IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Formulation And Evaluation of Luteolin Loaded Film

Anagha Sathian, D. Deborah Evangeline, Aiswarya.S, N.L. Gowrishankar

[1]M. Pharm Student,[2]Associate Professor,[3]Assistant Professor,[4] Principal

[1,2,3]Department Of Pharmaceutics, Prime College of Pharmacy, Erattayal, Palakkad, India

Abstract: This study presents an advanced approach to the formulation and evaluation of luteolin-loaded thin films, designed to enhance bioavailability and targeted delivery of this bioactive flavonoid. Luteolin, known for its potent antioxidant and anti-inflammatory properties, faces challenges in traditional delivery methods due to its low solubility and stability. To address these issues, we developed a novel thin film matrix utilizing biocompatible polymers and advanced loading techniques. The films were characterized for their physical properties, including thickness, morphology, and drug content. *In vitro* release studies demonstrated controlled and sustained release of luteolin, while stability tests confirmed the integrity of the active compound over time. Additionally, the films exhibited favorable mechanical properties and ease of application. This innovative formulation represents a significant advancement in luteolin delivery systems, offering potential applications in therapeutic and cosmetic fields.

***Keywords*:** Luteolin, Film formulation, Luteolin Nano-encapsulation,Mechanistic studies,Polymeric film

1.INTRODUCTION

Drugs with a short half-life, limited bioavailability, and a high first pass or hepatic metabolism are good candidates for film. These are used to lower the amount and frequency of dosing, increase oral bioavailability, and minimize systemic side effects while remaining economically viable. The medication is released for systemic absorption as soon as the film breaks down. The film's enormous surface area is mostly to blame for this quick dissolving process. Because of their high vascularity and permeability, fast dissolving films can be employed sublingually, allowing for speedy absorption and action of the integrated medication. Furthermore, sublingual delivery circumvents first-pass metabolism. By taking this method, medications that experience a significant first-pass effect can have their oral bioavailability increased. Due to its low solubility, Luteolin is a naturally occurring flavonoid or natural polyphenol secondary metabolite that has limited clinical applications and low oral bioavailability. The Biopharmaceutical Classification System places Luteolin in class II drugs. Significant anti-tumor action is demonstrated by Luteolin in a variety of cancer cells, including hepatocellular carcinoma. This medication has been used as an anti-inflammatory, anti-cancer, and antioxidant[1-19]

Fig 1: Film

1.1 Features of Film

- No requirement for water
- Many different sizes and forms of films.
- Quick dissolution leads to a prompt start of action in the film.
- Accessible in a range of forms and sizes quick release

1.2 Advantages of Film[20]

- Reduce the drug's unpleasant aftertaste and increase stability
- Rapid start of action Increased bioavailability
- Better patient adherence
- Precise dosage
- No requirement for water
- Avoid first pass metabolism.
- Large absorption surface area
- No concern about choking

1.3 Disadvantages of Film

- Film stored in dry environments due to its hygroscopic nature
- Drugs with high dosages cannot be combined
- Product stability should necessitate the use of specialized packaging

1.4 Preparation of Film

1.4.1 Casting and drying:

(a) Solvent Casting
(b) Semi-solid Casting

1.4.2 Extrusion:

(a) Hot melt extrusion
(b) Solid dispersion extrusion

1.4.3 Rolling method

1.4.1(a) Solvent Casting method:

The most popular technique for creating fast-dissolving films is solvent casting. Water-soluble components are dissolved using this approach to create a transparent, viscous solution. After dissolving the medication and additional excipient in a different appropriate solvent, the mixture is combined and the trapped air is evacuated. After that, the mixture is dried and put into a Petri dish.

1.4.1(b) Semi-solid Casting method:

The semi-solid casting method is typically employed in situations where quick film formation involves the use of an acid-insoluble polymer, such as cellulose acetate butyrate, cellulose acetate phthalate, etc. The water-soluble polymer that forms the film and the acid-insoluble polymer should have a 4:1 ratio. Using the semi-solid casting process, the water-soluble film-forming polymer solution is made. Next, the insoluble polymer is mixed with the water-soluble film-forming polymer. After that, add enough plasticizer to create gel mass. The film has a thickness of between 0.015 and 0.05 inches.[21]

1.4.2(a) Hot-melt extrusion method:

The hot-melt extrusion method involves using heat to form a film from the polymeric solution. API and additional materials are combined in a dry condition and then heated in the hot melt extrusion procedure. After that, the combination is released in its molten condition without the need of a solvent. After the film is cast using the molten mass, it is sliced into the appropriate size and shape. Thermolabile substances should not be processed using this method. It is crucial to optimize both the casting speed and drying time for commercial production

1.4.2(b) Solid dispersion extrusion:

The medication is dissolved in an appropriate solvent to turn it into a solution, which is then poured into a PEG that has melted below 70℃. Melted PEG is incompatible with the drug solution, and the solvent may have an impact on the drug's polymorphic form that precipitates in a solid dispersion.[22]

1.4.3 Rolling method:

This technique involves preparing the pre-mix, adding the active ingredient, and then rolling the film to produce it. A polar solvent, a film-forming polymer, and other formulation ingredients—aside from the medicine delivered to the masterbatch feed tank—are included in the pre-mix batch. Thereafter, the first metering pump and control valve feed a predetermined amount of the masterbatch. Once the mixer is filled with the desired amount of drug, it is blended for a long enough period of time to create a homogenized matrix. The second metering pump feeds a set amount of matrix into the pan. The film is finally formed on the substrate and carried away by the support roller. The wet is dried by applying controlled bottom drying.[23,24,25]

1.4.4 Film-forming polymers:

The polymers that are used to create a film are called film-forming polymers. Hydrophilic polymers are typically utilized in the film-forming process. The concentration range between 0-40%. The strength of film depends upon the type of polymer used. Polymer used either alone or some time in combination.

1.4.5 Plasticizers:

Plasticizers used to provide flexibility to film as well as reduce the brittleness of film. The concentration ranges from 1-20%. Plasticizers improve the mechanical strength of film such as tensile strength and elongation of the films. The main function performed by plasticizer is to decrease the glass transition temperature of the polymer between 40-60˚C for the non-aqueous system and below 75˚C for the aqueous system. Optimized plasticizers are used to get better OFDF's. The selection of plasticizer depends upon its compatibility with film-forming polymer and ingredient of formulation.

1.4.6 Sweetening agents:

Sweetening agents used to mask the bitter taste of the drug. Sweetening agents used alone or sometimes in combination, concentration ranges from 3-6%. Taste is the most important factor mainly in paediatric population. Both natural and artificial sweeteners are used in fast-dissolving dosage forms. But the natural sugar is limited in diabetic patients.

1.4.7 Flavouring agents:

Flavouring agents used to provide a flavour to the formulation. Mainly used to mask the taste of the drug. The concentration of flavouring agents between 1 to 2%. The selection of flavours depends on the age group of people.

1.4.8 Superdisintegrants:

Superdisintegrants are substances or combinations of substances that are added to a formulation in order to speed up the process of disintegration after administration.

1.4.9 Colouring agents:

FD&C approved coloring agents which are incorporated up to 1% w/w.

1.4.10 Saliva stimulating agents: -

Saliva stimulating agents are the agent which increase the rate of production of saliva. the concentration ranges between 2-6%. Saliva stimulating agents added in fast dissolving film which result in fast disintegration so it can provide fast onset of action

1.5 Evaluation of film [26]

1.5.1 Organoleptic properties:

The films were evaluated for organoleptic characteristics like colour, odour and shape. Films were visually inspected for colour and shape.

1.5.2 Mechanical properties:[27,28,29]

1.5.2.1 Thickness:

Thickness is considered an important parameter because it directly related to drug content uniformity so it become necessary to assure the accuracy of the dose of the drug in film. The thickness of the film is measured by micrometre screw gauze or calibrated digital Vernier Calliper at different spot. The mean thickness was calculated and thickness of the film should be in the range of 5-200µm.

1.5.2.2 Tensile strength:

It is the maximum stress applied to a point of film at which the film starts breaking. A film should have good tensile strength. Load failureis a weight at which film break. It is calculated by the applied load at breakage divided by the cross-sectional area of the film. Tensile strength was then calculated according to the given equation:

It is the maximum stress applied to Tensile Strength = Load at failure ×100/strip thickness × strip width

$$\text{Tensile Strength} = \frac{\text{Load at failure}}{\text{strip thickness}} \times 100$$

1.5.2.3 Folding Endurance:[30]

Folding endurance indicates the brittleness of film. It was determined by repeatedly folding the film at the same place till it breaks. The number of times it can be folded without breaking gives the value of folding endurance.

1.5.2.4 Percent Elongation:

When stress is applied on the film, it starts stretching and this is referred to as strain. Strain is basically the deformation of film divide by original dimension of the film. It depends upon on the plasticizer added.

Elongation of strip increases with increases in plasticizer concentration. Percent Elongation was then calculated according to the given equation:

$$\text{Percent Elongation} = \frac{\text{Increase in length of strip}}{\text{Initial length of strip}} \times 100$$

1.5.2.5 Surface pH test:

The surface pH considered an important parameter because it can cause side effects to the oral mucosa.

Method 1- In this method, the film is placed on Petri plate and film is wet by using distilled water and the pH of the film is noted with the help of pH meter. This process is repeated for at least 6 films of each formulation and the mean is calculated.

Method 2- Prepared films was placed on 1.5% w/w agar gel and then the pH paper is placed on the film. Change in the color of pH paper indicates the surface pH of the film.

1.6 Permeation studies:

Permeability study was done by using Modified Franz diffusion along with porcine buccal mucosa. This modified Franz diffusion cell consists of a donor and a receptor compartment. There is s donor and receptor compartments and mucosa then mounted between these two compartments. Then, the receptor compartment if filled with isotonic buffer pH 6.8 and temperature maintained at 37±℃. The donor compartment contains a 1 ml simulated saliva fluid of pH 6.8. Thermodynamics was maintained by a magnetic bead stirrer at a speed of 50 rpm is used. samples were withdrawn at suitable time intervals and replaced with an equal amount of phosphate buffer from the receptor compartment. The percentage amount of drug in the receptor compartment was determined by measuring the absorbance.

1.7 Scanning Electron Microscopy:[31,32]

SEM is an important to study the surface morphology of the film between drug and different excipients. A film sample was taken and placed in sample holder and at magnification and various photomicrographs were taken using the tungsten filament as source of electron[38].

1.8 Swelling Test:

The swelling properties of fast dissolving thin film was done by using simulated saliva solution. It is determined by using following equation:

$$\text{Degree of swelling} = \frac{\text{Final weight (Wt)} - \text{Initial weight (Wo)}}{\text{Initial weight (Wo)}}$$

1.9 Percentage moisture loss:

To determine percentage moisture loss 3 films of area 2 × 2 cm^2 was taken and weighed individually. Now the films were kept in desiccators containing fused anhydrous calcium chloride and film kept in desiccator for 72hr. After 72 hr, film is weighed again and the percentage moisture loss of films was measured by using the following equation:

$$\text{Percent moisture loss} = \frac{\text{(Initial weight} - \text{Final weight)}}{\text{Initial weight}} \times 100$$

1.10 Contact angle:

Contact angle measurement determine the wetting behaviour, disintegration time, and dissolution of oral film. Goniometer is a device used to determine the contact angle (AB Lorentzen and Wettre, Germany) and the measurements should be done at room temperature. Double distilled water is used to determine the Contact angle. A drop of double distilled water is placed on the surface of dry film. Images of water droplet are recorded within 10 s of deposition with the help of digital camera. Digital pictures can be analysed by image J 1.28v software (NIH, USA) for contact angle determination.

1.11 Disintegration time:

The disintegration time limit of 30 s or less for orally disintegrating tablets described in CDER guidance can be applied to fast dissolving oral film and no official guidance is available for oral fast disintegrating films, this may be used as a qualitative guideline for quality control test. Disintegration time is determined by using disintegrating test apparatus may be used for this study. Typical disintegration time for film is 5–30s.

1.12 Dissolution test:

Dissolution test is performed by using standard apparatus give in Pharmacopoeia that is Standard Basket or Paddle apparatus. Selection dissolution medium is important and selected as per sink condition and highest dose of drug. Dissolution medium maintained at 37 ± 0.5°C temperature and rpm at 50.

2. MATERIALS AND METHODS

2.1 Chemicals

Luteolin, Hydroxypropylmethylcellulose, Methylcellulose, Mint Oil, Saccharin Sodium, Sodium Starch Glycollate, Propylene Glycol, Xanthan Gum, Disodium Hydron Phosphate, Potassium Dihydrogen Phosphate, Sodium Chloride

3. EXPERIMENTAL WORK

3.1 Preparation of Film [33,34]

Polymeric solution was obtained by dissolving HydroxyPropyl MethylCellulose and Methyl Cellulose in 20 milliliters of warm distilled water. In a polymeric solution, mint oil and saccharin sodium were dissolved. Following levigation with the necessary volume of propylene glycol, the calculated amount of sodium starch glycollate was added to the polymeric solution. After being carefully combined with the polymeric solution, Luteolin was added. As a thickening agent, xanthan gum is added. 25ml was the final volume that was adjusted using distilled water. Aluminum foil was placed over the beaker to stop the solvent from evaporating. Using a magnetic stirrer, the casting solution was gently stirred for two hours. The casting solution was then put into a petridish, left to stand for 72 hours, then the film was separated from the petridish and subjected to additional evaluation.

3.2 Evaluation of film

3.2.1 Organoleptic properties

These films were evaluated for organoleptic characteristics like colour, odour and shape. Films were visually inspected for colour and shape.

3.2.2 Physical evaluation

3.2.2.1 Weight variation

Films were taken and weight of each film. Mean weight of the film was noted.

3.2.3 Mechanical evaluation

3.2.3.1Thickness

A calibrated Digital Vernier Calliper or a Micrometer Screw Gauge can be used to measure thickness at various points. The film's thickness should fall between 5 and 200 µm, according to the mean thickness that was determined.

3.2.3.2 Folding Endurance[126]

Fold the film repeatedly in the same spot until it breaks. The Folding Endurance value is determined by the number of folds it can withstand without breaking.

3.2,3.3 Tensile strength

The point at which a film breaks is the maximum stress applied to it.[127]

3.2.3.4 Percentage Elongation

Strain is the term used to describe the stretching that occurs in a film when stress is applied. In essence, strain is the film's distortion divided by its initial dimension[128]

3.2.3.5 Surface pH test

A pH meter is used to measure the pH of the film after it has been placed on a petri plate and moistened with distilled water.

3.2.4 *Invitro* disintegration

Film was kept at 37±0.5°C with a petridish containing 25 milliliters of pH 6.8 phosphate buffer and shaken every 10 seconds.

3.2.5 Drug content

Use a magnetic stirrer to dissolve the film in 100 milliliters of Phosphate buffer (pH 6.8) for one hour. Next, spectrophotometric analysis was used to determine the drug concentration

3.2.6 Dissolution test

The USP type II dissolution apparatus was used to conduct the dissolution test. The dissolution medium consisted of 900 cc of pH 6.8 Phosphate buffer, which was kept at 37±0.5 °C with a rotation speed of 50 rpm. A double beam UV-visible spectrophotometer was used to measure the absorbance after 5 milliliters of sample were taken at regular intervals and then replaced with the same volume of new pH 6.8 phosphate buffer

3.2.7 *Ex vivo* permeation study

Goat tongue was used in *ex vivo* permeation investigation utilising a modified Franz Diffusion cell. The donor compartment, receptor compartment and sampling port make up the diffusion cell. Using Phosphate buffer pH 6.8, the receptor compartment of the diffusion cell was filled. For the purpose of stirring the buffer solution, a tiny magnetic bead was inserted into the receptor compartment. The membrane was modelled after the goat tongue. Between the donor and receptor compartments, the mucosa was mounted. A 2×2 cm^2 film that had been specially designed was applied to the goat tongue membrane. The donor chamber was then placed over it and secured with clamps. 1 ml of phosphate buffer with a pH of 6.8 was placed in the donor

compartment. The solution in the receptor compartment was continually agitated while the entire system was mounted on a magnetic stirrer. The temperature was kept at 37.5 of a degree while the solution in the receptor compartment was continuously stirred. At the appropriate intervals, 1 ml samples were taken out and replaced with fresh fluid media, and then the system was subjected to spectrophotometric analysis

3.2.8 Stability studies

The formulated films were kept in aluminium foil pouches and kept for stability studies. The stability study was performed in accelerated conditions for the period of three months as per ICH guidelines.

4.RESULTS AND DISCUSSION

4.1. Formulation of film

Table 1: List of Ingredients Used in Film Preparation

Ingredients	Quantity required
Hydroxypropyl methylcellulose	0.1g
Methyl cellulose	0.1g
Saccharin sodium	0.007g
Sodium starch glycollate	0.014g
Propylene glycol	0.04ml
Xanthan gum	Qs
Distilled water	Qs

Fig 2: Luteolin Loaded Film

4.2. Evaluation of film

4.2.1 Organoleptic properties of film

Table 2: Organoleptic Evaluation of Film

Colour	Yellowish white
Odour	Odourless
Taste	Sweet
Shape	Rectangular

4.2.2 Physical evaluation

4.2.2.2 Weight variation test

The average weight of film was found to be 1.446g

4.2.3 Mechanical evaluation

4.2.3.1Thickness

The thickness of the film was carried out using Vernier Callipers and was found to be 0.433mm.

4.2.3.2 Tensile strength

The tensile strength of the film was found to be 1.11kg/mm^2 .

4.2.3.3 Folding endurance

Folding endurance of the film was found to be 375.

4.2.3.4 Percent Elongation

The Percent Elongation of the film was found to be 6.66%.

4.2.3.5 Surface pH test

The pH was measured using digital pH meter was found to be 6.99.

4.2.3.6 Swelling index

The swelling index of film was found to be 1.76%.

4.2.4 *Invitro* Disintegration test

The *Invitro* Disintegration test was found to be 24seconds.

4.2.5 Drug content

The Drug content was found to be 99.32%.

4.2.6 Dissolution test

Table 3: *Invitro* Drug Release Profile of Film

Sl no.	Time	Percentage release
1	0	0
2	15	57.17
3	30	86.40
4	45	88.74
5	60	93.47

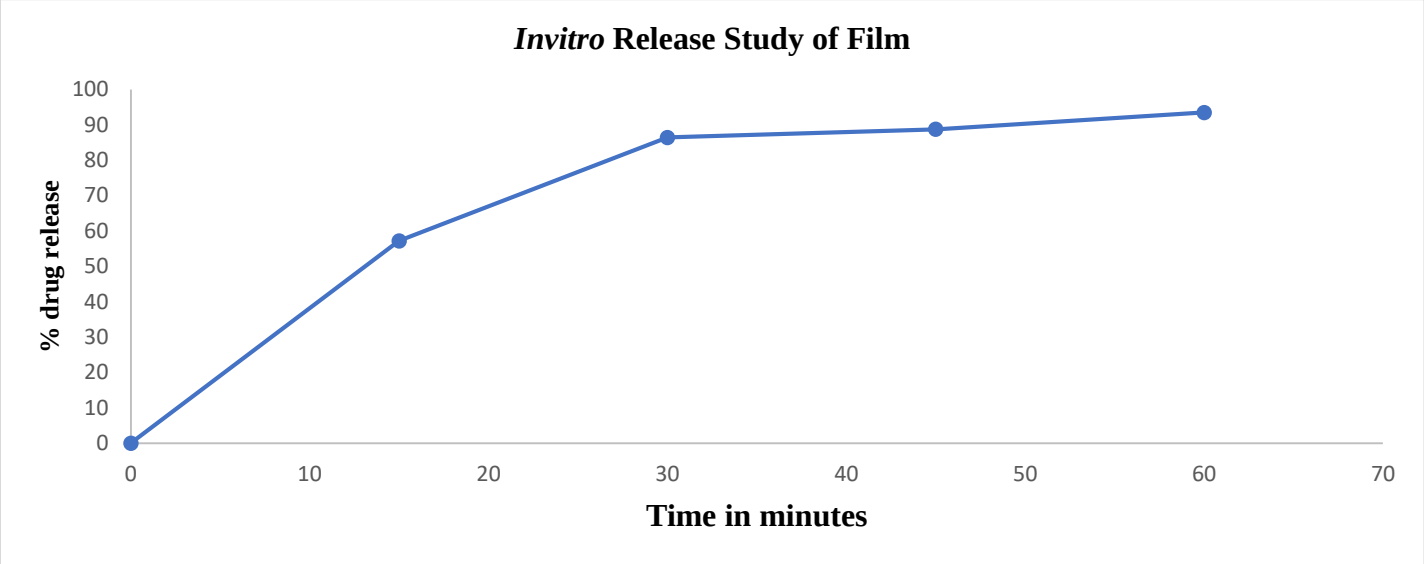

Fig 3: *Invitro* Drug Release (%) of Film

Result Analysis

The release of drug was found to be excellent which shows 93.47% release of drug in 6 hours. It indicates the rapid release of drug from film.

4.2.7 *Ex vivo* permeation

Franz diffusion cells were used to conduct ex vivo studies of film on goat tongue. The diffusion cell is composed of the sample port and donor compartment. The receptor compartment of the diffusion cell was filled with phosphate buffer (pH 6.8). To agitate the buffer solution, a small magnetic bead was placed within the receptor compartment. The membrane was designed with the goat tongue in mind. Mounting of the mucosa occurred between the donor and receptor compartments. The goat tongue membrane was covered with a specially made 2 x 2 cm film. The donor chamber was then positioned on top of it and clamped in place. The donor compartment held 1 milliliter of 6.8 pH phosphate buffer. The entire apparatus was fixed on a magnetic stirrer, which was used to continuously agitate the solution inside the receptor compartment. The temperature was kept at 37±5% of the standard degree. One milliliter of the sample was removed at the proper intervals and replaced with fresh fluid media, then spectrophotometric analysis was performed.

Fig 4: *Ex Vivo* Permeation Using Goat Tongue

Table 4: *Ex Vivo* Permeation Study of Film

Sl no.	Time in hours	Percentage drug release
1	0	0
2	1	85.05
3	2	88.2
4	3	92.2
5	4	95.4
6	5	97.2
7	6	98.1

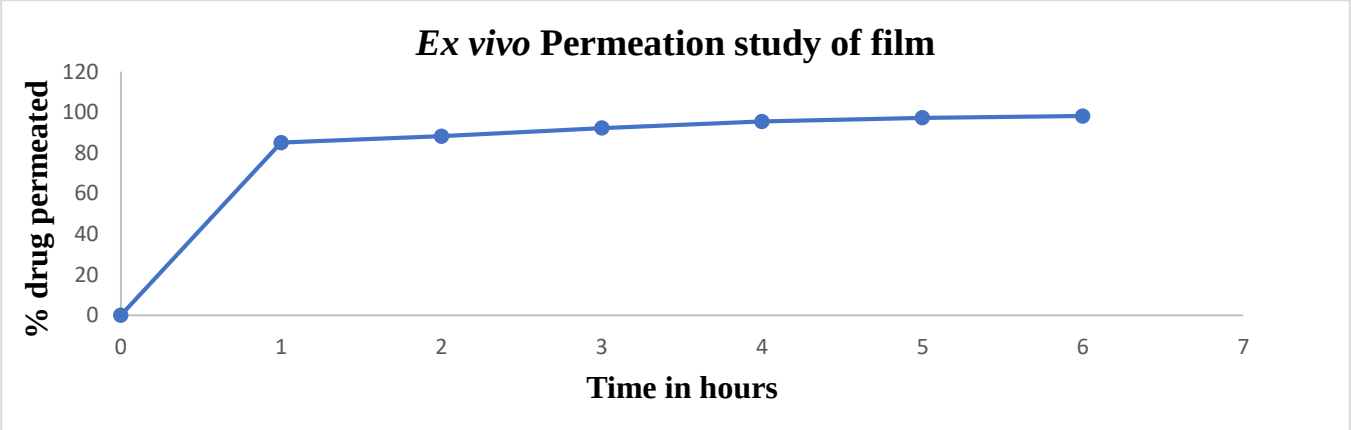

Fig 5: *Ex Vivo* Permeation Study of Film

Result analysis

Ex vivo permeation study was carried out for the film. The result showed that 98.1% drug has been permeated at the time of 6 hours. It reveals that the film has permeation through the sublingual route.

4.2.8 Stability studies

This study adheres to the ICH guidelines for stability testing, specifically ICH Q1A(R2) "Stability testing of new drug substances and products." There is no change in the physical appearance and their surface morphology.

Scanning Electron Microscopy (SEM)

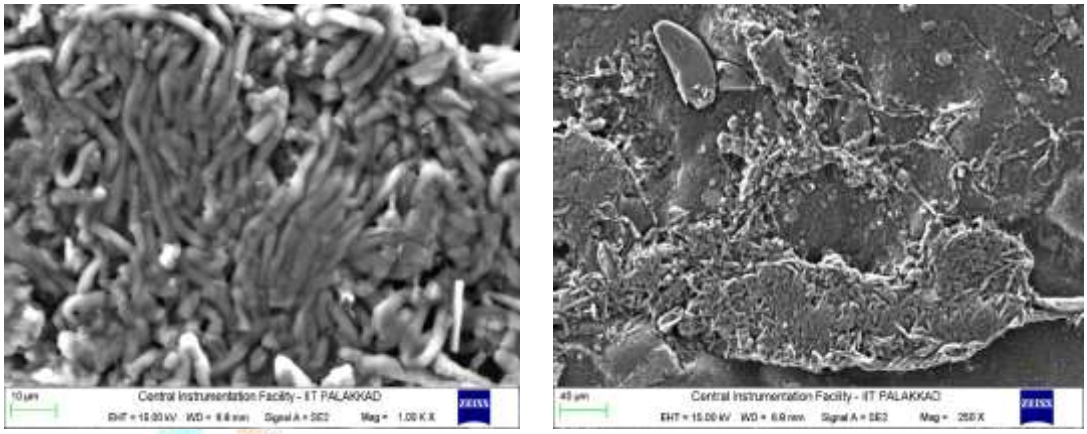

Fig 6: Scanning Electron Microscopy

Result analysis

The results confirms that the fast - dissolving film base did not show any significant changes in morphology, shape or dispersibility of the incorporated vesicles.

5. CONCLUSION

The study successfully demonstrates the potential of luteolin-loaded thin films as an innovative delivery system. The formulated films exhibited controlled and sustained release of luteolin, addressing the challenges associated with its solubility and stability. The films' favorable physical and mechanical properties, combined with their ability to maintain luteolin's integrity, highlight their effectiveness for both therapeutic and cosmetic applications. This novel approach not only enhances the bioavailability of luteolin but also paves the way for further research into optimized delivery systems for other bioactive compounds. Overall, the luteolin-loaded thin films represent a promising advancement in the field of drug delivery and formulation technology.

6. ACKNOWLEDGEMENT

We would like to thank the Management of Prime college of Pharmacy, Palakkad, Kerala for providing the facilities to carry out this research work.

7.CONFLICT OF INTEREST

Regarding the publishing of this article there is no conflict of interest.

8.REFERENCE

1. Syed Sarim Imam, Formulation and Evaluation of Luteolin-Loaded Nanovesicles: *In Vitro* Physicochemical Characterization and Viability Assessment, American chemical society (ACS publications),2022;7(1); 1048–1056.
2. Ana Cristina Puhl, Preparation and characterization of polymeric nanoparticles loaded with the flavonoid Luteolin, by using factorial design, International Journal of Drug Delivery,2011; 3 (4) 683-698.
3. Debatosh Majumdar, Luteolin Nanoparticle in Chemoprevention: *In Vitro* and *In Vivo* Anticancer Activity, American association for cancer research, 2014;7 (1): 65–73.
4. Lin, Luteolin, a flavonoid with potential for cancer prevention and therapy, 2008;8(7):634-646.
5. Lopez-Lazaro, Distribution and Biological Activities of the Flavonoid Luteolin,2009;9(1):31-59.
6. Melisa Cetinkaya, Therapeutic Potential of Luteolin on Cancer, MDPI ,2023;11(3):54-42.
7. Muhammad Imran, Luteolin, A Flavonoid, as an Anticancer Agent: A Review, Biomedicine & Pharmacotherapy (ELSEVIER),2019;112:1-10.
8. Gunter Seelinger, Anti-Carcinogenic Effects of the Flavonoid Luteolin, Open Access (MDPI),2008;13:2628-2651.
9. Fabian Gendrisch, Luteolin as a Modulator of Skin Aging and Inflammation, Open Access Journal (Biofactors),2021;47:170-180.
10. Nandakumar Muruganathan, Recent Updates on Source, Biosynthesis and Therapeutic Potential of Natural Flavonoid Luteolin: A Review, Open Access (MDPI), 2022;12(11):2-18.

11. Nan Zhang, Formulation and Evaluation of Luteolin Supersaturable Self-Nanoemulsifying Drug Delivery System (S-SNEDDS) for Enhanced Oral Bioavailability, Journal of Drug Delivery Science and Technology,2020;58:101-783.
12. Imran Kazmi, Formulation, Optimization and Evaluation of Luteolin-Loaded Topical Nanoparticulate Delivery System for the Skin Cancer, MDPI,2021;13:2-17.
13. Mohammad Javed Ansari, Formulation, Characterization, *Invitro* and *Invivo* Evaluations of Self-Nanoemulsifying Drug Delivery System of Luteolin, Journal of Taibah University for Science (Taylor and Francis),2020;14(1):1386-1401.
14. Parteek Prasher, Luteolin: A Flavonoid with a Multifaceted Anticancer Potential, Cancer Cell International (Springer),2022;22:386.
15. Maria Teresa Rocchetti, Multi-Faceted Role of Luteolin in Cancer Metastasis: emt, Angiogenesis, ecm Degradation and Apoptosis, International Journal of Molecular Sciences,2023;24:8824.
16. M. Imran, Luteolin, A Flavonoid, as an Anti-Cancer Agent: A Review, National Library of Medicine (PUBMED),2019;112:108-612.
17. Nur Aziz, Anti-Inflammatory Effects of Luteolin: A Review of *Invitro*, *Invivo* and *Insilico* Studies, National Library of Medicine (PUBMED),2018;28:342-358.
18. Kyoung Ah Kang, Luteolin Induces Apoptotic Cell Death Via Antioxidant Activity in Human Colon Cancer Cells, Journal of Oncology,2017;51:1169-1178.
19. Monika Majewska, Evaluation of Antioxidant Potential of Flavonoids: An *Invitro* Study, Drug Research,2011;4:611-615.
20. Prabhakara Prabhu, Formulation and Evaluation of Fast Dissolving Films of Levocetrizine di Hydrochloride, PUBMED Central,2011;1(2):99-104.
21. P. Narayana.Raju, Formulation and Evaluation of Fast Dissolving Films of Loratadine by Solvent Casting Method, The Pharma Innovation-Journal,2013;2(2):31-35.
22. Raj Rathore, Formulation and Evaluation of Fast Dissolving Films of Granisetron Hydrochloride, Journal of Drug Delivery and Therapeutics,2019;9(2):36-38.
23. Adithya Dinge, Formulation and Evaluation of Fast Dissolving Films for Delivery of Triclosan to the Oral Cavity, National Library of Medicine (PUBMED),2008;9(2):349-356.
24. Bhyan Bhupinder, Formulation and Evaluation of Fast Dissolving Sublingual Films of Rizatriptan Benzoate, International Journal of Drug Development and Research, 2012;4(1):97-107.
25. Prabhakara Prabhu, Formulation and Evaluation of Fast Dissolving Films of Levocetrizine di Hydrochloride, PUBMED Central,2011;1(2):99-104.
26. P. Narayana.Raju, Formulation and Evaluation of Fast Dissolving Films of Loratadine by Solvent Casting Method, The Pharma Innovation-Journal,2013;2(2):31-35.
27. Raj Rathore, Formulation and Evaluation of Fast Dissolving Films of Granisetron Hydrochloride, Journal of Drug Delivery and Therapeutics,2019;9(2):36-38.
28. Adithya Dinge, Formulation and Evaluation of Fast Dissolving Films for Delivery of Triclosan to the Oral Cavity, National Library of Medicine (PUBMED),2008;9(2):349-356.
29. Bhyan Bhupinder, Formulation and Evaluation of Fast Dissolving Sublingual Films of Rizatriptan Benzoate, International Journal of Drug Development and Research, 2012;4(1):97-107.
30. Ms.Mital, Formulation and Evaluation of Mouth Dissolving Film of Ropinirole Hydrochloride by using Pullulan Polymers, International Journal of Pharmaceutical Research and Allied Sciences,2012;1(3):60-72.
31. Apoorava Mahajan, Formulation and Evaluation of Fast Dissolving Buccal Films of Sertraline, International Journal of Drug Development and Research,2012;4(1):220-226.
32. Sumedha Bansal, Formulation and Evaluation of Fast Dissolving Film of an Antihypertensive Drug, International Journal of Pharmaceutical, Chemical and Biological Sciences,2013;3(4):1097-1108.
33. P.Narayana.Raju, Formulation and Evaluation of Fast Dissolving Films of Loratadine By Solvent Casting Method, The Pharma Innovation-Journal,2013;2(2):31-35.
34. A.Deepthi, Formulation and Evaluation of Fast Dissolving Oral Films of Zolmitriptan, American Journal of Advanced Drug Delivery,2014;2(2):153-163.