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Exploration of Banana Starch As A Sustainable Natural Excipient In Pharmaceutical Gel Preparation

Ms. Shruti D. Pawar[1*], Dr. Kiran A. Suryawanshi[2]
1.Research Student, SMBT College of Pharmacy, Nandihills, Dhamangaon, Nashik
2.Associate Professor, SMBT College of Pharmacy, Nandihills, Dhamangaon, Nashik

ABSTRACT

There is an increasing demand for natural, biodegradable and cost- effective excipients among people and companies which have encouraged the exploration of plant- based polymers in pharmaceutical formulations. Banana starch, obtained from unripe Musa species, possesses desirable physicochemical properties such as good swelling capacity, film- forming, biocompatibility, making it a promising pharmaceutical excipient. The present review looks at the formulation and development of medicinal gel using banana starch. Banana starch was isolated, purified and the parameters like pH, viscosity, swelling index, and gelatinization behavior was checked. Different concentrations of banana starch were taken to prepare gels and these gels were checked for clarity, homogeneity, pH, viscosity, spreadability, extrudability, drug content uniformity and ex-vivo drug release. The results show that the gels have properties and do not go bad easily. It showed acceptable physicochemical properties and good stability under short- term studies. Drug release studies indicated a controlled release pattern dependent on how much starch is present in the gel, due to matrix formation. The study suggests that banana starch can be used of man-made materials to make medicine gels. Banana starch is good for the environment, not poisonous and easy to get. This makes it suitable for use, in medicine delivery systems like gels you put on your skin. The banana starch gel can be a way to deliver medicine through the skin. It has potential to be used for making types of medicine gels.

Keywords: Banana starch, Pharmaceutical gel, Natural polymer, Anti- inflammatory gel, Plant-based excipient, topical drug delivery

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INTRODUCTION

Excipients are really important in medicine. They help make the medicine stable control how it is released and make it easier for patients to take. For a time man-made materials like carbopol, polyethylene glycol and polyvinyl alcohol have been used in gel medicines. However people are now worried about how these materials affect the environment, their toxicity and how expensive they are. This has made researchers look into using excipients instead. (1)

Natural polymers derived from plant sources are biodegradable, biocompatible, non- toxic, and economical. Among them, starch is one of the most widely used natural polymers in pharmaceutical formulations. Natural materials from plants are good for the environment safe, for people and not too expensive. It comes from plants and is used in many pharmaceutical products. Starch is biodegradable, biocompatible, non-toxic and economical. That is why starch and other natural polymers are being used more and more in medicine, like maize and potato starch are commonly employed, starch obtained from banana (Musa species) has recently gained attention due to its high starch content and functional properties.(1), (2)

Unripe bananas are rich in starch and are abundantly available in India. Utilization of banana starch not only provides natural alternative to synthetic polymers but also supports sustainable pharmaceutical development. This review focuses on the potential of banana starch as natural excipient in pharmaceutical gel preparation, with particular emphasis on its application in anti-inflammatory topical gels.

Banana Starch as a Natural Pharmaceutical Excipient

- Source of Banana Starch

  Banana starch comes from bananas that are not ripe yet these are green bananas of the Musa species. When bananas are green they have a lot of starch in them. As the bananas get ripe the starch in the banana turns into sugar. The bananas grown in India are really good due to their wide availability and high starch yield. The use of banana starch as a pharmaceutical excipient offers multiple advantages such as:

- Natural origin
- Non- toxicity
- Low cost
- Biodegradability
- Renewable resource
- Sustainable resource

These properties make banana starch suitable for use in various pharmaceutical dosage forms, including gels.(3)

MATERIALS AND METHOD

Extraction of Banana Starch

Banana starch is commonly extracted using a simple aqueous extraction method, which is suitable for laboratory- scale research. Banana starch is made from unripe bananas that are peeled and sliced. These bananas are then mixed with water to make a sort of liquid. This liquid is filtered to get rid of the parts and then it is left to sit. The starchy part that settles at the bottom is collected, washed a lot and dried at a temperature that is controlled. This starch is then turned into a powder and then stored in containers that are airtight.

This way of making banana starch does not use any chemicals, making it good for use as an excipient where it's important to be safe and simple.

Physiochemical Properties of Banana Starch Important For Gel Formulation

When making a pharmaceutical gel, certain physicochemical properties of banana starch are particularly important which have to be considered:

1. **Swelling Index**

   Banana starch is really good at absorbing water when it is in a liquid. This helps the starch particles to make a kind of network that's important for making gel. (4)(5)

2. **Viscosity**

   When banana starch with water and made an aqueous dispersion, it exhibit suitable viscosity, which increase with starch concentration which helps to make gels that easily get extruded and are easy to spread. (5).

3. **pH Compatibility**

   Banana starch mixed with water usually has a level that is close to neutral which means it is gentle on skin and good for putting on the skin.

4. **Gel- Forming Ability**

   When banana starch is heated and mixed with water it starts to break down and turn into gel. This makes it a great natural ingredient for making gels that are used in medicine. (4)(6)

These properties indicate that banana starch is suitable for gel formulations without the need for use of chemical modification to change it.

Role of Banana Starch in Pharmaceutical Gel Preparation

Pharmaceutical gels are semi- solids where the medicine is mixed into a special kind of material forming a polymeric matrix. This material is very important because it helps control how thick the gel is, how the medicine gets out and how long it lasts. Banana starch functions in gel formulation by:

- Absorbing water and swelling, that starts gel formation
- Formation of continuous gel matrix to hold the drug uniform
- Providing viscosity and structural integrity to maintain consistency
- Controlling drug release through matrix diffusion

Compared to synthetic polymers, banana starch offers a safer and more eco- friendly alternative. Moreover, banana starch has many advantages over synthetic or semi- synthetic polymers like carbopol, HPMC etc. for one thing starch is biodegradable, non- toxic. It is economical, and eco-friendly. Literature shows that starch-based gels we can see that they have some good qualities. Starch-based gels can be thick and easy to spread. They can also release drugs in a controlled way, which's very important. Patients tend to like them when they are made properly. Starch-based gels are an option because they have these advantages. (2), (7)

Anti- Inflammatory Gel Formulation Using Banana Starch

Anti-Inflammatory drugs are usually made into gels to work just on the area that needs it and not affect the whole body that is to give localized action. Banana starch is a choice for making these gels because it is natural and gentle, on the skin, which makes people more likely to use it.

Formulation Rational

In this formulation, banana starch is what makes the gel creating a matrix that holds the Anti-Inflammatory drug, (Diclofenac sodium) evenly throughout. We can use different amounts of banana starch to change its viscosity which helps control how fast the drug is released. If we use a banana starch in low the gel is soft and the drug comes out quickly. If we use banana starch in high concentration the gel is thicker and gives sustained release.

Table 1: Composition of gels:

Ingredients	F_1 (5%)	F_2 (7.5%)	F_3 (10%)	S (HPMC standard)
Diclofenac sodium	1 g	1 g	1 g	1g
Banana Starch	5 g	7.5 g	10 g	-
HPMC	-	-	-	2g (2%)
Methyl paraben	0.2 g	0.2 g	0.2 g	0.2g
Propyl paraben	0.06 g	0.06 g	0.06 g	0.06g
Propylene glycol (PG)	5ml	5ml	5ml	5ml
Triethanolamine(TEA)	q.s.	q.s.	q.s.	q.s.
Alcohol	5ml	5ml	5ml	5ml
Purified water	Upto 100 ml	Upto 100 ml	Upto 100 ml	Upto 100 ml

Evaluation parameters of the prepared gels

The three formulations with different concentrations of banana starch (5%, 7.5%, and 10%) were analysed using standard physicochemical and performance parameters commonly employed for topical semi solid dosage forms. The procedures were done as per the methods reported in pharmaceutics literature.

1. **Appearance (visual inspection)**

   The prepared gels were looked for color, transparency, consistency, homogeneity, and presence of any particles or if the gel is showing phase- separation. A small amount of gel was pressed between the thumb and index finger to see the consistency and smoothness.

   A small amount of gel was placed against a black and white background under adequate lighting to determine the clarity. There were no lumps, grittiness, or phase separation indicated uniform dispersion of drug and excipient.(8)

2. **Determination of pH**

   The pH of the gels was checked using a pH meter that was calibrated. 1 Gram of gel was mixed in 100 milliliters of distilled water. The meters electrode was put into the mixture and the pH was noted at room temperature. The gel pH was measured this way to get a reading for each sample. (8)

3. **Viscosity**

   Viscosity of the gel formulations was determined using a Brookfield viscometer equipped with a spindle no. 64. The measurement was carried out at room temperature at 20 rpm.(8)

4. **Spreadability**

   Spread ability was determined by slip and drag method using to glass slides.

   The spread ability was calculated using the formula:

   Where: S= spread ability, M=weight tied to upper slide, L= length moved by slide, T= time taken (9)

5. **Extrudability**

   Extrudability was checked by filling gel into an aluminum tube and how much gel came out of the tube when applied pressure was measured.

6. **Skin irritation test**

   This test was conducted on human volunteers to assess the suitability of the gels for topical use. For each formulation, the test was performed on three volunteers. About 1 g of gel was applied to the skin near the wrist over an area of approximately 2 square inches and observed for any signs of redness, irritation or lesions.(9)(10)

We made a calibration curve using solutions of Diclofenac sodium. We used amounts of Diclofenac sodium. 0.2, 0.4, 0.6, 0.8 and 1.0 micrograms, per milliliter. Then we measured how much light was absorbed by each solution at 276 nanometers using UV- Visible spectrophotometer.

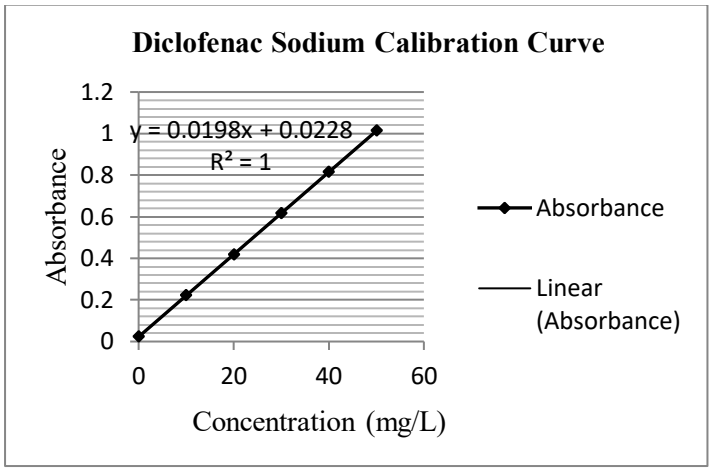

Figure 1: Diclofenac Sodium Calibration Curve

The goat skin was used for ex- vivo drug permeation study which was mounted on a Franz diffusion cell. The receptor compartment was filled with phosphate buffer (pH 7.4) and the temperature maintained at 37 ± 0.5˚C. 1% w/w Diclofenac sodium was used in each formulation. A measured amount of gel was applied to the donor compartment.

Samples from banana starch gel formulations (5%, 7.5% and 10%) were withdrawn at 5, 10, 15, 30 minutes, 1 hour and 2 hour, to 7 hours. And cumulative percentage drug release was calculated.(10)

For comparative evaluations, physicochemical parameters and ex- vivo drug release study for HPMC based gel were compiled from published literature. The values represent commonly reported ranges under similar experimental conditions.(11)(12)

RESULTS AND DISCUSSION

Table 1. Evaluation and Characterization of Formulated

Parameters	**F_1 (5%)**	**F_2 (7.5%)**	**F_3 (10%)**	**HPMC**
Appearance(colour)	Brown	Brown	Brown	Colourless
Homogeneity	Good	Very good (no lumps)	Poor (lumps)	Very good (No lumps)
pH (mean± SD)	6.22±0.2	6.39±0.1	6.6±0.2	6.0 – 7.0
Viscosity (cP)	745±0.23	973±0.3	1198±0.12	5,000- 25,000
Spread ability (g.cm/sec)	10-12	5.5- 8	3.2- 5	4- 6
Extrudability	Very good	Good	Fair	Very good
Skin irritation	No irritation	No irritation	No irritation	No irritation
%CDR	28.81±0.2	87.78±0.2	82.93±0.3	70- 80

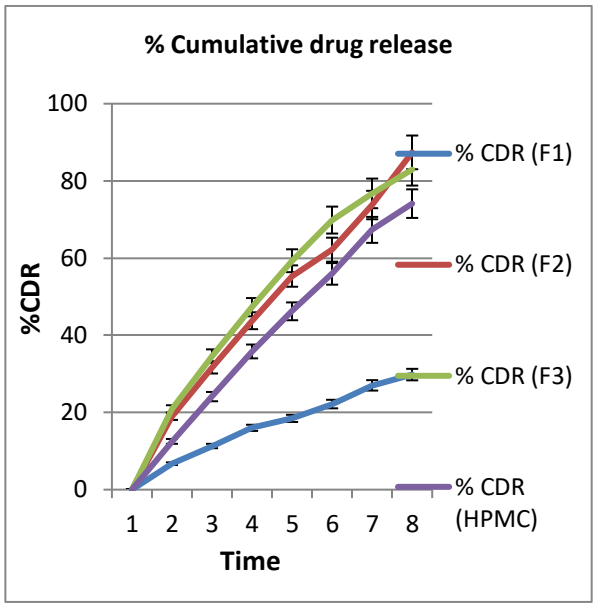

Table 3: Comparative Physicochemical Evaluation of Banana Starch Gel and Standard Hydroxypropylmethylcellulose

All prepared gel formulations were evaluated for physicochemical and performance characteristics. The results showed that the properties of the gel were significantly influenced by the concentration of the gelling agent. The 5% formulation exhibited low viscosity and very high spread ability, which may result in poor retention at the application site and rapid drug release. In contrast, the 10% formulation showed excessive viscosity, reduced spread ability, and difficulty in extrusion, which may affect patient compliance. The 7.5% gel demonstrated optimum consistency, good homogeneity, acceptable pH within the skin- compatible range, smooth extrudability, balanced spread ability. Ex- vivo drug release studies indicated controlled and sustained drug diffusion from the 7.5% formulation compared to very slow release from 5 % gel due to weaker solid matrix to help the drug move out and slower release from 10% gel due to higher matrix. (13)Studies have shown that banana starch- based gels exhibit acceptable physicochemical characteristics and controlled drug release behavior, indicating their suitability for topical anti- inflammatory applications.

Comparison with Hydroxypropyl Methylcellulose (HPMC)

The comparative evaluation of banana starch gel and Hydroxypropyl Methylcellulose gel showed that both types of gels possess suitable properties for topical drug delivery. Banana starch gel exhibited good viscosity, better spreading ability, and faster drug release, which can be beneficial for achieving quick therapeutic action. Additionally, its natural origin provides suitable biodegradability, biocompatibility, and cost- effectiveness compared to semi- synthetic HPMC.

Although HPMC gel showed more controlled drug release and clarity, banana starch gel displayed comparable performance with the added benefits of being eco- friendly and easily available.

Therefore, the optimized banana starch gel can be considered a promising alternative to polymers like HPMC for topical pharmaceutical gel formulations.(14)(15)

Parameter	Banana starch (7.5%)	HPMC
Nature	Natural polymer	Natural polymer
Viscosity	Moderate, balanced	Moderate
Spread ability	Good	Decreases with concentration
Drug release	Controlled	Sustained
Sustainability	Highly Biodegradable, eco- friendly	Slow biodegradable

CONCLUSION

Banana starch that comes from unripe bananas which is really good for making pharmaceutical gels. It works well because it has good swelling ability, it is thick and can form a gel. Banana starch is biocompatible making it suitable for topical drug delivery systems, particularly anti-inflammatory gels. The use of banana starch supports sustainable pharmaceutical development because it means we do not have to use many man- made polymers.

Although further studies are required for large- scale application and long- term stability, banana starch shows significant potential as an effective and eco- friendly pharmaceutical excipient.

(16)

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