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FORMULATION AND EVALUATION OF MICROSPONGE-BASED GEL CONTAINING POMEGRANATE PEEL EXTRACT FOR TOPICAL DELIVERY

R. Balakrishnan[1]*, Dr. V. Kalvimoorthi[2], L. Gopi[3], M. Eshvandhini[3], Dr. K. Kaveri[4]

[1]M. Pharm Student, [2]Professor Cum HOD, [3]Assistant Professor Department Of Pharmaceutics, [4]Principal

Aadhi Bhagawan College of Pharmacy, Rantham, Tiruvannamalai, Tamil Nadu.

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Corresponding Author: R. Balakrishnan

Address: M. Pharm Student Aadhi Bhagawan College of Pharmacy, Rantham, Tiruvannamalai, Tamil Nadu

ABSTRACT

While chemical-based drug substances are widely used, plant-based alternatives are gaining attention for their therapeutic potential and minimal side effects. Pomegranate peel extract, known for its medicinal properties, was successfully formulated into a microsponge-based gel. Among the formulations developed, formulation F4 demonstrated the most promising results in terms of performance and stability. The average particle size of the microsponge ranged between 5–300 µm, aligning with the desired specifications. Formulation F4 exhibited a yellow appearance and achieved a high percentage yield of 88.2%, attributed to the effective use of polymer in the formulation process. In conclusion, formulation F4 represents a successful development of a stable and effective microsponge gel containing pomegranate peel extract, highlighting the potential of plant-based drug delivery systems.

KEYWORD: Pomegranate peel extract, Microsponge gel, Herbal medicine, Phytopharmaceuticals.

1. INTRODUCTION

The Microsponge Delivery System (MDS) is a patented, polymer-based delivery technology composed of porous microspheres designed for the controlled release of active ingredients. These sponge-like spherical particles feature an interconnected network of voids within a

non-collapsible structure and possess a large porous surface, which facilitates sustained drug release. The particle size typically ranges from 5 to 300 μm in diameter. For instance, a 25 μm microsponge can contain up to 250,000 pores, with an internal pore network extending up to 10 feet in length, and a total pore volume of approximately 1 mL/g—enabling substantial drug loading and retention.

The surface area of these microspheres varies between 20 and 500 m^2/g, while the pore volume ranges from 0.1 to 0.3 cm^3/g. This configuration creates a significant internal reservoir capable of holding an amount of active agent equivalent to its own weight. In topical applications, microsponges can absorb skin secretions, thereby reducing excess oil and shine. These spherical particles, composed of aggregates of even smaller spheres, can hold up to four times their weight in skin secretions. The versatility of microsponge polymers allows for the encapsulation of a broad range of active ingredients, offering improved efficacy, prolonged release, increased product stability, and better skin tolerability—making them suitable for a variety of dermatological and cosmetic applications.

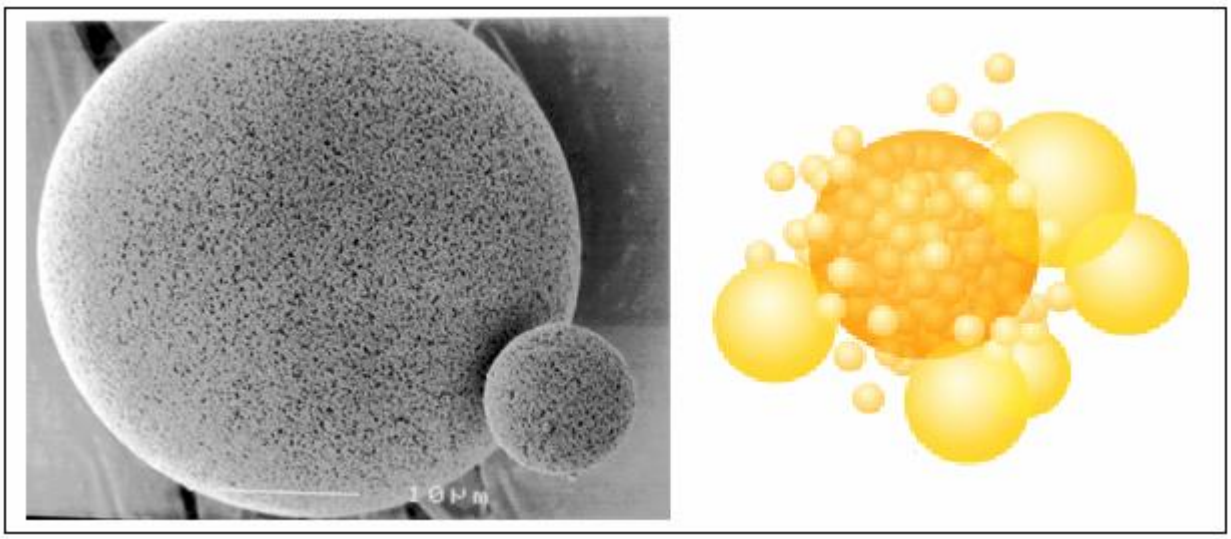


Fig. 1: Microsponges.

2. PLANT PROFILE

The pomegranate (*Punicagranatum*) is a fruit-bearing deciduous shrub in the family Lythraceae subfamily Punicoideae, that grows between 5 and 10 m (16 and 33 ft) tall. The pomegranate was originally described throughout the Mediterranean region. Pomegranates are widely cultivated throughout the Middle East and Caucasus region, north and tropical Africa, Iran, Armenia the Indian subcontinent, Central Asia, the drier parts of Southeast

Asia, and the Mediterranean Basin. P. granatum is grown for its fruit crop, and as ornamental trees and shrubs in parks and gardens. Mature specimens can develop sculptural twisted-bark multiple trunks and a distinctive overall form.

Fig. 2: Pomegranate.

2.1 Biological Source

- **Scientific Name:** *Punica granatum*
- **Family:** Lythraceae
- **Kingdom:** Plantae
- **Order:** Myrtales

Fig. 3: Pomegranate Peel.

3. MATERIALS AND METHODS

3.1 Extraction Of Pomegranate Peel

Pomegranate peels were separated and washed with tap water and subjected to drying in vacuum oven at 50 °C up to dryness under a vacuum of 700 mm Hg. The dried peels were

ground with pestle and mortar to coarse powder of approximately 1 mm size and stored in a incubator at 4 °C. 20 g of pomegranate peel powder were separately soaked in 100 ml solvents. The extract was prepared in 30 % ethanol: 70 % water. The samples were incubated at 37 °C for 24 h in a shaking incubator with 200 rpm. After this, the samples were filtered with Whatman no. 1 filter paper and filtrate was stored in the incubator at 4 °C. Finally, the extract was prepared.

3.2 Preparation Of Microsponge

The microsponges containing pomegranate peel extract were prepared by a *quasi-emulsion solvent diffusion* method using eudragit S-100, ethyl cellulose as a polymer. To prepare the inner phase, the polymer is added to ethanol and the extract solution . Polymer solution and extract solution dissolved under ultrasonication at 35 °C. This solution made inner phase. The inner phase was poured into the PVA solution in water (external phase). Following 2 h stirring at 1500 rpm, the mixture is filtered to separate the microsponges. The microsponges are dried in an air heated oven at 40 °C for 12 h and weighed to determine production yield.

Table: 1 Preparation Of Microsponge.

S. NO	INGREDIENTS	F1	F2	F3	F4
1.	Pomegranate Peel Extract (ml)	50	50	50	50
2.	Eudragit S-100 (mg)	100	80	70	60
3.	Ethyl Cellulose (gms)	0.3	0.3	0.3	0.3
4.	Ethanol (ml)	5	5	5	5
5.	PVA (gms)	0.5	0.5	0.5	0.5
6.	Distilled Water (ml)	50	50	50	50

3.3 Preparation Of Microsponge Gel

Accurately weighed amount of carbopol 940 was taken and dissloved in water using propeller. microsponge formulation containing pomegranate peel extract was added to above solution with constant stirring. This solution was neutralized by slowly added triethanolamine with constant stirring until microsponge gel is formed.

Table: 2 Preparation of Microsponge Gel.

S.NO	COMPONENTS	MG1	MG2
1.	Pomegranate Peel Extract Microsponge (gm)	Eq. to 10mg of Drug	Eq. to 10mg of Drug
2.	Carbopol (gm)	1	1.5
3.	Triethanolamine (ml)	1	1
4.	Distilled Water (ml)	100	100

3.4 Evaluation Of Microsponge Gel:

Morphology: The sample was placed in an evacuated chamber and scanned in a controlled pattern by an electron beam. Interaction of the electron beam with the specimen produces a variety of physical phenomena that, when detected, are used to form images and provide elemental information about the specimens. It was observed that the microsponges were spherical, and uniform with no drug crystals on the surface.

Surface Morphology Of Microsponges: For morphology and surface characteristics, prepared microsponges were coated with gold- palladium under an argon atmosphere at room temperature and then the surface morphology of microsponges was studied by scanning electron microscopy.

Determination Of Percentage Yield: The production yield of the microsponges was determined by calculation accurately the initial weight of the raw materials and the weight of the microsponge obtained, Production yield =(Wp/Wt) X 100 Where, Wp =Practical mass of microsponges Wt=Theoretical mass (polymer + drug)

Determination Of Encapsulation Efficiency: 10mg powder of the microsponge formulation was weighed and dissolved in 10ml of methanol under ultrasonication for 20min at 250C.then this sample was filtered and analysed at 242nm. %Encapsulation efficiency = (A/T) x 100 A = Actual amount of drug present in weighed quantity of microsponges T = Theoretical amount of drug present in microsponges.

Particle Size Analysis: Particle size analysis was performed on microsponge formulation by optical microscope.

Ph Determination Of Gel: The pH of gel was measured using a digital pH meter. The weighed amount of gel was taken and dispersed in 25ml of purified water. Then the pH of dispersion was measured using pH meter, which was previously calibrated.

Spreadability: Spreadability of gel was determined manually in which an accurate quantity of gel was weighed and then spreaded on the skin and after sometime scrapped the above gel from the skin and weighed. After subtracting the final amount of gel from the initial it was calculated that how much quantity of gel got spreaded on the skin.

Drug Content: 1 gm of pomegranate peel microsponge gel was accurately weighed and dissolved using methanol, sonicated for a period of 10-15 min and made up to the mark in 100 ml volumetric flask with methanol. From this 10 ml was pipetted out and diluted to 100 ml with methanol and the final dilution was made using distilled water to get a concentration within Beer's range. The absorbance was measured by UV spectrophotometer at 260 nm.

4. RESULTS AND DISCUSSION

4.1 Evaluation Of Microsponge Gel

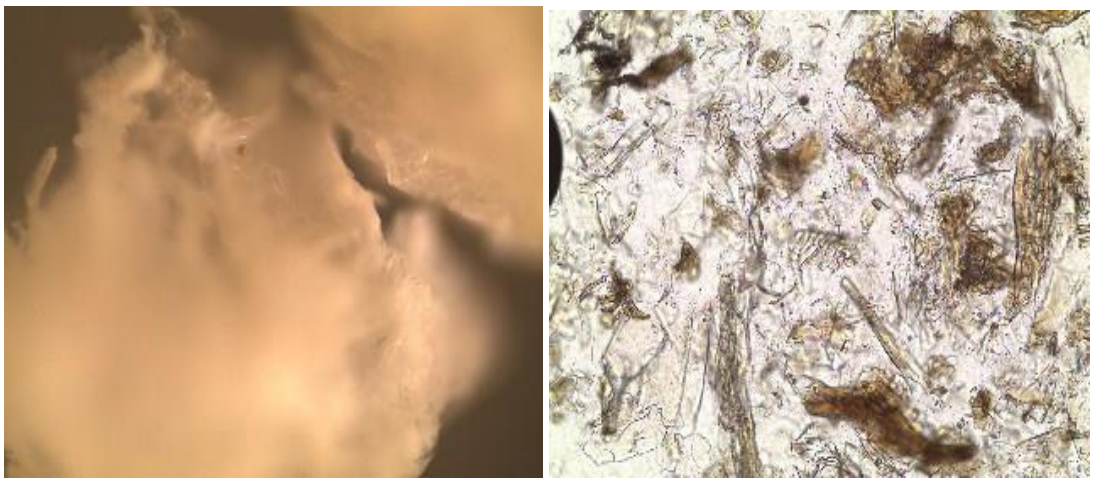
Table 3: Evaluation Of Microsponge Gel.

Formulation	Particle size	Appearance	Percentage Yield	Encapsulation Efficiency %
F1	49.27µm	Grey color	67.7%	55.5%
F2	41.60µm	Light sandle color	70.2%	62.4%
F3	51.82µm	Light yellow color	82.3%	69.6%
F4	52.55µm	Yellow color	88.2%	77.2%

Table 4: Evaluation Of Microsponge Gel.

Formulation	PH	Drug Content	Spradability	Percentage Yield
F1	7.8	79.65%	5.63	93.05%
F2	8.1	88.39%	6.69	90.98%
F3	7.4	90.31%	7.47	95.55%
F4	7.3	93.88%	6.65	98.11%

4.2 Morphology



Microsponge Microsponge Gel

Fig. 4: Microsponge Gel Morphology.

DISCUSSION

The present study focused on the formulation and evaluation of a microsponge-based gel containing pomegranate peel extract, utilizing the quasi-emulsion solvent diffusion method.

Four different microsponge formulations (F1–F4) were developed with varying concentrations of the polymer Eudragit S-100, while maintaining constant amounts of other ingredients. Among these, formulation F4 emerged as the most promising based on a range of physicochemical and performance parameters.

The morphology analysis revealed that the microsponges were spherical and uniform, with no drug crystals on their surface, indicating successful encapsulation. Scanning electron microscopy (SEM) confirmed the porous and sponge-like structure essential for sustained drug delivery.

Particle size analysis showed that all formulations fell within the optimal range (5–300 µm), with F4 exhibiting a mean particle size of 52.55 µm, which contributes to controlled drug release and better skin penetration.

The percentage yield increased as the polymer concentration decreased, with F4 showing the highest yield (88.2%), suggesting that lower polymer content can enhance the production efficiency without compromising stability.

Encapsulation efficiency also increased with decreasing polymer concentration, peaking at 77.2% in F4, possibly due to better drug entrapment in lower-viscosity polymer matrices. These results are critical because high encapsulation ensures sustained delivery and reduces wastage of the active ingredient.

The formulated microsponge gels (MG1 and MG2) were then evaluated for their pH, drug content, spreadability, and appearance. F4 again outperformed other formulations, with a drug content of 93.88%, spreadability of 6.65 cm, and pH of 7.3, which is suitable for topical application without causing skin irritation.

Spreadability is essential for patient compliance, and while F3 had slightly better spreadability (7.47 cm), F4 maintained a good balance between drug content and ease of application. All gels were within an acceptable pH range (7.3–8.1), ensuring compatibility with skin.

The data thus confirm that formulation F4 offers the best combination of drug content, encapsulation efficiency, stability, and cosmetic appeal (yellow color), making it the optimal choice for further development and potential clinical application.

5. CONCLUSION

The study successfully demonstrated the development of a microsponge-based gel formulation containing pomegranate peel extract using Eudragit S-100 and ethyl cellulose polymers. Among the four formulations tested, F4 showed superior performance in terms of encapsulation efficiency (77.2%), drug content (93.88%), and production yield (88.2%), with optimal physicochemical characteristics suitable for topical application. The pomegranate peel extract microsponge gel offers a natural, plant-based alternative for skin therapy, with benefits including controlled drug release, enhanced skin tolerability, and improved user compliance. These results support further investigation and scale-up of the F4 formulation for therapeutic or cosmetic use.

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