INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA):IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Research Article

Formulation And Evaluation Of Herbal Gel

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ARTICLE INFO

Received: 01 June 2024
Accepted: 05 June 2024
Published: 12 June 2024

Keywords:
Herbal gel, antimicrobials, antibacterial activity, polyherbal formulations.

DOI:
10.5281/zenodo.11610300

ABSTRACT

In the present study, three medicinal plants Cynodon dactylon (L.) Pers, Cassia tora Linn. and Cassia alata Linn having significant anti-inflammatory potential were selected to be formulated as polyherbal gels. The gels were prepared using the dried methanolic extract of Cassia tora Linn, Cassia alata Linn and Cynodon dactylon (L.) Pers. Polyherbal gel formulations were evaluated for its pH, appearance and homogeneity, viscosity, spreadability and skin irritation studies. Assessment of Anti-inflammatory activity was done by carrageenan induced rat paw edema and formalin- induced rat paw edema. Individual and polyherbal gel of Cassia alata Linn,Cassia tora Linn. and Cynodon dactylon(L.) Pers were found to possess anti-inflammatory effect in acute and chronic models. Polyherbal gel also showed synergistic effect as compared to individual gels which can be useful for the treatment of local inflammation. Herbal gel is a solid, jelly-like substance that can have properties ranging from soft and weak to hard and tough preparation. It is used topically for a variety of purposes, such as protectants, antiseptics, and antimicrobials. The herbal gel was made by combining Azadirachta indica, Curcuma longa, Berberis aristata, and Rubia cordifolia. Staphylococcus aureus, Pseudomonas aeruginosa, and Escherichia coli were used as test subjects for the antibacterial activity. It was shown that the herbal gel had the strongest effect on Staphylococcus aureus (Hand bacteria). To fully understand the mechanism of action and to create a formulation that can be useful in the health sector, more research is required.

INTRODUCTION

1. Herbal Medicines:-

Ever since the birth of mankind of there has been a relationship between life, disease and plants. There is no record that people in prehistoric times used synthetic medicines for their aliments but they tried to make use of the things they could easily procure. The most common thing they could find was there in environment i.e. the plants and animal World Health Organization (WHO) has defined herbal medicines are finished, labeled medicinal products that contain active ingredients, aerial or underground parts of the plants or other plant material or combination. Herbal

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

formulations have reached widespread acceptability as therapeutic agents like anti-microbial, anti-diabetic, anti-ageing, anti-arthritic, anti- depressant, anti-anxiety, anti-inflammatory, anti-HIV, treatment of cirrhosis, asthma, migraine, Alzheimer's disease and memory enhancing activities. The opoids or non-steroidal anti-inflammatory drugs, widely used to reduce the inflammation of various types, suffer from severe side effects like redness, itching etc. As a result, a search for other alternatives seems to be necessary which would be more beneficial.

Thus, an attempt was made to study the anti-inflammatory activity of individual as well as combination of extracts in a single dosage form which may show synergistic anti- inflammatory activity. Gel formulations are used to deliver the drug topically because of easy application, increase contact time and minimum side effects as compare to other topical preparation and oral administration. The plant Cassia tora and Cassia alata Linn has been found to be used traditionally for its various therapeutic properties like, Anticancer activity , Oral anti-inflammatory activity Antibacterial activity Antioxidant activity Skin disorder and wound-healing activity The plant Cynodon dactylon has been found to be used traditionally for various therapeutic properties like, antiviral activity Antidiabetic activity Antifungal activity Antibacterial activity Antioxidant activity Antiulcer activity Skin disorder and wound-healing activity.

2. Aloe Vera:-

Aloe barbadensis Miller, commonly referred to as Aloe vera, is one of more than 400 species of Aloe belonging to family Liliaceae. Aloe vera is considered the most potent and, thereby, the most popular plant in the research field. Important component in the traditional medicine of many Countries such as China, India, the West Indies, and Japan. Aloe vera is one of the most important medicinal plants in the world with applications in the cosmetic industry and also in the tonic or health drink product market. The main feature of the Aloe vera plant is its high water content, ranging from 99-99.5%. The remaining 0.5-1.0% solid material is reported to contain over 75 different potentially active compounds including water and fat soluble vitamins, minerals, enzymes, simple/complex polysaccharides, phenolic compounds, and organic acids. It has been used for many centuries for its curative and therapeutic properties and although over 75 active ingredients.

Figure 1. Aloe vera

Pharmacognostic account of aloe vera:-

Kingdom- Plantae
Order- Asparagales
Division- Spermatophyte
Subdivision- Angiospermae Class- Monocotyledoneae Genus- Aloe
Species- Barbadensis Mill
Botanical name- Aloe barbadensis miller
Synonyms- Aloe, Musabbar, Kumari
Family- Asphodelaceae (Liliaceae)

Biological source:

Aloe is the dried juice collected by incision, from the bases of the leaves f various species of Aloe.

Geographical source:

Aloes is indigenous to eastern and southern Africa and grown in Cape colony, Zanzibar and islands of Socotra. It is also cultivated in Caribbean islands, Europe and many parts of Indiaincluding North West Himalayan region. Aloe species are mostly

inhabitants of arid climates, and are widely distributed in Africa, India, and other arid areas.

Cultivation prospects:

Climate: suitable climate for its healthy growth is warm, humid, and dry weather.

Rainfall:

40-45 CM

Temperature:

30°C to 35°c

Altitude:

1000 metres above sea level

Soil requirement: sandy loam soil with good water drainage. Also grow in poor grade soil.

pH of soil-

8.5

Propagation:

root suckers or rhizome cuttings.

Time of cultivation: Towards last week of June or in month of July i.e. after first showers of monsoon.

Total duration of crop:

3-4 years.

Manures and fertilizers:

The roots do not penetrate deep into the soil, and the crop stands for 7 to 8 years after planting in the field. Hence, application of fertilizers, and manuress will help to increase the quality of crop. cow dung manure. For this purpose, mixture of 150 kg/ha. of nitrogen, potassium and phosphorus is used. Once the plants are established well, the application offertilizers near the root-system is recommended.

Irrigation:

Generally, it does not require planed irrigation. But, during dry seasons, it should be provided with protective irrigation and according to moisture content of soil, 5 to irrigations during period of one year are sufficient for the crop.

Weeding:

carried out twice a year and also, as and when it is required.

Harvesting:

The plants are harvested after 10 to 12 months of plantation or when leaves attain length of 35 to 40 cm. The drug is obtained from leaves, hence for collection of leaves, of single cut is given near the bases of leaves. In this way, the drug can be obtained from plants, for economically 3-4 years. After this plants are completely harvested by uprooting plants, manually or by using cultivator. The collected juice is then processed for the preparation of various types of aloes.

Yield:

The yield of crop on fresh weight basis is around 15000 to 18000 kg/ha. The yield of crop increases second year onwards.

Active components with its properties:

Aloe vera contains 75 potentially active constituents: vitamins, enzymes, minerals, sugars, lignin, saponins, salicylic acids and amino acids.

Chemical Constituents:-

The most important constituents of Aloes are the three isomers of Aloins, Barbaloin, - barboloin and Isobarbaloin, which constitute the so-called 'crystalline' Aloin, present in the drug at from 10 to 30%. Other constituents are amor-phous Aloin, resin, emodin and Aloe- emodin. Barbaloin is present in all the varieties; it is slightly yellow coloured, bitter, water soluble, crystalline glycoside. Isobarbaloin is a crystalline substance, present in Curacao aloe and in trace amount in Cape aloe and absent in Socotrine and Zanzibar aloe. The chief constituents of Socotrine and Zanzibar aloe are Barbaloin and-Barbaloin.

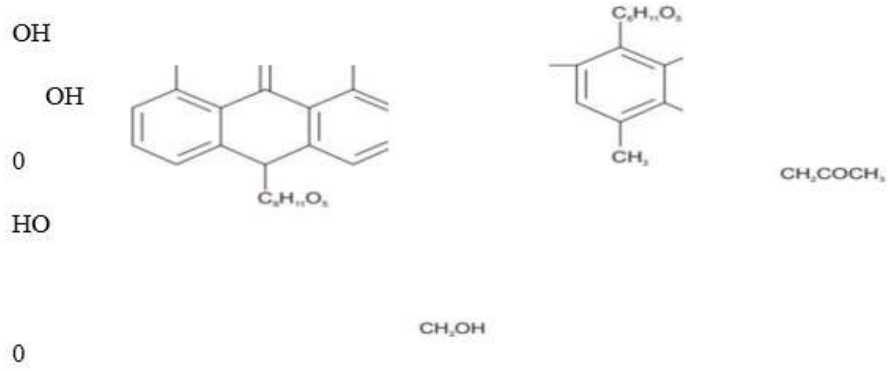


Table no. 1 Summary of the chemical composition of Aloe vera leaf pulp and exudates.

Sr. No.	Class	Components	Roles
1	Vitamins	Vitamin A(beta- carotene),C and E, Vitamin B12, Follie acid and choline.	Antioxidant, Neutralizer, Free radicals.
2	Enzymes	Aliase, alkaline phosphatise, amylase, bradykinase, carboxypeptidase, catalase, cellulose, lipase and peroxidise.	Bradykinase has anti Inflammatory property when applied topically on skin, while others help in the breakdown of sugars and fats.
3	Minerals	calcium, chromium, copper, selenium, magnesium, manganese, potassium, sodium and zinc.	Essential for the proper functioning of various enzyme systems m different metabolic pathways and few are antioxidants.
4	Sugar	monosaccharides (glucose and fructose) - mannose-6-phosphate and polysaccharides: (glucomannans/polymannose) glucomannans [beta-(1,4) acetylated mannan] Acemannan, glycoprotein, Cglucosyl chromone	antiallergic properties, called alprogen and novel anti-inflammatory compound
5	Anthraquinones	Aloe-emodin, aloetic-acid, (or emodin act as isobarbaloin, emodin, ester of cinnamic acid	Phenolic compounds anthranol, aloin A and B act as a laxatives. Aloin collectively known as barbaloin), and analgesics, antibacterials and antivirals.
6	Fatty acids	cholesterol, campesterol, P sisosterol and lupeol.	All these have anti inflammatory action and lupeol also possesses antiseptic and analgesic properties.
7	Hormones	Auxins and gibberellins	help in wound healing and have anti-inflammatory action.
8	Amino acid	Alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, hydroxyproline, isoleucine, leucine, lysine, methionine, phenylalanine, praline, threonine, tyrosine, valine	Aloe Vera Has Amino Acid several Benefits such as protein synthesis, tissue repair, and nutrient absorption.
9	Protein	Lectins, lectin-like substance	several biological roles
10	Others	salicylic acid	Anti-inflammatory

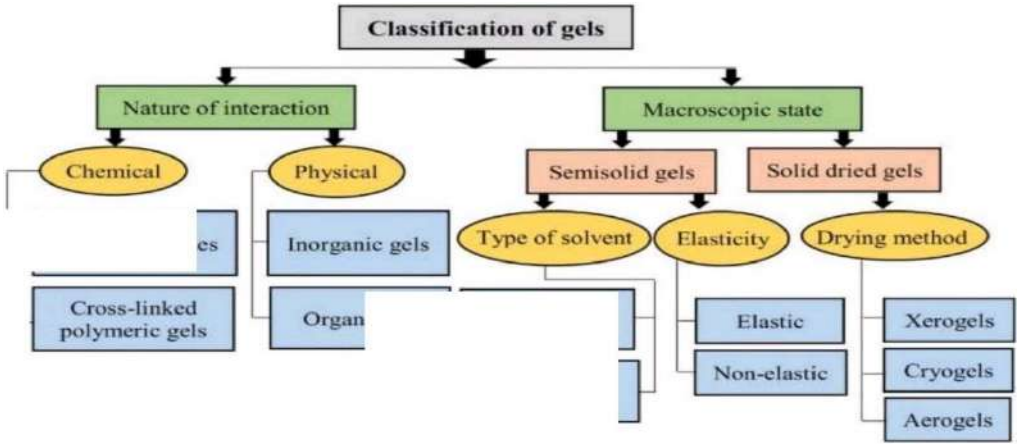
GEL

A gel is a semi-solid that can have properties ranging from soft and weak to hard and tough. Gels are defined as a substantially dilute cross-linked system, which exhibits no flow when in the steady state, although the liquid phase may still diffuse through this system. Gels are mostly liquid by mass, yet they behave like solids because of a three-dimensional cross-linked network within the liquid. It is the cross-linking within the fluid that gives a gel its structure (hardness) and contributes to the adhesive stick (tack). In this way, gels are a dispersion of molecules of a liquid within a solid medium. The word gel was coined by 19th-century Scottish chemist Thomas Graham by clipping from gelatine. The process of forming a gel is called gelation.

Gels consist of a solid three-dimensional network that spans the volume of a liquid medium and ensnares it through surface tension effects.This internal network structure may result from physical bonds such as polymer chain entanglements (see polymers) (physical gels) or chemical bonds such as disulfide bonds, see (thiomers),(chemical gels), As well as crystallites or other junctions that remain intact within the extending fluid. (Virtually any fluid can be used as an extender including water (hydrogels), oil, and air (aerogel). Both by weight and volume, gels are mostly fluid in composition and thus exhibit densities similar to those of their constituent liquids. Edible jelly is a common example of a hydrogel and has approximately the density of water.

Composition:-

Types of gels:-



Poly ionic polymers:-

Polyionic polymers are polymers with an ionic functional group. The ionic charges prevent the formation of tightly coiled polymer chains. This allows them to contribute more to viscosity in their stretched state, because the stretched-out polymer takes up more space. This is also the reason gel hardens. See polyelectrolyte for more information.

Colloidal gels:-

A colloidal gel consists of a percolated network of particles in a fluid medium, providing mechanical properties m particular the nse of elastic behaviour. The particles can show attractive interactions through osmotic depletion or through polymeric links. Colloidal gels have three phases in their lifespan: gelation, aging and collapse. The gel is initially formed by the assembly of particles into a space-spanning network, leading to a phase arrest.

Hydrogels :-

Hydrogels are highly absorbent (they can contain over 90% water) natural or synthetic polymeric networks. Hydrogels also possess a degree of flexibility very similar to natural tissue, due to

their significant water content. As responsive "smart materials," hydrogels can encapsulate chemical systems which upon stimulation by external factors such as a change of pH may cause specific compounds such as glucose to be liberated to the environment, in most cases by a gel-sol transition to the liquid state. Chemo-mechanical polymers are mostly also hydrogels, which upon stimulation change their volume and can serve as actuators or sensors. The first appearance of the term 'hydrogel' in the literature was in 1894.

Xerogels:-

A xerogel is a solid formed from a gel by drying with unhindered shrinkage. Xerogels usually retain high porosity (15-50%) and enormous surface area (150-900 m2/g), along with very small pore size (1-10 nm). When solvent removal occurs under supercritical conditions, the network does not shrink and a highly porous, low-density material known as an aerogel is produced. Heat treatment of a xerogel at elevated temperature produces viscous sintering (shrinkage of the xerogel due to a small amount of viscous flow) which results in a denser and more robust solid, the density and porosity achieved depend on the sintering conditions.

Nanocomposites hydrogels:-

Nanocomposites hydrogels or hybrid hydrogels, are highly hydrated polymeric networks, either physically or covalently cross-linked with each other and/or with nanoparticles or nanostructures. Nanocomposites hydrogels can mimic native tissue properties, structure and microenvironment due to their hydrated and interconnected porous structure. A wide range of nanoparticles, such as carbon-based, polymeric, ceramic, and metallic nanomaterials can be incorporated within the hydrogel structure to obtain nanocomposites with tailored functionality. Nanocomposites hydrogels can be engineered to possess superior physical, chemical, electrical, thermal, and biological properties.

Properties:-

Many gels display thixotropy - they become fluid when agitated, but resolidify when resting. In general, gels are apparently solid, jelly-like materials. It is a type of non-Newtonian fluid. By replacing the liquid with gas it is possible to prepare aerogels, materials with exceptional properties including very low density, high specific surface areas, and excellent thermal insulation properties.

Thermodynamics of gel deformation:-

A gel is in essence the mixture of a polymer network and a solvent phase. Upon stretching, the network cross-links are moved further apart from each other. Due to the polymer strands between cross-links act as entropic springs, gels demonstrate elasticity like rubber (which is just a polymer network, without solvent). This is so because the free energy penalty to stretch an ideal polymer segment monomers of size between crosslinks to an end-to-end distance is approximately given.

Animal produced gel:-

Some species secrete gels that are effective in parasite control. For example, the long-finned pilot whale secretes an enzymatic gel that rests on the outer surface of this animal and helps prevent other organisms from establishing colonies on the surface of these whales' bodies. Hydrogels existing naturally in the body include mucus, the vitreous humor of the eye, cartilage, tendons and blood clots. Their viscoelastic nature results in the soft tissue component of the body, disparate from the mineral-based hard tissue of the skeletal system.

Researchers are actively developing synthetically derivetissue replacement technologies derived from hydrogels, for both temporary implants (degradable) and permanent implants (non-degradable). A review article on the subject discusses the use of hydrogels for nucleus pulposus replacement, cartilage replacement, and synthetic tissue models.

Ideal properties of gel

Advantage of gel :-

- Ideally, the gelling agent must be inert, safe and cannot react with other formulation constituents.
- It should have suitable anti-microbial agent.
- The topical gel must not be sticky.
- The ophthalmic gel must be sterile.
- Advantages of gel:-
- Non-greasy application
- Being easy to formulate with active ingredients
- Adhering well to the application site
- Being washable and non-toxic
- Stability over time
- Ability to target affected area for rapid treatment and relief
- Preventing unwanted side effects through bypassing the digestive sys
- Easy spreading

Disadvantages of gel:-

- Some drugs aren't absorbed easily through the skin
- There's a possibility of an allergic reaction
- The effect of gels initiates slower (but lasts longer)
- Additives in the gel may irritate the skin
- Application site must be monitored for reactions.

Application :-

- Many substances can form gels when a suitable thickener or gelling agent is added to their formula.
- This approach is common in manufacture of wide range of products, from foods to paints and adhesives.
- Fiber optic communications, a soft gel resembling hair gel in viscosity is used to fill the plastic tubes containing the fibers.
- The main purpose of the gel is to prevent water intrusion if the buffer tube is breached, but the gel also buffers the fibers against mechanical damage when the tube is bent around corners during installation, or flexed.
- Additionally, the gel acts as a processing aid when the cable is being constructed, keeping the fibers central whilst the tube material is extruded around it.

SKIN:-

The human skin is the outer covenng of the body and is the largest organ of the integumentary system. Human skin is similar to most of the other mammals' skin, and it is very similar to pig skin. Though nearly all human skin is covered with hair follicles, it can appear hairless. There are two general types of skin, hairy and glabrous skin (hairless). The adjective cutaneous literally means "of the skin" (from Latin cutis, skin). The skin has up to seven layers of ectodermal tissue guarding muscles, bones, ligaments and internal organs

STRUCTURE:

Human skin shares anatomical, physiological, biochemical and immunological properties with other mammalian lines, especially pig skin[.IJ[2J Pig skin shares similar epidermal and dermal thickness ratios to human skin;DJ[2J pig and human skin share similar hair follicle and blood vessel pattems;DJ[2Jbiochemically the dermal collagen and elastin content is similar in pig and human skin;DJ[2Jand pig skin and human skin have similar physical responses to various growth factors. Skin has mesodermal cells, pigmentation, such as melanin provided by melanocytes, which absorb some of the potentially dangerous ultraviolet radiation (UV) in sunlight. It also contains DNA repair enzymes that help reverse UV damage, such that people lacking the genes for these enzymes have high rates of skin cancer.

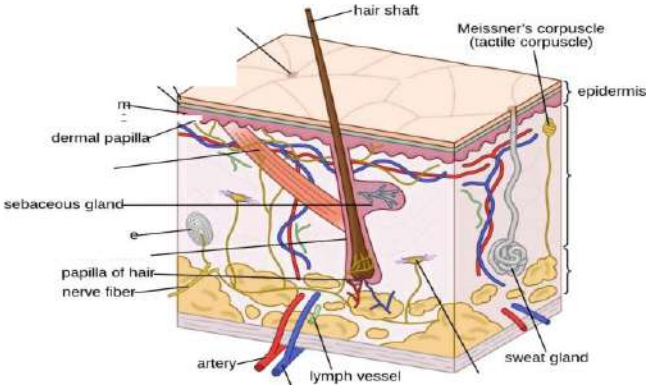


Figure 3:- Structure of skin

Epidermis

The epidermis is the strong, superficial layer that serves as the first line of protection against the outer environment. The human epidermis is composed of stratified squamous epithelial cells, which further break down into four to five layers: the stratum corneum, stratum granulosum, stratum spinosum and stratum basale. Where the skin is thicker, such as in the palms and soles, there is an extra layer of skin between the stratum corneum and the stratum granulosum, called the stratum lucidum. The epidermis is regenerated from the stem cells found in the basal layer that develop into the corneum. The epidermis itself is devoid of blood supply and draws its nutrition from its underlying dermis.

Its main functions are protection, absorption of nutrients, and homeostasis. In structure, it consists of a keratinized stratified squamous epithelium; four types of cells:

- Keratinocytes,
- Melanocytes
- Merkel cells
- Langerhans cells.

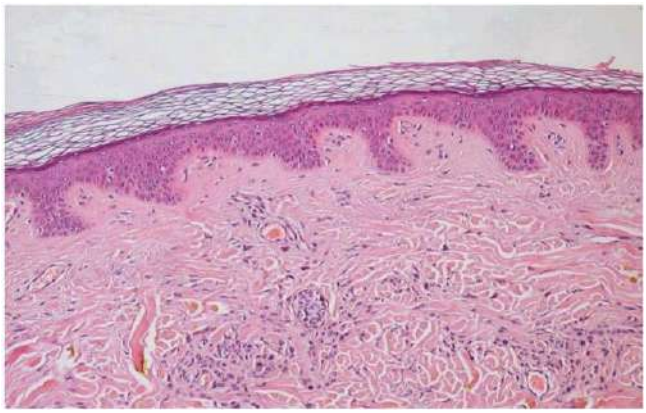


Figure 4:- Epidermis and dermis of human skin

The predominant cell keratinocyte, which produces keratin, a fibrous protein that aids in skin protection, is responsible for the formation of the epidermal water barrier by making and secreting lipids[. 61The majority of the skin on the human body is keratinized, with the exceptionof the lining of mucous membranes, such as the inside of the mouth. Non-keratinized cells allow water to "stay" atop the structure.

Sub-layers:-

The epidermis is divided into the following 5 sub-layers or strata:

- Stratum corneum
- Stratum lucidum
- Stratum granulosum
- Stratum spinosum
- Stratum basale (also called "stratum germinativum")

Dermis:-

The dermis is the underlying connective tissue layer that supports the epidermis. It is composed of dense irregular connective tissue and areolar connective tissue such as a collagen with elastin arranged in a diffusely bundled and woven pattern.

- The dermis has two layers:-
- The papillary dermis
- The reticular layer.

Papillary region:-

The papillary region is composed of loose areolar connective tissue. It is named for its finger- like projections called papillae, which extend toward

the epidermis. The papillae provide the dermis with a "bumpy" surface that interdigitates with the epidermis, strengthening the connection between the two layers of skin. In the palms, fingers, soles, and toes, the influence of the papillae projecting into the epidermis forms contours in the skin's surface. These epidermal ridges occur in patterns (see: fingerprint) that are genetically and epigenetically determined and are therefore unique to the individual, making it possible to use fingerprints or footprints as a means of identification.

Reticular region:-

The reticular region lies deep in the papillary region and is usually much thicker. It is composed of dense irregular connective tissue, and receives its name from the dense concentration of collagenous, elastic, and reticular fibres that weave throughout it. These protein fibres give the dermis its properties of strength, extensibility, and elasticity. Also located within the reticular region are the roots of the hairs, sebaceous glands, sweat glands, receptors, nails, and blood vessels. Tattoo ink is held in the dermis. Stretch marks, often from pregnancy and obesity, are also located in the dermis.

Hypodermis:-

The hypodermis, otherwise known as the subcutaneous layer, is a layer beneath the skin. It invaginates into the dermis and is attached to the latter, immediately above it, by collagen and elastin fibers. It is essentially composed of a type of cell known as adipocytes, which are specialized in accumulating and storing fats. These cells are grouped together in lobules separated by connective tissue.

FUNCTION OF SKIN:-

Protection: an anatomical barrier from pathogens and damage between the internal and external environment in bodily defence; Langerhans cells in the skin are part of the adaptive immune system. Perspiration contains lysozyme that break the bonds within the cell walls of bacteria.

Sensation:

contains a variety of nerve endings that react to heat and cold, touch, pressure, vibration, and tissue injury; see somatosensory system and haptics.

Heat regulation:

the skin contains a blood supply far greater than its requirements, which allows precise control of energy loss by radiation, convection and conduction. Dilated blood vessels increase perfusion and heat loss, while constricted vessels greatly reduce cutaneous blood flow and conserve heat.

Control of evaporation:

The skin provides a relatively dry and semi-impermeable barrier to fluid loss. Loss of this function contributes to the massive fluid loss in burns.

Aesthetics and communication:

others see our skin and can assess our mood, physical state and attractiveness.

Storage and synthesis:

acts as a storage centre for lipids and water, as well as a means of synthesis of vitamin D by action of UV on certain parts of the skin.

Excretion:

sweat contains urea, however its concentration is 11130th that of urine, hence excretion by sweating is at most a secondary function to temperature regulation.

Absorption:

The cells comprising the outermost 0.25-0.40 mm of the skin are "almost exclusively supplied by external oxygen", although the "contribution to total respiration is negligible"[. In addition, medicine can be administered through the skin, by ointments or by means of adhesive patch, such as the nicotine patch or iontophoresis. The skin is an important site of transport in many other organisms.

Water resistance: The skin acts as a water-resistant barrier so essential nutrients are not washed out of the body.

METHODOLOGY:-

- **Drug and polymeric profile:-**

Aloe vera extract: The aloe vera is the natural product . It is used in prevention and treatment of many diseases.

- **Turmeric Extract:**

The curcumin is a polyphenolic phytochemical of curcuma long. It belonging to the family zingiberaceae. The curcumin is an oil soluble pigment , practically water insoluble at acidic and neutral ph ,soluble in alkali. The melting point of curcumin is 175-180 C

- **Glycerine:**

Glycerin is also known as glycerol or glycerine . The glycerin has been a valuable ingredient for soap, cosmetic, producing food and pharmaceutical. The glycerol is a small molecule also that play a vital role in metabolism.

- **Acacia:**

Gum acacia which are obtained from branches and trunks of acacia species mainly acacia senegal and acacia seyal. Which is belonging to the family fabaceae. It is safe natural compound .

- **Vitamin C:**

It is also known as asborbic acid. Vitamin Care help to stimulate the collage synthesis and act as the antioxidant protection against UV induced photodamage Mostly vit c in skin appears intracellular compartment. Vit c found more in epidermis than in dermis.

- **Vitamin E:**

Vit e is a major lipid soluble vitamin .The vitamin E is discovered by Evans and Bioshop in 1992. It have a various important roles within the body due to its antioxidant activity. Vit Eis effective in various possible condition and diseases such as aging , cancer etc.

- **Hyaluronic acid:-**

The hyaluronaic acid is a naturally occuring polymer. It is discovered in 1934. It is used in wide range of medical field in cosmetic surgery. It is also for wound healing

- **Sodium benzoate :-**

Sodium benzoate is used as a preservative. It is also used to preserve non alcoholic carbonated beverage. It is used as a preservative for inhibit yeasts, molds and other bacterial growth in many products.

- **Experimental Procedure:-**

Raw Material: Curcuma longa (Turmeric) rhizome were collected from narayana brand variety consisting of 6% of curcumin. Solvents: ethanol or acetone or hexane.

- **Apparatus:**

Soxhlet apparatus, measuring cylinder, Distilling flask

RESULT AND DISCUSSION:-

The present work aimed to the formulation and evaluation of herbal gel. The acacia is a natural gelling agent is used in this formulation. The prepared formulation was characterized by good or smooth physical appearance, pH spreadability, Viscosity and skin irritancy.

Table:- 2 Characteristics and Observation/Result of herbal gel:

Characteristics	Observation/Result
Physical Appearance	-
Turbidity	Semi-so neutral (6.7)
Skin irritancy	Greenish yellow

The herbal gel was greenish in color and translucent in appearance and gave smooth feel on application which was maintained after tested stability study. PH also maintained through out the study which was found 6.91 to 7.0. Spreadibility was also measured and found to be less variation with the initially prepared gel after performs the stability study. The initial viscosities of developed gels were measured using Brookfield viscometer with spindle. Further stability test for three months has been carried out and results revealed gel containing 2.5% C. infortunatum showed better

stability than 5%. Initial viscosity for gel containing 2.5% and 5% C. infortunatum extract were 27390 cps and 29640 cps respectively and after stability study there were not much variation at different temperature and humidity. The gel was non-irritant upon application on to the skin. The control and experimental rabbits showed no signs of tremor, convulsion and reflex abnormalities. The food intake per day had also foundnormal during 7 days repeated dose dermal toxicity evaluation.

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HOW TO CITE: Rituraj Rajjan Singh , Somprabha Madhukar, Shruti Rathore, Formulation And Evaluation Of Herbal Gel, Int. J. of Pharm. Sci., 2024, Vol 2, Issue 6, 644-655. https://doi.org/10.5281/zenodo.11610300