair. Thus, amla is an ideal component that can be selected in traditional recipes for herbal hair oil.

Hibiscus or Hibiscus rosa sinensis has been used for ages in Ayurveda to cure many ailments. The flowers of *Hibiscus rosa-sinensis* have been reported to possess wound healing, antibacterial and immunomodulatory properties. Several studies have proved the presence of anti-oxidant, anti-fungal, and antimicrobial properties in flowers of *Hibiscus rosa-sinensis*. (Vastrad and Bydagi, 2018) [67].

The leaves and flowers of *Hibiscus rosa sinensis* have been reported to possess hair growth promoting and anti-greying properties in traditional literature. The flowers and leaves are traditionally used as a shampoo plus conditioner after grinding into a fine paste with water. Hibiscus leaves and flowers are rich in anthocyanins and phenolics, minerals like calcium, phosphorus and iron, vitamin B1, riboflavin, niacin and vitamin C which stimulate and promote thicker hair growth and prevent premature greying of hair (Adhirajan *et al.*, 2003) [2]. Phytosterols, triterpenoids and flavanoids found in flower extract are advantageous for hair growth (Agrawal *et al.*, 2016) [3].

Hibiscus is used for rejuvenating the hair growth and for controlling dandruff (Khare, 2004) [34]. The hair growth potential of *Hibiscus rosa sinensis* aqueous flower extract was

evaluated by Agarwal and Singh (2017) [4]. The results indicated an increase in hair length and hair follicle length after 30 days. Similar results were reported by Pathak and Gala, (2018) [48] in which *Hibiscus rosa-sinensis* flower and leaf extracts recorded significant hair growth promoting characteristics after 30 days without adverse effects compared to minoxidil. *Hibiscus* also helps to improve the overall texture and health of hair. Considering these clinical evidences, the leaf and flower extract of *Hibiscus rosa sinensis* could be selected as a constituent in the herbal hair oil formulation.

Curry leaf or *Murraya koenigii* is widely used as a spice throughout India and other tropical countries for its characteristic aroma as a flavouring agent in curries and chutneys. The plant is also widely used to treat various types of ailments in the Indigenous system of medicine. It has been reported to have antioxidant, antimicrobial, anti-inflammatory, anticholinesterase and anti-amnesic activity. The leaves of *M. koenigii* are rich in minerals, proteins, carbohydrate, fibre, carotene, nicotinic acid, Vitamin C, Vitamin A, calcium, oxalic acid, crystalline glycosides, alkaloids, flavonoids, terpenoids, koenigine, resin etc., (Tiwari *et al.*, 2011; Rakesh and Sandeep, 2012) [64, 51].

Curry leaves boiled with coconut oil is an excellent hair tonic for retaining natural hair tone and stimulating hair growth. A cream based skin-lightening cosmetic formulated from the extract of *M. koenigii* was found to have moisturizing property which suggested that it can be used as an adjuvant in other formulations to maintain or enhance natural skin and hair pigmentation (Tsuneo *et al.*, 1995) [65]. The essential oil from curry leaf is also utilized by perfume, soap, cosmetic and aromatherapy industry (Prajapati *et al.*, 2003) [49]. Hence it is worth selecting it as a component in herbal hair oil.

Aloe vera, is widely known for its therapeutic effects and has been used as a natural remedy for centuries (Shelton, 1991) [60]. It is rich in anti-oxidants and is a broad source of essential micronutrients (Na, Ca, Mg, K), Vitamin C, E and total phenolic compounds which are anti-ageing. Topical application of *Aloe vera*, is reported to be highly effective in accelerating the healing process of wounds and burns including sunburns (Atherton, 1997) [5] and reducing the scar. *Aloe vera* clears acne and skin allergies, dark spots and skin blemishes, and makes the skin clearer. *Aloe vera* is also effective in treating skin disorders like dermatitis, and even psoriasis and eczema of the skin, relieve itching and facilitate skin healing in exanthematic diseases such as measles, rubella, and varicella (Garces Mendoza, 2004) [5].

Basically *Aloe Vera* is a cellular regenerator by boosting the circulatory system. As a result, *Aloe vera* wards off wrinkles and age related changes. It nourishes the hair and is used for the treatment of scalp and hair loss. *Aloe vera* lotion is used for treating seborrheic dermatitis (Dandruff). *Aloe vera* hair conditioners and shampoos are used widely for the purpose (Chithra *et al.*, 1998) [14]. It can also be used as a hair styling gel and works especially well for conditioning the damaged hair.

Henna or *Lawsonia inermis* (Lythraceae) or Mailanchi is a hair care plant reported to possess immuno modulatory, antiviral, antibacterial, antifungal, anti-inflammatory, and antioxidant properties. Henna is an important source of natural hair colouring agent due to presence of lawsonone, a red orange dye present in dried leaves of the plant. Carbohydrates

present in it give the henna paste a suitable consistency for sticking to the hair (Patel *et al.*, 2013) [47]. Henna has also antifungal activity against *Malassezia* species which is the causative organism of dandruff (Fariba *et al.*, 2010) [22]. Henna prevents premature hair fall by balancing the pH of the scalp and greying of hair (Chaudhary, 2013) [13]. Henna has a natural affinity with the proteins in our hair, making it able to stain the colour onto the hair shaft. Hence, these properties qualify henna for selecting it as one of the component of the herbal hair oil, which will complement the overall quality of the product.

Bhringraj or *Eclipta alba* Hassk is traditionally known to stimulate hair growth as well as to check hair loss and greying of hair. The oil based extract of leaves has been used traditionally for improving hair growth and for imparting natural hair colour. Bhringraj is a major component of Neelibhringaadi Thailam, a popular hair tonic based on classic ayurvedic text. Numerous pharmacological properties including hair growth-promoting activity, anti-inflammatory, antioxidant, antimicrobial activities have been demonstrated.

The extracted juice of bhringraj applied to the scalp blackens the hair (Kritikar and Basu, 1975) [35]. Treatment with 5% of petroleum ether extract of bhringraj initiates greater number of hair follicles (Khare, 2004) [34]. Topical application of Ethanol extract of *Eclipta alba* Hassk reduced hair growth initiation time and the time required to complete hair growth significantly and exhibited greater number of hair follicles compared to minoxidil 2% treatment (Roy *et al.*, 2008) [56]. Datta *et al.* (2009) [19] and Begum *et al.*, (2014) [11] also reported that the whole plant extract of bhringraj exhibited strong hair growth promoting activity compared to other ingredients tried.

Eclipta alba has been reported as an ingredient in various polyherbal formulation and in the preparation of various oil, shampoo, hair dye etc. (Banerjee and Sharma, 2009) [8-9] for hair growth promotion. Thus, *Eclipta alba* extract can be used as an effective and complementary ingredient in herbal hair oil formulations.

Tulsi, Holy basil or *Ocimum sanctum* is a tropical aromatic herb having a vast array of health benefits which offers solutions to many modern-day health problems. It is a powerful antimicrobial with antibacterial, antiviral, antifungal, antiprotozoal, antimalarial, and anthelmintic properties. It is also an antioxidant, anti-inflammatory, radioprotective, hepatoprotective, neuroprotective, cardioprotective, anti-diabetic, anti-hypertensive, anti-carcinogenic, anti-pyretic, anti-allergenic, and analgesic properties (Cohen, 2014) [17].

A number of scientific studies have been conducted on Tulsi's various potential uses for hair-related disorders. Essential oil of Tulsi was capable of enhancing normal hair growth and promoting follicular proliferation in controlling chemotherapy induced hair loss (Orafidiya *et al.*, 2005) [45]. Tulsi also have been reported to have potential to address alopecia (Rathi *et al.*, 2008) [52]. It is a plant that is easily available locally in every household and thus can be selected as one of the ingredients.

Shallots, *Allium cepa* var. *aggregatum* or small onions, are a member of the allium family, but their flavour is richer, sweeter and more potent than onions. Shallots are rich in antioxidants, and have anti-inflammatory, antimicrobial, and anti-allergic properties (Mahmoudabadi and Naseri 2009,

Dhulappa, 2014, Sun *et al.*, 2019) [40, 20, 63]. Shallots have a rich content of Sulphur and phenolic compounds which is considered to be healthy for hair as it facilitates the production of collagen tissues that stimulate hair growth. Shallots can also help treat hair loss and might even cure baldness to some extent. Shallot juice can also help treat scalp infections and dandruff.

Common Indigo, 'neelayamari' or Indigofera tinctoria Linn is a leguminous medicinal plant valued for the blue dye (indigo) content in its leaves. It is a well-known Ayurvedic herb for hair treatment, and the leaf extract of the plant is used to prevent juvenile greying of hair and to promote hair growth (Nair *et al.*, 1991) [44]. It is a traditional practice of Indian women to soak the dried or fresh leaves of indigo in water and usually apply it mixed with henna as a paste to intensify the black colour of hair.

Renukadevi *et al.*, (2011) [54] reported that the leaf extract of *Indigofera tinctoria* have profound antibacterial, anti-oxidant and sedative activity. The extract was found to contain bioactive compounds like flavonoid, saponins, tannins, steroidal terpenes, phenols and anthroquinone which was responsible for antibacterial activity. Application of ethanol extract of *Indigofera tinctoria* significantly reduced hair growth initiation time and the time required to complete hair growth, and exhibited greater number of hair follicles compared to minoxidil treatment.

Herbal formulations always have attracted considerable attention because of their good bustle and comparatively lesser or nil side effects with synthetic drugs (Banerjee *et al.*, 2009) [8-9]. The hair care industry has become aware of this consumer demand and hence, delivering active formulations and promoting their adoption is necessary. By keeping these points in view, a study was conducted with an objective to develop polyherbal hair oil from Virgin coconut oil, and nine locally available herbs at Regional Agricultural Research Station, Pilicode, Kerala, India.

Materials and Methods

The present work was aimed to develop and evaluate a polyherbal hair oil containing herbs, such as amla (fruits), hibiscus (leaf & flower), curry leaf, Aloe vera (fresh leaf), henna (leaf), bhringraj (leaf), tulsi (leaf), small onion (whole fruit) and neela Amari (leaf), using Virgin coconut oil as base (Fig 1). All these herbs have well-known potential in the

nourishment of hair and cure for hair related problems as validated through literature. Raw materials of the above 9 plants were collected and then formulation was prepared by extracting them in a definite proportion using virgin coconut oil as a base and adding an essential oil for fragrance. Different ingredients used in the formulation of herbal oil are presented in Table 1.

Collection of raw materials

The raw materials selected for the preparation of herbal hair oil were Virgin Coconut Oil, amla, hibiscus, curry leaf, Aloe vera, henna, bhringraj, tulsi, small onion, neela amari and lavender oil for fragrance of which all of them except small onion and lavender oil are collected from Regional Agricultural Research Station, Pilicode, Kerala, India. Small onions were procured from the nearby supermarket. Lavender oil was supplied by M/S Synthite industries Pvt. Ltd. Kolenchery, Kochi, Kerala.

Preparation of herbal extracts

All the fresh herbs are weighed accurately according to the ratio presented in Table 1. Virgin coconut oil is added to a vessel on the proportion fixed and heated on a medium low flame. When oil is hot, grated amla fruit and small onion is added to it first, because of their higher water content. Mix it well for some time and then add the remaining ingredients like hibiscus, curry leaf, Aloe vera, henna, bhringraj, tulsi, neela amari and heated further in virgin coconut oil with constant stirring for about 20-30 min. The mixture has to be stirred continuously and carefully to avoid sticking to the bottom of the vessel when the moisture present in the herbs gets evaporated. A piece of cotton cloth is dipped into the mixture and taken out to conduct flame test to know whether moisture has completely got evaporated from it. The correct stage of finishing the extraction of herbs in virgin coconut oil is until the entire drugs are extracted and when the entire moisture is removed. At this stage, there won't be any cracking sound while boiling and the heat source is closed and left it for cooling. The mixture containing Virgin coconut oil and the herbs is filtered by straining through a muslin cloth or stainless steel mesh. Finally, the mixture is filtered again using filter paper to get the pure oil in homogenous condition. Lavender oil was added to the extracted oil for fragrance in the ratio proposed after which it was filled in glass bottle.

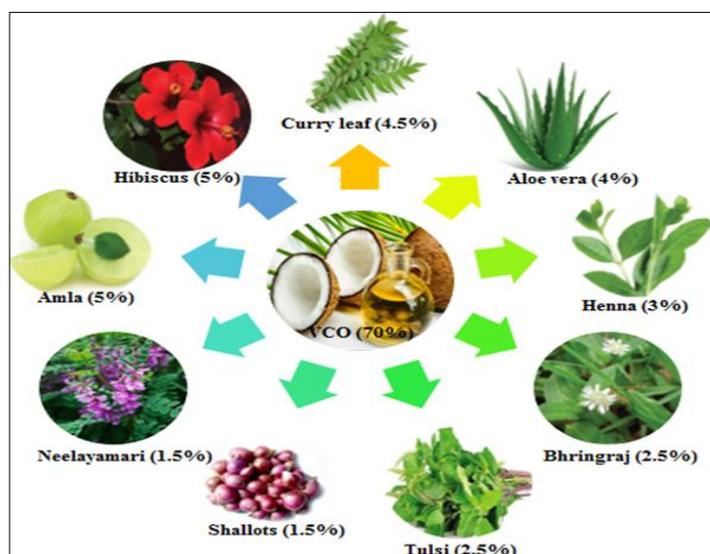


Fig 1: Ingredients for the herbal hair oil

Table 1: Ingredients and formulation of herbal hair oil

Sl. No.	Ingredients	Botanical name	Part used	Formulation (%)
1	Virgin coconut oil	Cocos nucifera	Kernel/milk	70.0
2	Amla	Phyllanthus emblica	Fruit pulp	5.0
3	Hibiscus	Hibiscus rosa sinensis	Leaf (2.5) & flower(2.5)	5.0
4	Curry leaf	Muraya koenigii	leaves	4.5
5	Aloe vera pulp	Aloe vera	Leaf pulp	4.0
6	Henna	Lawsonia inermis	leaves	3.0
7	Bhringraj	Eclipta alba	leaves	2.5
8	Krishna Tulsi	Ocimum sanctum	leaves	2.5
9	Small onion (Shallots)	Allium cepa var. Aggregatum	whole fruit	1.5
10	Neela amari	Indigofera tinctoria	leaves	1.5
11	Lavender	Lavendula officinalis	Oil	0.5

Evaluation of herbal hair oil

The formulated herbal hair oil was evaluated for its organoleptic properties and quality parameters.

Organoleptic Evaluation:

A team consisting of twelve semi-trained members was selected as respondents for the organoleptic test. Male/female volunteers between 22-40 years of age group having complaint of hair loss for near about three months duration was selected for this study. Each of them was provided with 300 ml of the prepared herbal hair oil and they were instructed to massage 10 ml every day on their scalp smoothly for 10 minutes during night after shower. The oil is left for a maximum of 12 hours and then washed out during morning bath. They were also advised to use this hair oil after morning bath. The total duration of the study was 15 days. The volunteers were also advised not to use any shampoo during the trial period. Each volunteer was reviewed after 15 days and their response was recorded.

The Organoleptic evaluation was carried out on a nine-point hedonic scale for their color, odour, appearance, texture, stickiness and overall acceptability of the developed product. The volunteers are requested to assess the product in terms of general acceptability on a 9 point hedonic scale. *i.e.*, Score system: Like extremely-9, Like very much-8, Like moderately-7, Like slightly-6, Neither like nor dislike-5, Dislike slightly-4, Dislike moderately-3, Dislike very much-2 and Dislike extremely-1. It was judged by the selected panel and the results were analyzed.

Quality evaluation

The herbal hair oil was evaluated to determine the physical parameters such as moisture content, acid value, saponification value, pH, viscosity and specific gravity. Biological parameter like irritation test was also performed on the same volunteers and their response was recorded.

Moisture content

Moisture content was analysed based on the American Oil Chemists Society (Firestone, 2009) [23] method. About 5.0 g of the herbal hair oil sample was placed into a pre- heated and pre- weighed crucible with lid and then heated at 105°C for at least 24 hr. The sample was then placed in a desiccator and allowed to cool down to room temperature. The crucible containing the herbal oil was then re- weighed. The moisture and volatile content was calculated using the following formula:

Moisture content (%) = (Initial weight - Final weight)/ Initial weight × 100

Acid value

Preparation of 0.1 molar solutions: Weighed 0.56 g KOH pellets and dissolved in 100 mL of distilled water and stirred continuously. The prepared 0.1 molar KOH solution was filled in the burette.

Preparation of sample: Measured 10 ml oil and dissolved in 25 mL of ethanol and 25 mL of ether mixture and shaken. Added 1 mL of phenolphthalein solution and titrated with 0.1 molar KOH solution.

Acid value = $5.61V N / W$

Where, V = Volume of standard sodium hydroxide used (ml), N = Normality of the sodium hydroxide solution, W = Weight of the sample (g).

Saponification value: 1 ml of herbal hair oil is accurately weighed in a 250 ml conical flask. A mixture of ethanol: ether is prepared in 2: 1 proportion and 10 ml of this mixture was added to the oil. To this, 25 ml of 0.5 N alcoholic KOH was added and was kept undisturbed for 30 minutes. When the flask is cool, this solution is titrated against 0.5 N HCl using phenolphthalein indicator. Similarly, the blank titration was performed with HCl excluding oil sample. Amount of KOH used (in mg) was calculated using formula,

Saponification value = $56.1(B-S) N/W$

Where, B= Volume of standard HCl (ml) required for the blank, S= Volume of standard HCl (ml) required for the sample, N= Normality of standard HCl, W= Weight of the oil (g) used for the test.

Specific gravity: Specific gravity of the herbal hair oil is arrived at using the following method. A specific gravity bottle was rinsed with distilled water, dried in hot air oven for 15 minutes, cooled, capped, weighed (g) and weight noted (A). Now the same specific gravity bottle was filled with the sample, capped and again weighed (B). Again the bottle is emptied thoroughly cleaned and rinsed with distilled water and dried for 15 minutes in oven, cooled and filled with distilled water and weighed(C). The specific gravity of the oil was calculated from the following relationship (Singh, 1996) [62]:

Specific Gravity = $B-A / C-A$

Where, A = weight (g) of specific gravity bottle, B = weight (g) of specific gravity bottle with oil, C = weight (g) of specific gravity bottle with water.

pH: The pH of herbal hair oil was determined using digital pH meter. 20ml of herbal hair oil was transferred in a beaker and the bulb of pH meter was dipped in hair tonic. The pH value displayed is recorded.

Viscosity: It is an index of resistance of a liquid to flow. The higher the viscosity of the liquid, the greater is the resistance to flow. The viscosity was determined using Ostwald's viscometer and the readings recorded.

Skin irritation test: This test was performed to evaluate the irritation of the formulated oil on the skin of selected volunteers for organoleptic test. The prepared herbal hair oil was applied on 1 cm² skin of hand after cleaning with absolute alcohol and exposed to sunlight for 4-5 minutes and observed and their response recorded.

Results and Discussion

This study reports the formulation, development and evaluation of a VCO based herbal hair tonic for organoleptic properties, quality characteristics and overall acceptability. After developing the formulation, the samples were tested for organoleptic properties, Physicochemical properties like moisture content, acid value, saponification value, specific gravity, pH, viscosity and biological parameters like skin irritation test and the experimental results obtained from the present study have been discussed hereunder:

The product was judged by the consumer panel team

consisting of twelve semi-trained members and the average organoleptic scores were presented in Table 2.

Table 2: Organoleptic score card for herbal hair oil

Characteristics	Average scores
Colour	8.0
Odour	7.8
Appearance	8.4
Texture	8.2
Stickiness	7.9
Overall acceptability	8.8

Organoleptic evaluation revealed that the herbal hair oil is dark green in colour, having pleasant aromatic odour, less viscous, smooth in texture, non-greasy and good overall acceptability (Table 3). Colour and odour of the oil sample was typical of their constituents and the fragrance added. Organoleptic evaluation indicates the acceptability of the product.

Table 3: Organoleptic evaluation of herbal hair oil

Sl. No	Parameters	Results
1.	Colour	Dark green
2.	Odour	Aromatic
3.	Appearance	Less viscous
4.	Texture	smooth
5.	Greasiness	Non greasy
6.	Overall acceptability	Good

The various quality parameters like moisture content, acid value, saponification value, Specific gravity, pH, and viscosity of the herbal hair oil was evaluated and presented in Table 4.

Table 4: Quality evaluation of herbal hair oil

Sl. No.	Parameter	Inference
1	Moisture content	0.21
2	Acid value	1.60
3	Saponification value	256.08
4	Specific gravity	0.916
5	pH	6.6
6	Viscosity	0.966

Moisture content: These are important determinants of oil quality (Choe and Min, 2006) [15]. Raghavendra and Raghavarao (2011) [50] reported that hydrolytic rancidity of fats and oils are due to presence of high moisture. It is desirable to keep the moisture content low as it will increase the shelf life by preventing oxidation and rancidity processes. The moisture content recorded in the herbal hair oil is 0.21% and the values are within the set standards and hence facilitate keeping quality. Due to low moisture content, there is only minimal possibility of the deterioration of the formulation.

Acid value: This is defined as the number of milligrams of potassium hydroxide required to neutralize the free fatty acids present in one gram of fat. It is a relative measure of rancidity as free fatty acids are normally formed during decomposition of oil glycerides. More acid value indicates the higher percentage of free fatty acid leading to more oxidation and less quality of oil. Acid value calculated for the herbal hair oil sample was only 1.60. The low acid value recorded indicates that the oil contains relatively little or no water. Lower the acid value, higher the quality of oil. The observed values were in agreement with the trend reported by Kumar, *et al.* (2010) [36] for coconut oil (2.1mgKOH/g) based formulations. Similar

results were recorded by Chothe *et al.* (2018) [16] and Begum and Begum (2019) [10] in Herbal hair oil.

Saponification value (SV): This measures the average molecular weight of fatty acids present in the oil. It is directly proportional to the shorter chain fatty acids on the glycerol back bone. In this study, the herbal oil recorded a saponification value of 256.08 mg KOH⁻¹ oil. High saponification value indicates higher proportion of short chain fatty acids. This may probably due to the extraction of the herbal components in VCO which have a saponification value in the range of 250-260 KOH/g of oil as reported by Marina *et al.*, (2009) [43].

Specific gravity: Specific gravity of the herbal oil was 0.916 which are within the range proposed by BIS. It is lighter than water and is thin. This result was in agreement with that obtained by Kamal (2015) [31] for herbal hair oil.

pH: The pH of oil was found to be 6.6 indicating near neutral value, which was relevant with human skin. Similar pH of 6.9 was recorded by Rohan *et al.*, (2018) [55] and 6.8 by Joshi and Dyawarkonda (2017) [30] for coconut oil based herbal hair oil.

Viscosity: Viscosity of the oil was found to be 0.966. This was in conformity with the studies conducted by Gautham *et al.* (2012) and Rohan *et al.*, (2018) [55] which recorded a viscosity of 0.93 and 0.9936 respectively for herbal hair oil.

Biological Evaluation: Primary skin irritation test conducted using the prepared formulation on intact skin of volunteers revealed that it was non irritant and was safe for use.

The result thus shows the acceptance of the product in organoleptic test. The quality evaluation reveals that the levels of physicochemical and biological parameters of finished product have optimum standards which are within the safe limits.

Conclusion

The herbal hair tonic developed was dark green, pleasantly aromatic, non-greasy and appears as light, smooth, free flowing with uniform consistency. When applied to the hair it adheres as a film and gets absorbed into the scalp quickly with in a shorter period of time. It has a cooling effect and is helpful in relieving stress.

The results for the evaluation of physical parameters like moisture content, acid value, saponification value, specific gravity, pH and viscosity are according to the standard values and are under the specified limits. It is constituted completely with natural ingredients and is safe, devoid of any side effects and is free from skin irritancy.

The developed herbal formulation did not show any sedimentation stored at the room temperature up to three months and has good stability. Virgin coconut oil which constitutes a major proportion of the formulation itself acts as a preservative increasing the shelf-life of the herbal hair oil and prevents it from microbial degradation. The product developed thus has long shelf-life and is quite stable.

Virgin coconut oil is an incredible base for herbal hair oils because of its appreciable contents of hair grooming and curative principles. The presence of medium chain fatty acids, essential nutrients, vitamins, minerals and antioxidants in VCO nourish and restore the hair naturally through moisture retention and hydration, softening, smoothening and protecting the hair. The herbal constituents chosen for the present formulation also have been reported to possess extremely good content of principles vital to the nourishment of hair and providing protection from hair loss related problems. Virgin coconut oil with rich functional properties and diverse herbal ingredients when blended together elicit a synergistic effect in nourishment of hair, promoting hair growth. A product developed through such a combination will be effective in compensating protein loss through higher penetration deep into the hair follicles making it stronger, maintaining normal function of sebaceous glands, turning grey hairs to black, providing protection from dandruff, resulting in healthy lustrous hairs.

It can be concluded that this hair care formulation based on VCO along with other herbal ingredients devoid of any preservatives could be an effective remedy for hair loss treatment. This process technology and formulation could be applied in industrial scale and is viable for mass production.

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