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Research Article

Formulation and Evaluation of Polyherbal Antioxidant Hydrogel from Moringa

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ABSTRACT

Hydrogels are semisolid topical formulations widely used in pharmaceutical and cosmetic applications because of their excellent Spreadability, soothing effect, and enhanced patient compliance. The present study focuses on the formulation and evaluation of a polyherbal antioxidant hydrogel using Moringa extract for skin protection and wound healing support. Moringa is rich in flavonoids, phenolic compounds, vitamins, and natural antioxidants that help reduce oxidative stress and protect the skin from free radical damage. The hydrogel was prepared using a suitable gelling polymer such as Carbopol 934/940, along with humectants, preservatives, neutralizers, and purified water. The herbal extract was incorporated into the gel base under controlled stirring conditions to obtain a smooth and homogeneous formulation. The prepared hydrogel was evaluated for physical appearance, pH, viscosity, Spreadability, homogeneity, washability, extrudability, and stability. Antioxidant activity was assessed by suitable in vitro methods such as DPPH radical scavenging assay. The developed hydrogel showed good consistency, acceptable pH for skin application, excellent Spreadability, and satisfactory stability, indicating its suitability for topical use. The presence of herbal antioxidants provides additional benefits such as skin nourishment, moisturization, and protection against environmental stress. The study concludes that the formulated polyherbal antioxidant hydrogel is a promising, safe, and effective herbal topical preparation for cosmetic and pharmaceutical applications.

INTRODUCTION

Introduction to Skin

The skin is the largest organ in the human body, and it represents the exterior protective cover of the body. The skin carries out various essential roles such as protection, sensation, temperature

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regulation, elimination of waste, immune response, and prevention of water loss from the body. The skin provides the first line of defense against any pathogens, UV rays, chemicals, and environmental pollutants. The skin plays a key role in maintaining internal homeostasis in addition to being a route for the penetration of drugs into the body.

Structure of Skin

The skin structure is divided into three primary layers; epidermis, dermis, and hypodermis (subcutaneous tissue). The epidermis is the outer protective layer that consists of keratinized cells

protecting the body from pathogens, chemicals, ultraviolet radiation, and water loss. Under the epidermis is the dermis, a thick layer consisting of connective tissue containing collagen and elastic fibers, which include nerves, blood vessels, sweat glands, hair follicles, and sebaceous glands to provide strength, flexibility, nourishment, and sensory innervations to the skin. Lastly, there is the hypodermis, consisting primarily of fatty tissue (adipose tissue), providing shock absorption, insulation from cold temperatures, and an energy storage depot. These layers play a role in the protection, sensations, regulation of temperature, and absorption of topical preparations such as hydrogels and creams

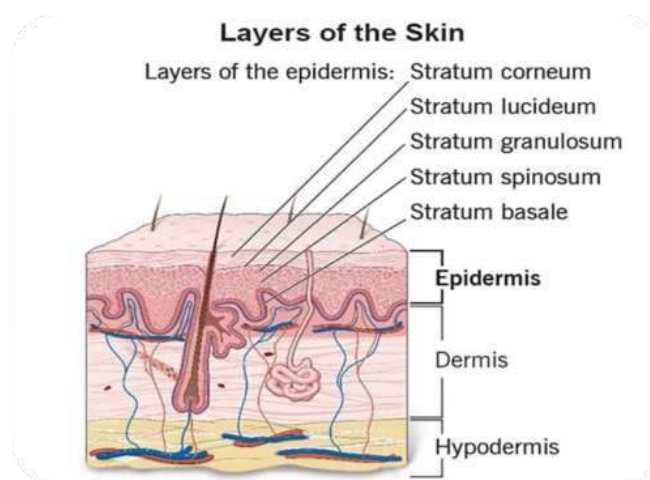


Fig no.1: - Structure of Skin

Introduction to Skin Cosmetics

Skin cosmetics are special formulations that are used to apply on the skin surface for cleansing, moisturizing, protecting, beautifying, and improving skin appearance. These cosmetics have great significance in keeping the skin healthy as they prevent drying of skin, make the skin soft, and protect the skin from external influences like dust, pollution, ultraviolet radiations, etc. Some examples of skin cosmetics are creams, lotions, gels, ointments, serums, face packs, hydrogels, etc. which usually consist of moisturizers, emollients, antioxidants, extracts of herbs, vitamins,

sunscreens, etc. Herbal skin cosmetics have gained popularity over chemical cosmetics due to the reasons that they are safer, provide natural nourishment, and cause fewer side effects.

Polyherbal antioxidant hydrogel

Polyherbal antioxidant hydrogel can be described as a sophisticated semi-solid topical preparation formulated by incorporating one or more herbal extracts with antioxidative properties in a hydrogel matrix. Polyherbal antioxidant hydrogel has various uses in pharmaceutical as well as cosmeceutical products for protecting the skin,

moisturizing, wound healing, anti-aging effect, and scavenging of free radicals. A hydrogel matrix is usually composed of synthetic or natural polymers such as Carbopol 940 that creates a clear, smooth, and non-oily hydrogel system that retains a high percentage of moisture. Antioxidants in the herbs like moringa and aloe vera help neutralize free radicals in the body, reduce oxidative stress, and protect skin from harmful effects of ultraviolet rays, pollutants, and aging effects. Hydrogels are very ideal carriers of such herbal ingredients due to spreadability, cooling effect, easy removal from the skin, extended contact with skin, and enhanced patient compliance. With hydrophilic and biocompatible properties, polyherbal antioxidant hydrogels have promising potential as topical skin care as well as herbal cosmetics preparations.

Choosing the Right Hydrogel for Your Skin Type

- 1) For Dry Skin: -Choose hydrogels with glycerin, aloe vera, hyaluronic acid, or panthenol. Provides deep hydration and long-lasting moisturization.
- 2) For Oily Skin: -Select oil-free and non-comedogenic hydrogels. Prefer ingredients like niacinamide, green tea, tea tree, or salicylic acid. Helps in sebum control. Prevents pore blockage and acne formation
- 3) For Sensitive Skin: -Use fragrance-free and alcohol-free hydrogels. Best ingredients: aloe vera, chamomile, Centella, allantoin. Provides soothing and anti-inflammatory effect. Reduces redness and irritation
- 4) For Combination Skin: -Choose lightweight hydrogels with balanced humectants. Hydrates dry areas without making oily zones greasy. Maintains skin moisture balance.

Benefits of antioxidant hydrogel

- Neutralizes free radicals and protects skin from oxidative damage.
- Prevents premature aging by reducing wrinkles and fine lines.
- Provides deep hydration and keeps skin soft and smooth.
- Gives a cooling and soothing effect on irritated skin.
- Promotes wound healing and supports tissue repair.
- Shows anti-inflammatory action by reducing redness and swelling.
- Protects skin from UV rays and pollution damage.
- Enhances the delivery of herbal antioxidant actives into the skin.



Fig no.2: - Hydrogel

2. PLANT PROFILE

a. Moringa Seed:

Moringa oleifera, commonly known as Moringa or Drumstick tree, is a highly valued medicinal plant used in Ayurveda and traditional medicine systems. The seeds of moringa are rich in bioactive compounds and are widely used for their

antioxidant, antimicrobial, and anti-inflammatory properties.



Fig no. 3: -Moringa seed

Its seeds are obtained from long pods and are known for their oil content (Ben oil) and therapeutic benefits. In traditional medicine, moringa is considered a “miracle tree” due to its multiple health benefits. The seeds are used for skin care, water purification, and pharmaceutical formulations, especially in antioxidant hydrogels

Botanical classification: -

Kingdom: Plantae

Division: Magnoliophyte

Class: Magnoliopsida

Order: Capparales

Family: Moringaceae

Genus: Moringa

Species: Moringa oleifera Lam

Common Name:

English: Drumstick Seed, Ben oil Seed

Hindi: Sahjan ke Beej, Munaha ke Beej

Marathi: Shevgyachya Biya, Shevga beej

Geographic Source of Moringa:

Native Region: Sub-Himalayan tracts of North-Western India mainly the foothills of the Himalayas in present-day Uttar Pradesh, Uttarakhand, and parts of Bihar.

Global Distribution: Moringa is now cultivated and naturalized in tropical and subtropical regions worldwide, mainly in Asia, Africa, America and other regions like Hawaii, Oceania and parts of the Arabian Peninsula.

Major Geographic Sources:

India: By far the largest producer of moringa globally. Major producing states include Tamil Nadu, Karnataka, Kerala, and Andhra Pradesh.

Africa: Countries like Kenya, Nigeria, Senegal, Zambia, and Zimbabwe are major producers.

Southeast Asia: The Philippines and Indonesia are prominent for leaf production.

Other Producers: Taiwan, Nicaragua, and Brazil are growing commercial producers.

Morphology:

Stem:

- Stem is often characterized by its rapid growth, soft wood, and distinctive, corky, whitish-gray bark.

Leaves:

- Shape- Individual leaflets are small, mostly elliptical to obovate.
- Size-The entire leaf (including the stalk) is quite large, ranging from 30-60cm long
- Texture- leaflets are smooth on top, pale and hairless underneath, but young leaves are often hairy.

- Arrangement-The leaves are alternate spiral on the branches.
- Color- Light green when young, deep green when mature.

Flowers:

- Shape- zygomorphic (bilaterally symmetrical) and have drooping, reflexed appearance.
- Color- blooms are predominantly white to creamy white.
- Petals- five unequal, thinly veined, spatulate (spoon-shaped) petals.
- Sepals- Five linear- lanceolate, greenish-white sepals.
- Flowering season- late spring/early summer (April- June) and again in late fall/early winter (Nov-Dec)

Seeds:

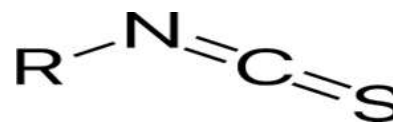
- Round or triangular, protected by brownish, semi- permeable seed hull.
- They are characterized by three whitish, papery wings that facilitate wind.

Root System:

- Moringa features a prominent, deep, and stout white taproot system, which serves as a nutrient and water storage organ.
- Seedlings develop a carrot- like tuberous main root, which later system, with roots often developing a pungent odor.

Chemical Constituents:

1. **Isothiocyanates:** Specifically in seeds, these compounds act as a strong antioxidant and antimicrobial agents.



Isothiocyanates

2. **Behenic Acid (Fatty Acid):** High concentrations are found in seed "Ben Oil" which is used as a high-quality edible oil, biofuel and in cosmetics.
3. **Niazimicin:** A potent compound present in leaves and seeds known for its anti-tumor and antimicrobial activities.
4. **4-(alpha-L-rhamnopyranosyloxy) benzyl glucosinolate:** Present in leaves and seeds, it provides anti-inflammatory benefits and helps in water purification.
5. **Quercetin and Rutin:** These powerful antioxidants are rich in leaves.
6. **Kaempferol:** A strong antioxidant found in leaves and flowers that promotes apoptosis (cancer cell death)
7. **Phenolics:** present in roots and leaves, these provide significant antioxidant and anti-cancer properties
8. **Dimeric cationic proteins:** these are used as natural flocculants in water treatment to remove impurities

Medicinal use:

1. Antioxidant & anti-inflammatory: Leaves and seeds reduce oxidative stress and inflammation.



2. Antidiabetic: Leaf powder lowers blood glucose levels.
3. Antimicrobial: Seed, bark, and root extracts active against bacteria and fungi.
4. Antihypertensive: Leaves help reduce blood pressure due to quercetin and nitrile.
5. Glycosides Cholesterol-lowering: Leaf extract reduces LDL and triglycerides.
6. Hepatoprotective: Protects liver against damage.
7. Wound healing: Leaf paste applied externally promotes healing.
8. Galactagogue: Increases breast milk production in lactating mothers.
9. Anemia: High iron content in leaves helps treat iron deficiency.
10. Water purification: Crushed seeds clarify and disinfect water due to coagulant proteins.

Other uses of Moringa:

1. Animal fodder: Leaves used as high-protein feed for cattle, goats, poultry
2. Biofuel: Seed oil suitable for biodiesel production
3. Cosmetic: used in skin creams, hair oils, perfumes due to stability and antioxidants
4. Industrial: Seed cake after oil extraction used as fertilizer or animal feed

Marketed formulation



Fig no 4: -Natural Moringa Powder Fig no 5: -Moringa &Neem face wash Fig no 6: - Moringa Tablet

b. Aloe vera:

The Aloe vera plant has been known and used for centuries for its health, beauty, medicinal and skin care properties. The name Aloe vera is derived from the Arabic word “Alloeh” meaning “meaning shining bitter substance,” while “vera” in Latin means “true” The properties includes- Healing properties, Protective effects against radiation damage to the skin, Anti-inflammatory action,

Laxative effect, Anti-tumor activity, Moisturizing, Anti-aging effect and Antiseptic effect.



Fig no.7: -Aloe vera

Botanical Classification:

- Kingdom: Plantae
- Division: Magnoliophyta
- Class: Liliopsida
- Order: Asparagales
- Family: Asphodelaceae
- Genus: Aloe
- Species: Aloe Vera
- Green to grey-green with white spots when young
- Margins have small white spiny teeth Apex acute
- Upper surface flat, lower surface convex
- Inner mucilaginous gel/parenchyma

Geographical source:

- **Native region:** Arabian Peninsula, specifically Oman, and Northeast Africa including Sudan and parts of Ethiopia.

- **Widely naturalized/cultivated now in:**

Asia: India - Rajasthan, Gujarat, Maharashtra, Tamil Nadu; China, Pakistan

Americas: Mexico, Dominican Republic, Venezuela, USA - Texas, Florida,

California Africa: South Africa, Kenya,

Mediterranean: Spain, Greece

Australia: Northern regions

Morphology:

Growth Habit: Perennial, succulent xerophytic herb with short stem or stemless

Leaves: Rosette arrangement at base

- Thick, fleshy, lanceolate, 30-50 cm long, 10 cm broad

Roots: Fibrous, shallow root system

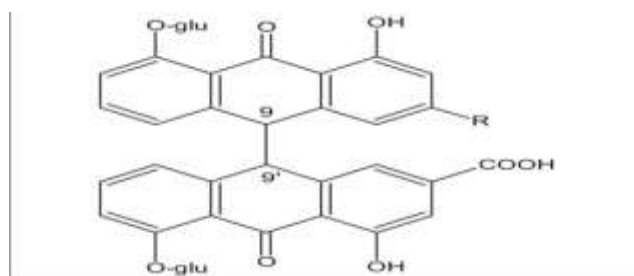
Inflorescence: Raceme on long scape 60-90 cm, flowers yellow/orange, tubular

Fruit: Triangular capsule containing numerous seeds.

Chemical constituents:

- Anthraquinone glycosides** – in yellow latex layer:

1. Barbaloin/Aloin A & B (10-30%) – main purgative
2. Isobarbaloin, Aloe-emodin, Chrysophanol



Anthraquinone glycosides

- Polysaccharides** – in inner gel

1. Acemannan – immunomodulatory, main active
2. Glucomannan, Mannose-6-phosphate

- Other constituents:**

1. Enzymes: Amylase, lipase, bradykinase, alkaline phosphatase.

2. Vitamins: A, C, E, B1, B2, B6, B12, folic acid.
3. Minerals: Ca, Mg, Zn, Fe, K, Na, Cu, Mn.
4. Amino acids: 20 out of 22 required, 7 out of 8 essential.
5. Sterols: Lupeol, campesterol, β -sitosterol – anti-inflammatory.
6. Salicylic acid – analgesic, anti-inflammatory.
7. Saponins – cleansing, antiseptic.
8. Lignin – enhances penetration of other ingredients.

Medicinal uses:

Gel - inner mucilage:

9. Wound healing & burns: Accelerates healing of 1st and 2nd degree burns, cuts, abrasions
10. Anti-inflammatory: Reduces skin inflammation, psoriasis, eczema, acne
11. Moisturizer: Used in cosmetics for skin hydration
12. Antidiabetic: Oral gel lowers blood glucose levels
13. Immunomodulatory: Acemannan stimulates macrophage activity
14. Anti-ulcer: Protects gastric mucosa

Latex - yellow sap:

15. Purgative/laxative: Strong stimulant laxative due to aloin – used for constipation
16. Emenagogue: Stimulates menstrual flow.
17. Other: Antimicrobial, Anti-arthritis, Dental

EXPERIMENTAL WORK

Requirements:

Apparatus: Beaker, Mortar pestle, Spatula, Stirrer, Measuring cylinder, Conical flask, Iodine flask, Water bath, Funnel, Petri plate.

Instrument: Weighing balance, pH meter, Mixer.

Chemicals: Triethanolamine, Carbopol 940, methyl paraben.

Formula :

Table no 1 :- Ingredients for polyherbal antioxidant hydrogel

Sr. no	Ingredients	Quantity Taken (50 gram)	Roles
1.	Moringa extract	2.5gm	Active Ingredients
2.	Aloe vera extract	2.5gm	Active Ingredients
3.	Carbopol 940	0.5gm	Gelling Agent
4.	Glycerin	4gm	Humectant
5.	Methyl paraben	0.1gm	Preservatives
6.	Triethanolamine	q. s.	Neutralizer
7.	Rose water	2.5 ml	Perfuming Agent
8.	Distilled water	q. s. to 50 gm	Solvent / vehicle

3. METHODOLOGY:

Extraction:

- 1 Collection And Authentication: Mature seed of moringa oleifera were collected from reliable source and authenticated for botanical identify. The seeds were cleaned to remove adhering dust and foreign materials.
- 2 Preparation of raw material: The collected seeds were manually dehulled to remove outer covering. The kernels were then washed with distilled water and allowed to dry under shade



at room temperature to prevent degradation of thermolabile constituent. The dried seed were coarsely powdered using a mechanical grinder and stored in airtight container until further use.

- 3 Preparation of extraction solvent: A hydroalcoholic solvent system consisting of ethanol and distilled water in the ratio of 70:30 was prepared. This solvent system was selected due to its efficiency in extracting both polar and moderately non-polar phytoconstituents.

Extraction Procedure (Maceration Technique):

1. A weighed quantity of powdered seeds material (e.g., 50g) was transferred into clean, dry conical flask.
2. To this, an adequate volume of prepared solvent (approximately 250-300 mL, maintaining a 1:5 ratio) was added.
3. The flask was tightly sealed to prevent solvent loss and kept at room temperature for a period of 48-72 hours.

4. During this period, the mixture was intermittently shaken to ensure proper interaction between the solvent and plant material, facilitating efficient extraction.

Filtration:

After completion of the extraction period, the mixture was filtered through Whatman filter paper to separate liquid extract from solid residue.

Concentration of Extract:

The obtained filtrate was subjected to solvent removal using water bath maintaining at temperature not exceeding 40-50°C to avoid degradation of active constituents.

Storage:

The final extract was transferred into an airtight container and stored under refrigerated conditions (4–8°C) to maintain its stability and prevent microbial contamination or oxidative degradation.



Fig no.8: - Extraction from moringa seed

Methodology for preparation of polyherbal antioxidant hydrogel:

Collection of Materials:

Carbopol, moringa seed extract, propylene glycol, preservatives, triethanolamine, distilled water



Preparation of gel base:

Carbopol weighed → Slowly added to distilled water with continuous stirring → Allowed to swell for 1–2 hours



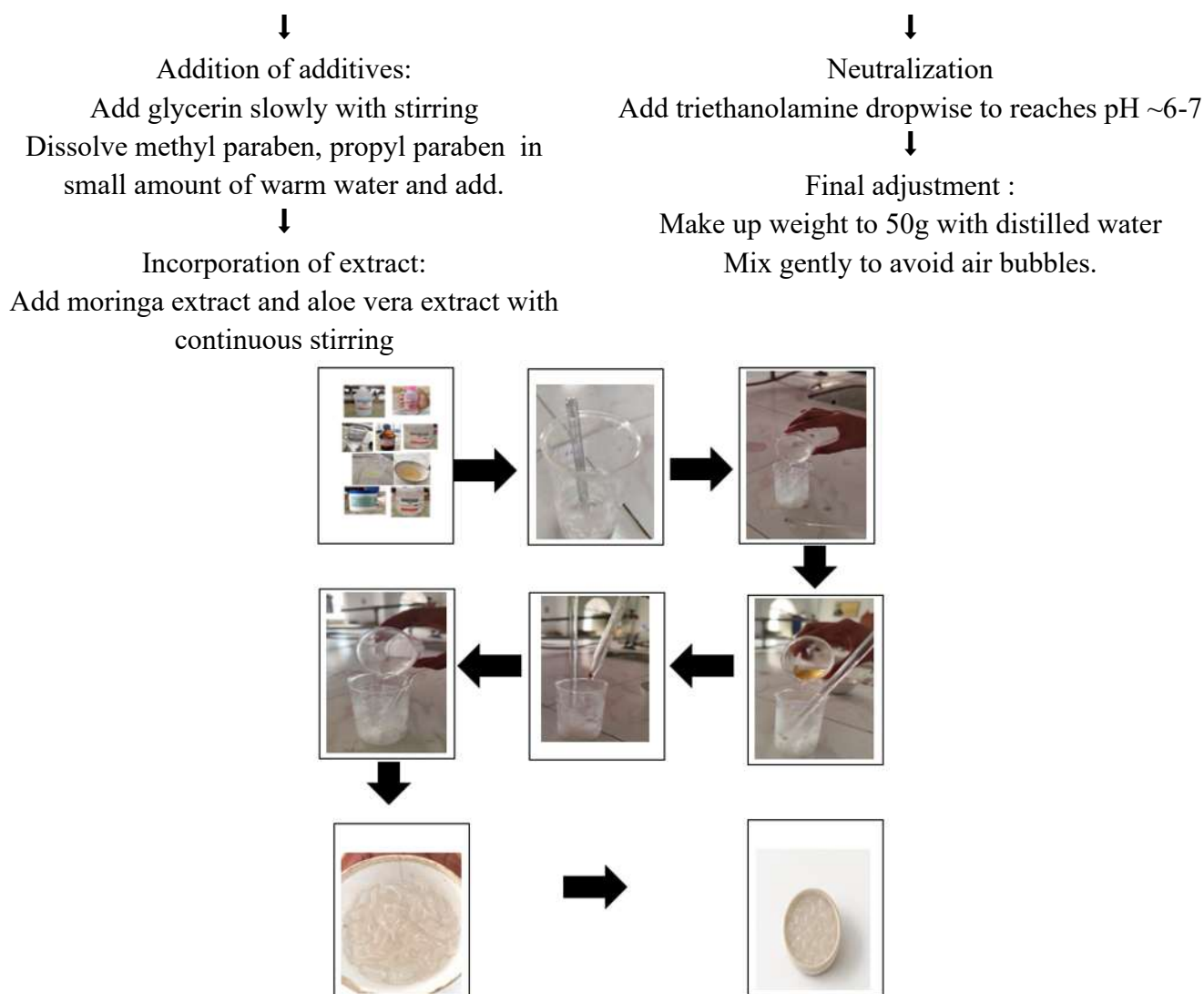


Fig no.9: - preparation of polyherbal antioxidant hydrogel

4. EVALUATION PARAMETERS

1. Organoleptic Properties:

- a) color
- b) Odor
- c) Consistency
- d) Clarity
- e) Homogeneity
- f) Appearance

2. pH Determination

3. Spreadability

4. Washability

5. Skin Irritation Test

6. Stability Study

7. Viscosity measurement

8. Antioxidant Activity

1. Organoleptic Properties: - Physical Appearance was evaluated by visual inspection.

2. pH Determination

- 1 g of hydrogel was taken and dispersed in 100 ml distilled water. The pH of hydrogel was measured by calibrated digital pH meter.

3. Spreadability



1g of hydrogel was placed between two glass slides. A weight of 500 g was placed on the upper slide for 1 minute. The diameter of the spread hydrogel was measured in cm.

$$S=ML/T$$

Where: M = Weight of upper slide

L = Length of glass slide

T = Time take

4. Washability

A measured quantity of hydrogel (around 1–2 g) was applied uniformly on a clean glass slide. The glass slide was held under running tap water for 1–2 minutes without rubbing.

It was observed whether the hydrogel was removed completely, partially, or left any residue.

5. Skin Irritation Test

The hydrogel was applied on a small area of skin. The site was observed for redness, swelling or irritation over 24–72 hours.

6. Stability Study

The formulation was subjected to stability testing under different conditions:

Room Temperature (25°C) Accelerated conditions (40°C ± 2°C / 75% RH ± 5%)

Samples were evaluated periodically for changes in pH, viscosity, color, and drug content.

7. Viscosity Measurement

The viscosity of hydrogel was determined using a Brookfield viscometer with spindle no. 64

At 10 rpm. 10 g of hydrogel was taken in a beaker and the spindle was immersed in it.

The reading was recorded after 1 minute of rotation at 25°C and expressed in centipoise (cps).

8. Antioxidant Activity

The antioxidant activity of hydrogel was evaluated using the DPPH free radical scavenging assay. A known concentration of gel extract was mixed with DPPH solution and the decrease in absorbance was measured at 517 nm.

5. RESULT

Antioxidant hydrogel containing moringa seed was formulated and evaluated successfully.

1. Organoleptic Properties:-

Table No. 2 : Organoleptic properties of hydrogel

Sr. No.	Parameter	Observation
1	Color	Light Green
2	Odor	Mild Characteristic Herbal
3	Consistency	Semi-solid gel
4	Clarity	clear
5	Homogeneity	Uniform
6	Appearance	Smooth gel

2. pH Determination:-

Observation: pH was found to be 6.25



Fig no.10: - pH testing of Hydrogel using pH meter

3. Spreadability:-

$$S=ML/T$$

Where: M = Weight of upper slide

L = Length of glass slide

T = Time taken

$$S = 20 \times 10/6 = 33.3$$

Observation: Spreadability was found to be 33.3.



Fig no. 11: - Result of Spreadability test



4. Washability

Observation:- Completely Washable (Easily washable with water)

5. Skin Irritation Test:

Observations: - There is no irritation, redness, or itching was observed on skin.



Fig no.12: - Result of skin irritancy test

6. Stability:

Table no 3 : Results of stability test

Parameter	Initial	After 15 days	After 30 days	Remark/Observation
color	Light Green	NO Change	NO Change	Stable
PH	6.5	6.4	6.5	Stable
Viscosity	32,500	32,500	32,800	Slightly Changes

7. Viscosity

Table no 4: Results of viscosity test

Trial	RPM	Viscosity(cPs)
1	10	32,500
2	10	32,500
3	10	32,800

$$\text{Average viscosity} = \frac{32,500 + 32,500 + 32,800}{3}$$

$$= \frac{97,800}{3}$$

$$= 32,600$$

Observation - Viscosity was found to be 32,600.

8. Antioxidant Activity test:

Table no 5 : Results of antioxidant activity test

Sr. no	Concentration (µg/mL)	Absorbance (517 nm)	% Inhibition
1	20	0.682	24.2
2	40	0.516	37.6
3	60	0.438	51.3
4	80	0.312	65.4
5	100	0.198	78.0

Control absorbance (A0) = 0.900

$$\% \text{Inhibition} = \frac{A_0 - A_1}{A_0} \times 100$$

Example (for 20 (µg/mL): =

$$\frac{0.900 - 0.682}{0.900} \times 100 = 24.2\%$$

Observation: The percentage inhibition of DPPH free radicals increased with increase in concentration of the hydrogel. The formulation exhibited maximum inhibition of 78.0% at 100 µg/mL, indicating significant antioxidant activity due to the presence of bioactive constituents in Moringa oleifera extract.

10. DISCUSSION:

Present research work is conducted to develop topical formulation of herbal antioxidant hydrogel containing Moringa oleifera seed extract which prevents oxidative skin damage. Hydrogel specifically targets the common skin problems related to free radicals and UV exposure by providing antioxidant protection to skin, also helps to prevent premature ageing. Antioxidant activity of Moringa oleifera seed extract is due to presence of flavonoids like quercetin, kaempferol, and phenolic acids which also act as natural skin protectants. Strength and moisturizing activity of Carbopol 940 with Glycerin provides good consistency to hydrogel so there is no problem of phase separation, homogeneous formulation with good texture is formulated.

In this formulation all ingredients are hydrophilic in nature so there is no problem of phase separation, homogeneous formulation with good consistency is formulated. The resulting hydrogel is light green in color and its evaluation like-characteristic odor, smooth texture, pH and Homogeneity indicating its quality. The formulation was satisfactory with respect to pharmaceutical elegance, Spreadability, washability and pH indicating its suitability for topical application. Thus, formulation was evaluated for antioxidant activity by DPPH assay which revealed that overall activity of hydrogel showed significant free radical scavenging property. Therefore, the result of herbal antioxidant hydrogel study revealed that overall activity of formulation was comparable to marketed antioxidant gels and found to be stable, safe and effective.

SUMMARY AND CONCLUSION:

- Study focus on formulation and evaluation of polyherbal antioxidant hydrogel containing moringa extra and aloe vera extra having antioxidant and skin protective properties.
- Hydrogel are semisolid topical preparation that provide soothing, moisturizing and colling effects on the skin and good patient acceptability.
- The prepared polyherbal hydrogel was intended to provide antioxidant activity, improve skin hydration, and protect the skin from oxidative damage caused by free radicals.
- Herbal formulation are widely preferred due to their natural origin, safety, biocompatibility, low toxicity and minimal side effect compared to synthetic preparations.



- During the formulation process, the hydrogel was evaluated for various physicochemical parameters such as appearance, color, odor, pH, viscosity, spreadability, homogeneity, washability, extrudability, and stability characteristic.
- Phytochemical screening confirmed the presence of active constituent such as flavonoids, tannins, phenolic compounds, and antioxidants responsible for therapeutic activity.
- Antioxidant activity of the formulation was evaluated by suitable in-vitro methods and the hydrogel showed satisfactory free radical scavenging activity.
- Stability studies indicated that prepared hydrogel remained stable under different storage condition without significant change in color, consistency, pH, or phase separation.
- The formulation exhibited good spreadability and consistency, which ensured easy application and better drug diffusion on the skin surface.
- Overall results demonstrated that the formulated polyherbal antioxidant hydrogel from moringa extract was safe, stable, effective, and suitable for topical application.

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