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Pharmaceutical Innovations in Rejuvenating Gel Formulations: A Review of Recent Progress

D. Deborah Evangeline[1], Athira. A.K[2], Geethu. P[3], Dr. Deepu.S[4], Kanaka. V.S[5], Ranitha.R[6], Neenu Anna Thomas[7], Srathika. K[8]

1. Associate Professor, Department of Pharmaceutics, 2. Student of eighth semester B Pharm, 3. Student of eighth semester B Pharm, 4. Professor & HOD, Department of Pharmaceutics, 5. Associate Professor, Department of Pharmaceutics, 6. Assistant Professor, Department of Pharmaceutics, 7. Assistant Professor, Department of Pharmaceutics, 8. Assistant Professor, Department of Pharmaceutics. Ahalia School of Pharmacy, Palakkad, 678557, Kerala, India

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ABSTRACT

Skin aging is a multifactorial biological process influenced by intrinsic factors and external stressors such as ultraviolet radiation, pollution, and oxidative stress. In recent years, rejuvenating gel formulations have gained significant attention as effective topical delivery systems for anti-aging and skin-protective agents. This review focuses on recent pharmaceutical innovations in rejuvenating gel formulations, with particular emphasis on antioxidant-based and herbal ingredients. Natural bioactive compounds derived from plant sources exhibit potent antioxidant, anti-inflammatory, and skin-repair properties, making them safer and more compatible alternatives to synthetic agents commonly associated with irritation and adverse effects. Antioxidant gels play a crucial role in neutralizing free radicals, thereby preventing collagen degradation, reducing wrinkles and fine lines, improving skin hydration, and enhancing overall skin texture and elasticity. The review also discusses commonly used gelling agents, formulation strategies, evaluation parameters, and in vitro antioxidant assessment methods such as the DPPH radical scavenging assay. Recent studies indicate that herbal-based rejuvenating gels demonstrate significant antioxidant activity, good physicochemical stability, and improved skin compatibility. Overall, this review highlights the therapeutic potential and growing importance of natural antioxidant gel formulations as safe, effective, and sustainable approaches for skin rejuvenation and anti-aging skincare.

Keywords: skin, rejuvenating gel, anti-aging, antioxidants, herbal formulations

INTRODUCTION

Facial skin aging is a combined result of both intrinsic and extrinsic stressors. Synthetic materials are commonly used for skin rejuvenation procedures targeting these stressors. Synthetic materials are producing some harmful effects than the natural substances, so using natural herbal extracts as active ingredients for preparing anti-aging or rejuvenating gel formulation. [1]

Gels are semisolid transparent preparation for skin application. Anti-aging cream is used as a pharmaceutical product for the rejuvenation of skin. Anti-oxidants are mainly used in the rejuvenation of skin. Antioxidants protect the skin by neutralizing harmful free radicals formed due to UV exposure, pollution and environmental stress, which cause premature aging and skin damage. Oxidative stress from free radicals leads to wrinkles, fine lines, pigmentation and loss of skin elasticity, which antioxidants help prevent. Topical antioxidant formulations support skin health by reducing inflammation, enhancing collagen production and promoting a youthful, radiant complexion. Natural antioxidant-rich extracts in facial gels provide a safe, effective way to maintain skin vitality and protect against daily environmental aggressors. [1,2,14].

1. COSMETICS

“Cosmetics” means any article intended to be rubbed for skin application, poured, sprinkled or sprayed on, or introduced into, or otherwise applied to, the human body or any part thereof for cleaning, beautifying, promoting attractiveness, or altering the appearance. [3]

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The word cosmetics derived from a Greek word- "kosmeticos" that means to adorn. From that time any material used to beautify or promote appearance is known as cosmetics. The word "cosmetics" actually stems from its use in Ancient Rome. They were typically produced by female slaves known as "cosmetae" which is where the word "cosmetics" stemmed from. [4]

Cosmetics are used to enhance appearance. Makeup has been around for many centuries. The first known people who used cosmetics to enhance their beauty were the Egyptians. Makeup those days was just simple eye colouring or some material for the body. Now-a-days makeup plays an important role for both men and women. The importance of cosmetics has increased as many people want to stay young and attractive. [5]

Cosmetics are readily available today in the form of creams, lipstick, perfumes, eye shadows, nail polishes, hair sprays, etc. Other cosmetics like face powder give glow to the skin after applying the base cream. Then we have lipstick, which is applied by many women of all ages. They are made from wax and cocoa butter in the desired amount. Cosmetics like creams, gels and colognes are used on a daily basis by both women and men. [6]

Recent research has shown that makeup helps in protection from harmful rays of the sun. Many beauty products manufacturers have utilized the needs of people to protect themselves and their skin from the rays of sun. The importance of cosmetics helps to enhance our appearance and makes us feel more confident. With more cosmetics on the market today than ever before. It becomes obvious to us that they play a great role in our everyday life. [7]

2. COSMACEUTICALS

Cosmaceuticals are the cosmetic products that contain bioactive ingredients with medical or therapeutic benefits, acting as a bridge between traditional cosmetics and pharmaceuticals. They are designed to improve the skin's health and appearance by influencing its biological function, such as enhancing collagen production or treating conditions like acne or signs of aging. [8]

3. HUMAN SKIN

Skin is the largest organ in the body, covering its entire external surface. The skin has 3 layers- the epidermis, dermis, and hypodermis, which have different anatomical structures and functions. The skin's structure comprises an intricate network that serves as the body's initial barrier against pathogens, ultraviolet (UV) light, chemicals, and mechanical injury. This organ also regulates temperature and the amount of water released into the environment. [9]

The skin is the organ that forms the border between the organism and the environment. The skin prevents skin hydration. Stops the permeations of noxious foreign materials and microorganisms, cushions against mechanical shock, helps to maintain a constant body temperature, and transducers incoming stimuli. To perform these functions, skin must be maintained in good condition, an important objective in cosmetic formulators. [10]

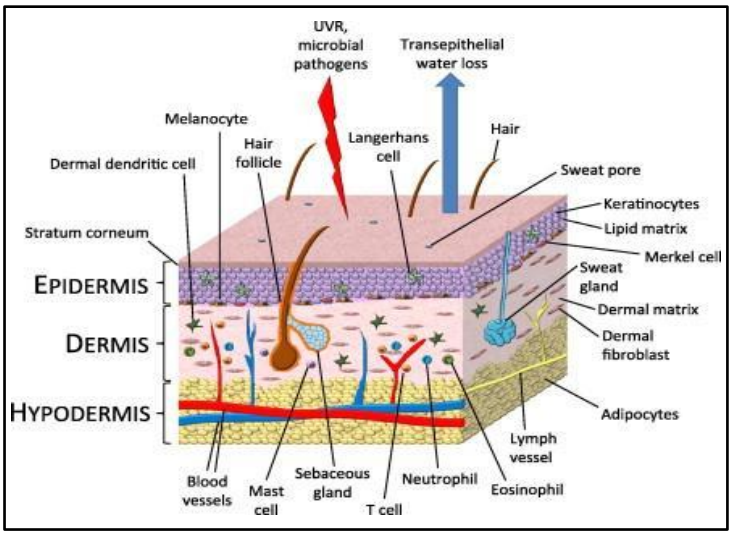

Fig no 1.1: - Skin structure

3.1. SKIN MORPHOLOGY

The skin is divided into three layers:

1. Epidermis
2. Dermis
3. Subcutaneous

3.1.1. EPIDERMIS:

The epidermis is the outermost layer of the skin and consists of a stratified squamous epithelium. Its thickness varies, depending on location, and varies from 0.05 mm to 1.5 mm. The epidermis is made up primarily of keratinocytes, whose basic function is to produce a filamentous protein, keratin, to serve as a protective barrier in combination with various lipid components. These cells also produce several other proteins, for example, cytokines, which play a role in the cutaneous inflammatory response. Separated from the epidermis by the basement membrane, the dermis is composed primarily of the so-called ground substance, which includes glycosaminoglycans (GAGs) and the structural protein collagen. Its thickness also varies with location from 0.3 mm to 3.0 mm.

3.1.2. DERMIS:

The dermis is divided into two layers: the papillary layer, which interdigitates with the epidermal rete ridges, and the reticular layer, which extends to the subcutaneous tissue. This deepest layer of the skin, also known as the hypodermis, is composed primarily of lipocytes with fibrous septae providing structure and support.

3.2. TYPES OF SKIN

Skin types based on Hydration and Lipid content:

1. Normal skin
2. Dry skin
3. Oily skin
4. Sensitive skin

3.2.1. NORMAL SKIN:

It is generally described as not too oily, not too dry. At a cosmetological level, normal skin is structurally and functionally balanced and it has fine pores; it is smooth and well supplied with blood. In addition, it has no or only a few imperfections, no severe sensitivity, and a radiant complexion.

3.2.2. DRY SKIN:

It is relatively common most people experience it from time to time due to various factors. It can be characterized as scaly, rough and dull which can lead to tautness and itchiness. In addition, it generally has red patches and can be characterized with less elasticity and a rough complexion. Dry skin tends more toward premature aging and is likely to have more wrinkles. Environmental factors, such as low relative humidity, cold weather and sunlight in addition to repeated contact with water, surfactants and solvents plus numerous skin diseases and dietary deficiencies can produce dry skin.

3.2.3. OILY SKIN:

It has enlarged pores; therefore, it is very shiny as a result of over activity of the sebaceous glands. Oiliness is most visible on the forehead, nose and chin and these parts are oily to the touch. Oily skin usually develops with the onset of puberty and affects a large percentage of young people. There are several factors that can cause and/or contribute to oily or greasy skin, including genetic inheritance, hormonal changes, diet, stress and external agents (such as cosmetics, chemicals, UV light). Individuals with this skin type often tend to suffer from acne and dandruff as adolescents. Combination skin, as its name implies, is the combination of normal

and oily skin or of oily and dry skin. This type of skin tends to be greasy in the central T -zone of the forehead, nose, and chin. The skin on the other area (cheeks and hairline) is normal or dry.

3.2.4. SENSITIVE SKIN:

It is a complex dermatological condition, defined by abnormal sensory symptoms for example, tingling, chafing, burning or prickling, and possibly pain or pruritis by various chemicals (e.g., cosmetics, soaps, water, pollution) physical factors (e.g., UV light, heat, cold and wind), microorganisms, psychological factors (e.g. Stress) and hormones (e.g. Menstrual cycle). It is often thought to be a specific skin type similar to oily or dry skin. However, it is more of a condition since normal, oily, dry and combination skin can also be sensitive to various irritants. The term "sensitive skin" mainly refers to facial skin, but it can also concern other body areas, such as hands, scalp, or genital area. Its pathophysiology includes the alteration of the skin barrier, allowing potential irritants and microorganisms to penetrate the skin and generate an inflammatory reaction.

Fig 1.2: - Types of skin

3.3. SKIN DISORDERS

1. Acne
2. Rosacea
3. Wrinkled skin

3.3.1. ACNE:

It is a very common chronic inflammatory dermatosis found predominantly in adolescents in both sexes. The lesions are seen more commonly on the face, upper chest and upper back. The appearance of lesions around puberty is related to physiological hormone variation. The condition affects the hair follicle, the opening of which is blocked by keratin material resulting in formation of comedones. Comedones may be open having central black appearance due to oxidation of melanin called black heads, or they may be in closed follicles referred to as white heads. Closed comedones may get infected and result in pustular acne.

P. acnes has been cited as the cause of acne because it is typically present in teenagers with acne and not those without acne. It is known that sebum accumulation because of excess lipid secretion and hyperkeratosis at the infundibulum leads to an increase in *p. acne* around the hair follicles. The presence of the bacteria is likely not a direct cause of acne breakouts though. It is more likely that the inflammation seen in acne is caused by free fatty acid that results from the breakdown of triglycerides in the sebum owing to bacterial lipases. Other extracellular enzymes proteases and hyaluronidase may also play an important role in the inflammatory process. [11]

Fig no 1.3: -Acne

3.3.2. ROSACEA:

Rosacea is a well-recognized, chronic, cutaneous condition presenting as central facial erythema, telangiectasia, papules and pustules. It is usually diagnosed between the ages of 30 and 50 years and although both genders can be affected, it is more common in women, with more men experiencing the phymatous changes. Rosacea is also more prevalent in fair skinned than dark skinned individuals. Sun damage, a propensity to flush and genetic predisposition are risk factors in acquiring rosacea.

The precise casual pathway of rosacea still remains unknown. In addition to genetic pre-disposition, many other factors have been implicated in the pathogenesis of rosacea. These include demodex folliculorum mites, helicobacter pylori infection, vascular lability, response to chemical and ingested agents, and psychogenic factors. Sunlight, heat, alcohol consumption and spicy foods are also very well known for their contributions in aggravating rosacea symptoms it has been suggested that intestinal inflammation and bacteria may cause hypersensitization of facial sensory neurons via the plasma kallikrein-kinin pathway and production of bradykinin, a well-known vasodilator. Another leading theory is based on vascular response. Flushing telangiectasias are major symptoms in patients affected with rosacea. A combination of super facility of cutaneous vasculature on the face, higher blood flow of facial skin and vascular dysregulation via humoral and neural mechanisms may explain the rationale behind this theory. In addition to prostaglandins, other neurotransmitters including histamine, serotonin, and substance P may also play a role in the erythema response of rosacea. [12]

Fig no 1.4: - Rosacea

3.3.3. WRINKLED SKIN:

The desire to maintain or restore a youthful appearance has become a significant concern for many people in today's world. Evidently, "wrinkles" are considered one of the major obstacles in this arena. Cutaneous wrinkles, defined as furrows or ridges on the skin surface, appear to be multifactorial in etiology and a consequence of intrinsic and extrinsic aging. While genetic predisposition is an important factor in developing wrinkles, engaging in particular lifestyle behaviors such as excessive sun exposure and smoking are also known causes of cutaneous aging. Aging is a process that occurs in all organs, but is most visible in the skin. The skin may very well reflect or act as an outward sign of processes occurring in the internal organs. In fact, the amount of facial wrinkling has been shown to correlate with the extent of lung disease in COPD.

The pathophysiology involves collagen loss, elastin degradation and telomere shortening. The collagen loss involves mainly abnormal and reduced collagen is a major finding of wrinkles, both in sun exposed and non-sun exposed skin. Collagen modification in wrinkled skin can be explained with a combination of different concepts. It is well known that collagen synthesis is decreased in aging skin. In elastin degradation the wrinkled skin is known to exhibit decreased resilience because of abnormal elastic tissue. In the setting of UV exposure, the quantity of elastase, the enzyme responsible for degrading elastin, increases and leads to "elastosis" a hallmark of photoaged skin. In telomere shortening, the telomeres are the thermal portions of mammalian chromosomes that are composed of hundreds of short sequences of repeat base pairs. Therefore, these terminal sequences are continuously lost on replication, resulting in shortening of the chromosome. When telomeres get "too short," apoptosis of the cells is triggered. For this reason, telomeres are thought to play a role in aging. [13]

Fig no 1.5: - Wrinkled skin

4. SKIN REJUVENATION (ANTI-AGING)

Skin rejuvenating means the various treatments to restore youthful skin by addressing wrinkles, scars, uneven tone, and dullness, primarily by boosting collagen, stimulating cell turnover, and improving texture through different methods. Anti-aging cream is used as a pharmaceutical product for the rejuvenation of skin. Anti-oxidants are mainly used in the rejuvenation of skin.

Ageing is defined as a progressive deterioration of physiological functions in organisms, eventually leading to senescence and death. Also, each part of the body ages with time, the skin is the most visible organ in which it makes us aware of the aging process every minute. [14] The signs of ageing include fine lines and wrinkles, alterations in skin pigmentation, and a thinner appearance of the skin due to epidermal and dermal atrophy. [14] The main cause of ageing is photo-ageing (UV-A and UV-B rays) causes production of free radicals that affect DNA production. Also smoking, hormonal changes and life style are responsible for ageing. [15]

4.1. REJUVENATING GEL

The word gel is derived from the word "Gelatin", liquid setting to a solid which does not flow. It is a semi rigid system. [16] A gel-cream consists of oily and aqueous phases together with a stabilizing, thickening and or emulsifying agent. Gel-cream has a smooth texture, good spreadability, feel and provides good nourishment with moisturization. It has rapid drug permeation and is also thermodynamically stable. [17]

Herbal anti-oxidants are more advantageous than synthetic drugs because they fight against the free radical and provide nourishment to the skin causing rejuvenation at the same time. Plant based skin anti-aging and rejuvenation products are used widely because of the harmful effect of other chemical compounds found in all skin care products. The herbal products like aloe, turmeric, cocoa, neem, papaya, etc. These contain anti-oxidant, anti-inflammatory, anti-bacterial, anti-aging components. [18]

Hyaluronic acid (HA) is more commonly used ingredient in many topical products due to its strong humectant properties and essential role in skin hydration; however, limitations of delivery of HA to only the surface of skin has hindered leveraging the full capacity of HA biology necessary for skin rejuvenation. But hyaluronic acid and other chemicals may lead to some adverse effects due to the continued usage. It may produce redness, allergic reactions, itching, inflammation, etc. [19, 20] So that in this study it describes that the herbal products are safer than the chemical substances.

5. DETERMINATION OF ANTIOXIDANTS BY DPPH RADICAL SCAVENGING ACTIVITY

This is for the study of identification of antioxidants using (DPPH) 2,2-Diphenyl-1-picrylhydrazylradical scavenging activity in *Ficus religiosa*, as *F. religiosa* is an important herbal plant, and every part has various medicinal properties such as antibacterial properties that can be used for the researchers in the development and design of various new drugs. It is more common, easily and quickly available and affordable for the test for anti-oxidant activity of the compounds.

Antioxidants function by donating electrons to unstable free radicles, thereby neutralizing their harmful effects on cellular structure and preventive oxidative damage. Free radicals are mainly associated with oxidative stress. The combination of oxygen with specific chemicals results in the generation of free radicals, and then, once created, the potential threat is the damage they may cause when they combine with essential cellular elements such as DNA and proteins, as well as the cell membrane. Antioxidants react with free radicals and then it stops damage before it starts by neutralizing them. Anti-oxidants are present in the secondary metabolites produced by plants. [21]

Topical antioxidants like vitamin C, vitamin E, and polyphenols are commonly used in skincare formulations, their clinical effectiveness is often hampered by issues such as poor stability, limited skin absorption, and degradation when exposed to air or light. [22]

6. VARIOUS FORMULATION OF GEL

Gels were developed with polymers as thickening agents, for example carbopol 934 or sodium carboxymethyl cellulose using a dispersion method. Carbopol 934 is commonly used polymer. [23]

"Formulation and standardization of polyherbal face wash gel" for acne management mainly the ethanolic extract is used. Sodium lauryl sulphate (SLS) and carbopol 934 are used in this formulation. The concentration of SLS was optimized by adding varying quantities of SLS to 1.0% w/v carbopol. The carbopol was dispersed in distilled water and continuously stirred and kept overnight to allow hydration of the substance. By adding triethanolamine, adjust the pH and complete the gelation process. Evaluate the viscosity and spreadability by preparing the gel using different concentrations of carbopol (1g,1.5g,2g,2.5g). The gel base 1 g is most suitable for viscosity and spreadability. The herbal extract was incorporated into the gel base and evaluated the appearance, spreadability, pH, viscosity, foamability, greasiness, antibacterial evaluation. [24]

"Formulation and Evaluation of Polyherbal Face Scrub Gel for Skin Exfoliation." This study developed and assessed a polyherbal facial scrub gel using natural extracts. The formulation incorporates ingredients like liquorice, orange peel, and marigold flowers to exfoliate skin effectively. Alcoholic extracts from these herbs underwent maceration before incorporation into a carbopol-based gel, along with additives such as propylene glycol, sodium benzoate, and triethanolamine. The gel base formed with carbopol received the herbal extracts and other excipients, resulting in a stable scrub product. Tests covered appearance, pH, viscosity, spreadability, wash ability, grittiness, stability, irritancy, and patch testing, confirming suitability for skin use. [25]

Table 1: List of ingredients used in polyherbal face scrub gel.

Sr. No.	Ingredients	Quantity (%)		
		F1	F2	F3
1	Orange peel extract	2	2	2
2	Mari gold flower extract	2	2	2
3	Liquorice root extract	2	2	2
4	Orange peel powder	3	2	1
5	Carbopol	1	2	3
6	Sodium benzoate	0.1	0.1	0.1
7	Sodium lauryl sulphate	1	2	3
8	Tri ethanolamine	2	2	2
9	Propylene glycol	2	2	2
10	Distilled water	q.s.	q.s.	q.s.

Table 2: List of evaluation tests of polyherbal face scrub gel.

Sl. No.	Parameters
1	Colour
2	Odour
3	Texture
4	State
5	pH
6	Consistency
7	Viscosity
8	Spreadability
9	Washability
10	Grittiness
11	Foam ability
12	Irritancy
13	Extrudability
14	Stability
15	Patch test

"Formulation of facial cleansing gel using Aloe Vera as natural surfactant." This research focuses on developing a facial cleanser gel that employs Aloe Vera as its natural surfactant. Experimental design methods guide the process, encompassing phytochemical screening of Aloe Vera extract samples, gel preparation by incorporating carbomer 960 at 0.5%, 0.7%, and 2% concentrations into the extract solution, and selection of essential oils tailored to facial skin requirements. Triethanolamine neutralizes the Aloe Vera extract to create a stable gel meeting Indonesian National Standard (SNI 2588:2017), with carbomer 960 added at specified percentages. Analysis confirmed the presence of flavonoids, triterpenoids, saponins, and polyphenols in the Aloe Vera extract. The superior formulation includes 0.7% carbomer 960, eight drops of triethanolamine, 1 ml moringa seed oil, 1 ml virgin coconut oil, one drop lavender oil, five drops whey kefir, and two natural vitamin E capsules. The resulting gel exhibits an essence-matched aroma, soft texture, cloudy white hue, gel consistency, cooling sensation on skin, foam-free lather, and a pH of 5 compliant with SNI standards. [26]

Table 3: Formulation of facial cleansing gel using Aloe Vera as natural surfactant.

Sl. No.	**Ingredients**	**Evaluation tests**	**Phytochemical present**
1	Aloe Vera extract	Colour	Flavonoid
2	Aquades	Odour	Tannin
3	Carbomer	Viscosity	Polyphenols
4	Triethanolamine	pH	Steroid/ triterpenoid
5	Whey kefir	Spreadability	
6	Lavender oil	Antimicrobial	
7	Orange oil	Cleansing	
8	Moringa seed oil		
9	Virgin coconut oil		
10	Phenoxy ethanol		

"Formulation and evaluation of cosmetic gel using Maranta Arundinacea L" in this research they formulate an herbal cosmetic gel containing anti-inflammatory and ani bacterial properties. Also, this formulation helps to nourish the skin, reduce oiliness, and anti-irritant properties. Mainly this is formulated by two polymers carbopol 934 and sodium carboxy methyl cellulose in different ratios since they found that the carbopol is the best formulation. The method of formulation is dispersion method 1:5 ratio shows better results. [23]

Table 4: Composition of cosmetic gel of Maranta arundinacea linn.

Sl.No.	Ingredients	F1	F2	F3	F4	F5	F6
1	Arrowroot powder	1	1	1	1	1	1
2	Carbopol 934	1	3	5	-	-	-
3	Sodium carboxy methyl cellulose	-	-	-	1	3	5
4	Methyl paraben	1	1	1	1	1	1
5	Glycerine	1	1	1	1	1	1
6	Rose water	3	3	3	3	3	3
7	Triethanolamine	0.5	0.5	0.5	0.5	0.5	0.5
8	Distilled water	20	20	20	20	20	20

Table 5: Evaluation tests

Sl.No.	TESTS
1	Physical appearance
2	Homogeneity
3	Spreadability
4	Viscosity
5	pH
6	Anti-microbial test
7	Stability test

7. ADVANTAGES OF REJUVENATING GEL

- **Enhanced skin appearance**: Gels can reduce the look of fine lines, wrinkles, and sagging skin by stimulating collagen and elastin production.

- **Improved tone and texture**: They help manage hyperpigmentation, reduce dark spots, and create a smoother, more even complexion.

- **Increased hydration**: Many gels, especially those with hyaluronic acid, provide deep, long-lasting moisture, making skin appear plumper and healthier.

- **Acne and scar reduction**: Certain formulations can help clear breakouts, reduce acne scars, and minimize enlarged pores.

- **Soothing properties**: Some gels contain ingredients like aloe or chamomile to calm irritation and soothe inflamed skin.

8. DIS ADVANTAGES OF REJUVENATING GEL

- **Potential for irritation**: Common side effects can include redness, dryness, scaling, itching, or dermatitis, especially with strong ingredients like high-concentration retinoids.

- **Increased sun sensitivity**: Many rejuvenating ingredients make the skin more vulnerable to sun damage, requiring diligent use of sunscreen.

- **Not a permanent solution**: The beneficial effects typically require consistent use or maintenance treatments; results will diminish over time if discontinued.

- **Variable results**: Effectiveness can depend on the specific product formulation, individual skin type, and proper usage technique, meaning results are not guaranteed for everyone.

- **Risk of allergic reactions**: As with any skincare product, there is a possibility of developing a hypersensitivity or allergic reaction.

- **Professional supervision may be needed**: Some potent rejuvenating products or procedures require a dermatologist's guidance to avoid misuse and adverse effects.

9. CONCLUSION

In this study we conclude that rejuvenating gel protects the skin from harmful free radicles, pollutes and nourishes the skin and protects from wrinkles, fine lines, acne and promotes a youthful appearance to the skin. The gels are mainly prepared by dispersion method, carbopol 934 is commonly used as polymer. And also find that the herbal preparations are less harmful than synthetic gels.

Based on this review we conclude that the following ingredients will be used for the formulating rejuvenating gel are plant extract, carbopol 934, propylene glycol, propyl paraben, methyl paraben, triethanolamine, distilled water. And its evaluation parameters including: physical appearance, viscosity, spreadability, homogeneity, pH, anti-microbial, anti-oxidant, anti-inflammatory, stability, phytochemical analysis.

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	**D. Deborah Evangeline** Associate Professor, Department of Pharmaceutics, Ahalia School of Pharmacy, Palakkad.
	**Athira. Ak** Eight Semester Student, Ahalia School of Pharmacy, Palakkad.
	**Geethu. P** Eight Semester Student, Ahalia School of Pharmacy, Palakkad.
	**Kanaka. V.S** Associate Professor, Department of Pharmaceutics, Ahalia School of Pharmacy, Palakkad.
	**Ranitha.R** Assistant Professor, Department of Pharmaceutics, Ahalia School of Pharmacy, Palakkad.