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Formulation of *Aloe vera* based curcumin topical gel and its *in-vitro* evaluation

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Abstract: Curcumin is a polyphenolic compound obtained from the rhizome of plant. Curcuma longa possesses antioxidant, anti-inflammatory, and wound-healing properties. The current study was designed to formulate an Aloe vera-based curcumin topical gel. To enhance curcumin's solubility, it was first complexed with β-cyclodextrin, given its hydrophobic nature. While Carbopol, carboxy methyl cellulose and guar gum were used in various concentrations as gelling agents for preparation of the formulations. The effect of propylene glycol as a permeation enhancer was also observed. The prepared formulations were tested for different parameters such as physical appearance, spreadability, drug content, pH, viscosity and *in-vitro* permeation. All the formulations were found to be stable. All formulations consisting of propylene glycol showed permeation within the range of 80-90%. The maximum percentage of drug release was observed in the formulation containing 1% Carbopol 940 as the gelling agent which also exhibited good spreadability. In comparison to gels formulated with carboxymethyl cellulose and guar gum, Carbopol 940 gels appeared more translucent. Consequently, it was concluded that curcumin's permeation improved following its complexation with β-cyclodextrin. This complex when further used for the formation of an aloe vera based topical gel with 1% Carbopol 940 and 10% propylene glycol demonstrated maximum efficacy.

Keywords: Topical, hydrogel, permeation enhancers, curcumin, *Aloe vera.*

INTRODUCTION

Topical drug delivery systems involve the direct application of pharmaceutical dosage forms to the skin (Sharadha *et al*., 2020). Topical drug delivery is an advantageous methodology for the treatment of various skin or cutaneous problems. Topical route of drug delivery system provides therapeutic effect after application on skin(Barone *et al*., 2020, Umar *et al*., 2020, Singhvi *et al*., 2019). Various topical dosage forms exist such as powders, ointments, creams, gels, and lotions. Topical gel formulations are suitable dosage forms due to their non-greasy nature and ease of removal from the skin (Navarro-Partida *et al*., 2021). For drugs efficiently and effectively to the target site, other delivery methods besides oral and parenteral have been investigated by formulation scientists in response to advancements in pharmaceutical technology (Roberts *et al*., 2021, Parmar *et al*., 2021, Krishnan and Mitragotri, 2020). Effective medication administration includes the prompt and efficient delivery of medicines to the site of action (Vaneev *et al*., 2021, Kim *et al*., 2020). Skin is the largest organ of the body that acts as a barrier against toxins, microbes, and ultraviolet radiation (Munir *et al*., 2023). It inhibits the water and electrolytes lost from the body by protecting skin and efficiently processes metabolism, excretion, immunology, temperature regulation, and sensation (Hew *et al*., 2016, Waqar *et al*., 2023). Structurally, the skin has three layers including epidermis, dermis and subcutaneous tissue. Between these layers, junction structure hinders the transport of biomolecules (Bader and Worsley, 2018).

Selection of natural active ingredients are more likely to use over synthetic ones regarding the safety and efficacy of drug by overcoming the side effects (Waqar *et al*., 2022). Variety of formulations are designed by using the natural sources (Ghumman *et al*., 2022a, Ghumman *et al*., 2022b, Noureen *et al*., 2022). *Aloe vera* is a succulent plant from the Liliaceae family. It is predominantly composed of 99.5% water due to which it is widely used in formulations to provide soothing and moisturizing effects (Sánchez *et al*., 2020). The colorless mucilaginous gel from *Aloe vera* leaves has been extensively used with pharmacological and cosmetic applications. These studies have revealed that *Aloe vera* and its major compounds (aloesin, aloin and emodin) exert their protective action mainly through antioxidant and anti-inflammatory mechanisms. (Hęś *et al*., 2019) Curcumin also known as diferuloylmethane is a natural polyphenol (Ternullo *et al*., 2019) obtained from the rhizome of *Curcuma longa*. It has remarkable antioxidant, antimicrobial, and anti-inflammatory properties (Mansouri *et al*., 2020). The topical delivery of curcumin seems to be more advantageous in providing a localized effect in skin diseases (Waghule *et al*., 2020).

The primary aim of this research was to formulate a topical gel consisting of natural substances i.e., *Aloe vera* and curcumin considering their rare side effects. *Aloe*

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vera based gel possesses a hydrophilic polymeric matrix. High water content makes these topical gels highly biocompatible and non-greasy. However, loading of hydrophobic drugs into the hydrophilic polymer matrices is a major challenge. In the case of *Aloe vera*-based gel, which serves as a hydrophilic polymeric matrix, incorporating hydrophobic curcumin into the aloe vera matrix presents a particular difficulty. Thereby, an approach to increase the compatibility of gels with hydrophobic drug has been designed involving the formation of an inclusion complex with cyclodextrins. Curcumin was complexed with β-cyclodextrin to enhance its solubility. β-cyclodextrin was preferred due to its ideal cavity size, cost-effectiveness and easy accessibility.

MATERIALS AND METHODS

The research material included Curcumin, *Aloe vera*, β-Cyclodextrin, Carbopol 940, guar gum, carboxymethyl cellulose, methyl paraben, propyl paraben, glycerine, and distilled water. All of which were of analytical grade.

Pre-formulation studies

The pre-formulation study involved constructing a calibration curve of curcumin. For this purpose, serial dilutions were prepared from a stock solution of 1mg/ml concentration of curcumin. The absorbance of these prepared dilutions was then observed with the help of a UV spectrophotometer at a wavelength of 425nm.

Formation of curcumin B-cyclodextrin complex

The kneading method was used at two different ratios for the preparation of the curcumin β-cyclodextrin complex. Accurately weighed quantities of curcumin and β-cyclodextrin in a proportion 1:1 and 1:2 was triturated in a mortar and pestle with ethanol: water (25:75) solution for 45 minutes. As a result, a slurry was formed which was then dried in a hot air oven at 45ºC for 24 hours. The dried complex obtained was then pulverized and sifted through sieve no 120.

Solubility studies of curcumin B-cyclodextrin complex

A comparative study was conducted between the solubility of the inclusion complex and curcumin in water with the help of a UV visible spectrophotometer. The concentration was determined using a regression equation.

FTIR analysis

FTIR analysis was performed to verify the formation of the inclusion complex between curcumin and β-cyclodextrin. The complex was then also compared with curcumin and β-cyclodextrin individually.

Collection of Aloe vera

Aloe vera was purchased from the local food market of Lahore, Pakistan. *Aloe vera* leaves were obtained from the plant and washed with water for 15 minutes and rinsed with distilled water. They were longitudinally dissected using a sterile knife. The parenchymatous cells containing the mucilage/gel were separated and homogenized in a mixer. 1% benzoic acid was added as a preservative to this gel to preserve it for further use. Any lumps were removed prior to using it in the preparation of the formulation.

Preparation of the topical gel

Different gel preparations (table 1) were prepared by the cold dispersion method. The polymers i.e., Carbopol 940, guar gum, and carboxy methyl cellulose were soaked overnight in quantities of sufficient distilled water. Measured quantities of *Aloe vera* extract were added. The pH of Carbopol gels was adjusted using triethanolamine. These aloe vera gels were used as a gel base for the preparations. These gels were vortexed to remove any lumps. Curcumin β-cyclodextrin complex was dissolved in a sufficient quantity of distilled water and then incorporated into the formulated gels. To these formulations required quantity of glycerine was added. Propylene glycol was then added as a permeation enhancer. Methyl and propylparaben were added to the formulations as preservatives by dissolving in distilled and heating at 70ºC in a water bath. The formulated gels were than stirred vigorously to ensure uniform mixing.

Characterization of the topical gels

Organoleptic evaluation

The formulated gels were evaluated for their colour, grittiness, greasiness and homogeneity. Visual assessment was conducted for all formulations to check their colour. Grittiness was evaluated by rubbing the gels between the thumb and index finger. Greasiness was determined by their application to the skin. The presence of any lumps or aggregates was observed both visually and microscopically.

pH

A digital pH meter was used to determine the pH of all gel formulations. The digital pH meter was set to the pH mode and the temperature was adjusted to 25°C. The electrodes were rinsed with deionized water prior to being placed in the gel sample to be tested. The pH displayed on the digital pH meter was noted. The electrodes were rinsed with deionized water and dried each time prior to measuring the pH of the next sample.

Drug content

To determine the drug content of the test formulations, an accurately weighed quantity of the gel was dissolved in ethanol and filtered through a Whatman's filter paper. Measured quantity of this solution was transferred to a 10mL volumetric flask for the preparation of a dilution similar to the standard solution. Ethanol was used for the making of volume. A UV spectrophotometer was then used at a wavelength of 425nm to check the absorbance of the dilutions made, through which the drug content was calculated.

Viscosity

A Brookfield viscometer was employed to measure the viscosity of the topical gel. For this measurement, spindle 4 was selected. The chosen spindle was immersed in the gel sample, and the torque needed to rotate the spindle at a predetermined speed was determined. As torque is directly proportional to the amount of viscous sample resistance exerted on the spindle, it offered an evaluation of the product's viscosity, reported in centipoise units (cP).

Spreadability

Glass slides were used for the measurement of the spreadability of the topical gel formulations. For this purpose, a glass slide was taken and marked with a circle of 2cm diameter, and 0.5g of the gel was spread on it. Meanwhile, another glass slide was placed on top of the first slide. A weight of 500 grams was placed on these slides for a duration of 5 minutes. Following the removal of the weight, the diameter of the gel after spreading was determined.

In-vitro skin permeation studies

In-vitro skin permeation studies were performed on the topical gels with the help of a Franz diffusion cell. 6.8 phosphate buffer was used as media whereas, the temperature of the cell was kept constant at 37±2ºC in a water bath. A dialysis membrane was placed between the receptor and donor compartment of the Franz diffusion cell. Approximately, 1g of gel was introduced through the donor compartment and samples were drawn from the cell at various time intervals mainly 15 minutes,30 minutes, 1, 2, 3, 4, 5 and 6 hours. Every sample withdrawn was replaced with an equal quantity of fresh media. These samples were then observed in the UV-visible spectrophotometer at an appropriate wavelength.

FTIR studies

FTIR spectroscopy is a technique that employs infrared light to determine chemical characteristics in required samples. Infrared radiation is passed through the sample and as a result, some of it is absorbed, transmitted or reflected from the sample. The absorbed radiation is transformed into vibrational or rotational energy. The resulting signal at the detector produces a spectrum, which displays the sample's molecular fingerprint.

Skin irritation studies

A skin irritation test was carried out to evaluate any irritation or discomfort associated with the use of the prepared gels. For this purpose, three human volunteers were selected for each gel. Approximately 0.5g of the gel was applied to the back of the hand and then the area of application was visually inspected for any signs of redness. The volunteers were questioned for experiencing any sort of irritation or discomfort.

Ethical approval

The Institutional Animal Ethical Committee, University of Central Punjab, Lahore, Pakistan, authorized the experimental protocols for conducting the animal studies.

STATISTICAL ANALYSIS

Statistical analysis of One-way Analysis of Variances (ANOVA) was employed for the evaluation of the release data. Level of confidence interval was set to 95%.

RESULTS

Pre-formulation studies

Calibration curve of curcumin

The absorbance of the prepared dilutions (table 2) of specific concentrations of curcumin were observed in the UV spectrophotometer. The concentrations and absorbance were plotted on the x-axis and y-axis respectively. R^2 value was calculated to be 0.998.

Solubility studies of curcumin B-cyclodextrin complex

The solubility of curcumin and curcumin complexes is shown in table 3 and fig. 2 describes the graphical manner of the solubility of curcumin and its complexes.

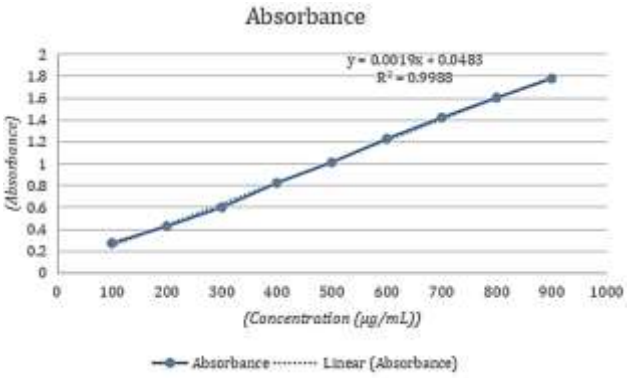

Fig. 1: Calibration curve of curcumin

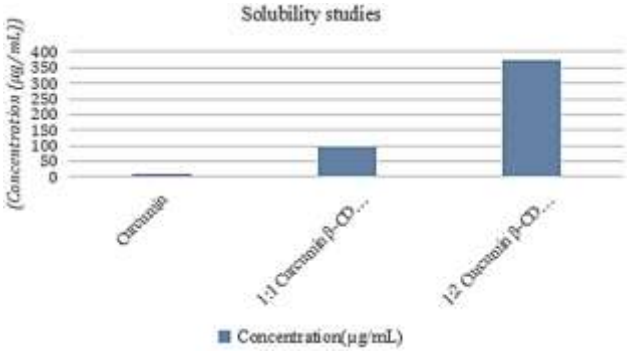

Fig. 2: Solubility studies of curcumin, 1:1 curcumin β-cyclodextrin complex and 1:2 curcumin β-cyclodextrin complex.

FTIR analysis

FTIR spectrum of curcumin (fig. 4) exhibited different peaks at 3286cm^{-1} and 3513cm^{-1}. These peaks indicate the

phenolic O-H stretching as mentioned by Rachmawati (Rachmawati *et al*., 2013). Another sharp band observed at 1597cm^{-1} was attributed to the presence of the aromatic ring of curcumin. FTIR spectrum of β-cyclodextrin (fig. 3) showed peaks at 2854cm^{-1} and 1650cm^{-1}.

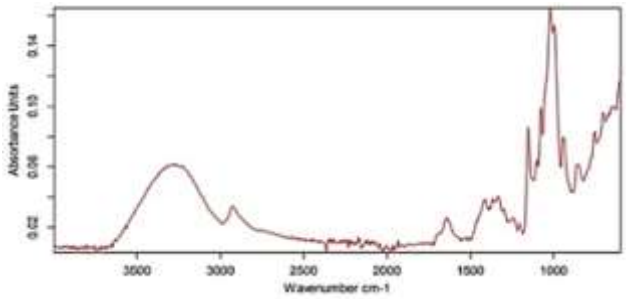

Fig. 3: FTIR spectrum of β-Cyclodextrin

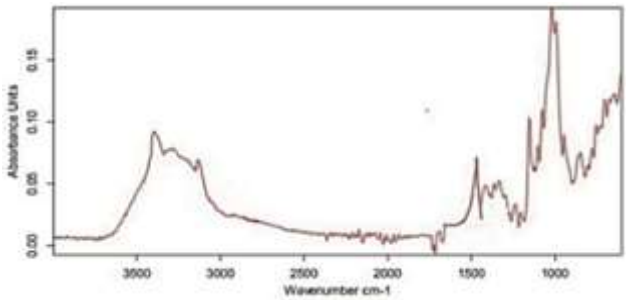

Fig. 4: FTIR spectrum of curcumin

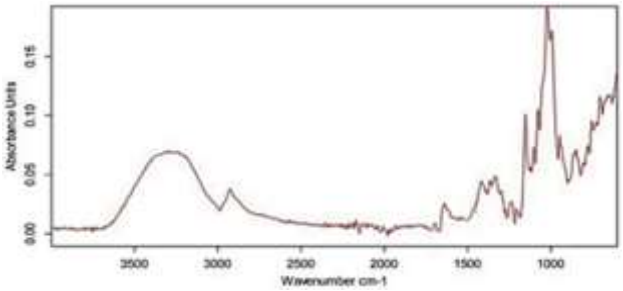

Fig. 5: FTIR spectrum of curcumin β-Cyclodextrin complex

As mentioned in the study conducted by Abarca (Abarca *et al*., 2016) the peak at 2854cm^{-1} indicates the C-H stretching while the peak at 1650cm^{-1} was associated with the H-O-H deformation bands of water present in the β-cyclodextrin. The FTIR spectrum of the curcumin β-cyclodextrin inclusion complex (fig. 5) was similar to the FTIR spectrum of β-cyclodextrin observed by Mangolim (Mangolim *et al*., 2014). The distinctive peaks of curcumin particularly the one at 1597cm^{-1} disappeared upon complexation with β-cyclodextrin. Rachmawati (Rachmawati *et al*., 2013) elucidated that the disappearance of this peak is attributed to the encapsulation of curcumin's aromatic ring within the hydrophobic cavity of β-cyclodextrin, resulting in hydrophobic interactions between the two entities.

Fig. 6: Appearance of the formulated topical gel

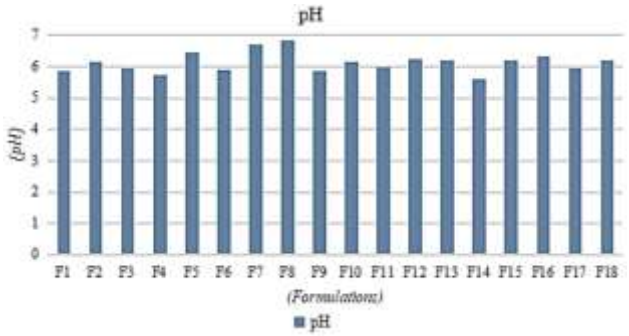

Fig. 7: pH of all the topical gel formulations

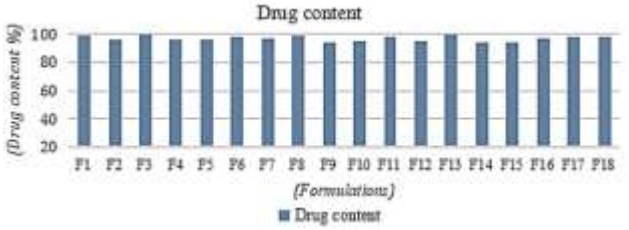

Fig. 8: Percentage drug content of all formulations

The FTIR spectrum of β-cyclodextrin showed a peak at 2854cm^{-1} due to C-H stretching. O-H stretching was observed by the presence of a peak at 3285cm^{-1}. C-O stretching vibration was observed at 1077cm^{-1}. A peak at 1023cm^{-1} represented the C-O-C stretching vibrations (Niu *et al*., 2019).

FTIR spectrum of curcumin exhibited peaks at 3286cm^{-1} and 3513cm^{-1} indicating phenolic O-H stretching. The peak at 1597cm^{-1} corresponded to the stretching of the aromatic ring of curcumin (Ismail *et al*., 2014).

The FTIR spectra of the complex had peaks belonging to β-cyclodextrin. Characteristic peaks of curcumin especially the absorption band at 1597cm^{-1} disappeared indicating that the ring of curcumin was enveloped within the β-cyclodextrin cavity bound by hydrophobic interactions (Mangolim *et al*., 2014).

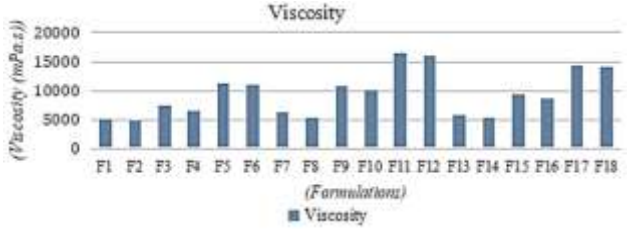

Fig. 9: Viscosity of all the formulations

Table 1: Formulation design of topical gels, q.s (quantity sufficient), CMC (Carboxymethylcellulose)

Formulations	Cur β-CD complex (g)	Carbopol 940 (g)	CMC (g)	Guar gum (g)	Aloe vera (mL)	Glycerine (mL)	Propylene Glycol (mL)	Methyl paraben (g)	Propyl paraben (g)	TEA (mL)	DW (mL)
F1	3	1	-	-	20	5	10	0.1	0.1	q.s	q.s
F2	3	1	-	-	20	5	-	0.1	0.1	q.s	q.s
F3	3	1.5	-	-	20	5	10	0.1	0.1	q.s	q.s
F4	3	1.5	-	-	20	5	-	0.1	0.1	q.s	q.s
F5	3	2	-	-	20	5	10	0.1	0.1	q.s	q.s
F6	3	2	-	-	20	5	-	0.1	0.1	q.s	q.s
F7	3	-	3	-	20	5	10	0.1	0.1	q.s	q.s
F8	3	-	3	-	20	5	-	0.1	0.1	q.s	q.s
F9	3	-	3.5	-	20	5	10	0.1	0.1	q.s	q.s
F10	3	-	3.5	-	20	5	-	0.1	0.1	q.s	q.s
F11	3	-	4	-	20	5	10	0.1	0.1	q.s	q.s
F12	3	-	4	-	20	5	-	0.1	0.1	q.s	q.s
F13	3	-	-	1	20	5	10	0.1	0.1	q.s	q.s
F14	3	-	-	1	20	5	-	0.1	0.1	q.s	q.s
F15	3	-	-	1.5	20	5	10	0.1	0.1	q.s	q.s
F16	3	-	-	1.5	20	5	-	0.1	0.1	q.s	q.s
F17	3	-	-	2	20	5	10	0.1	0.1	q.s	q.s
F18	3	-	-	2	20	5	-	0.1	0.1	q.s	q.s

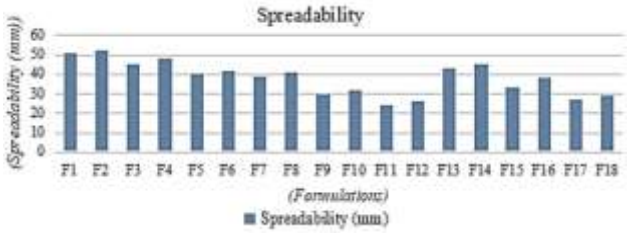

Fig. 10: Spreadability of all topical gel formulations.

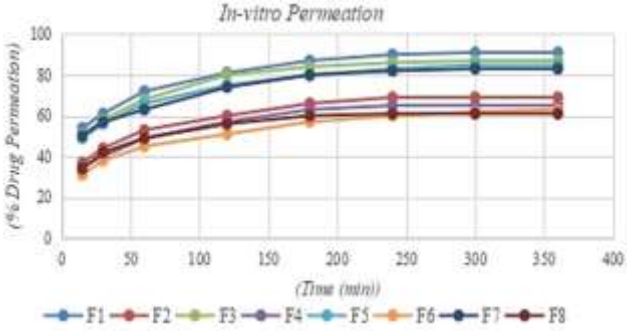

Fig. 11: Graphical representation of the % drug permeation from F1, F2, F3, F4, F5, F6, F7 and F8 at 15, 30, 60, 120, 180, 240, 300 and 360 minutes.

Organoleptic evaluation

Table 4 represents the organoleptic features of the prepared gel and prepared lipogel has been shown in fig. 6.

pH

pH of the human skin is known to be slightly acidic ranging from 4.5 to 6.8 (Hahnel *et al*., 2017). The minor acidification of the epidermis of the skin was first described as an acid mantle, by Schade and Marchionini. This acid mantle acts as a barrier preventing bacterial colonization (Kuo *et al*., 2020). A very high pH can cause irritability, dehydration, and alteration in the normal flora of the skin. pH of all the formulations (fig. 7) was between 5.62 to 6.81 which is in compliance with the pH of the skin (Tarun *et al*., 2014).

Table 2: Absorbance values of serial dilution with different concentrations of Curcumin

Concentration (µg/ml)	Absorbance
100	0.269
200	0.423
300	0.596
400	0.819
500	1.007
600	1.222
700	1.416
800	1.598
900	1.773

Drug content

The drug content of all formulations was between 90 to 100% as shown in fig. 8, meeting the specifications outlined by the United States Pharmacopoeia (USP). This study depicted that formulated gels are capable of offering drug content uniformity, hence convenient for topical application. The results demonstrated a uniform distribution of curcumin within the gels with negligible drug loss during the formulation process (Shiva *et al*., 2021).

Table 3: Aqueous solubility of curcumin and inclusion complexes of curcumin

Concentration (µg/ml)		
Curcumin	Cur β-CD complex (1:1)	Cur β-CD complex (1:2)
9.2	96.9	374.5

Table 4: Organoleptic Evaluation of Gel

Colour	Yellow
Grittiness	No grittiness
Greasiness	No greasiness
Homogeneity	No aggregates or lumps

Table 5: Percentage drug permeation of F1, F2, F3, F4, F5, F6, F7, F8 and F9 at 15, 30, 60, 120, 240, 300 and 360 minutes

% Drug permeation									
Time (min)	F1	F2	F3	F4	F5	F6	F7	F8	F9
15	54	37	51	35	49	31	50	34	46
30	61	44	58	40	56	38	57	42	51
60	72	53	68	49	66	45	63	49	60
120	81	60	80	57	75	51	74	56	67
180	87	66	84	63	80	57	80	60	72
240	90	69	86	65	83	60	82	61	78
300	91	69	87	65	85	62	83	61	80
360	91	69	87	65	85	63	83	61	80

Table 6: Percentage drug permeation of F11, F12, F13, F14, F15, F16, F17 and F18 at 15, 30, 60, 120, 180, 240, 300 and 360 minutes

% Drug permeation									
Time (min)	F10	F11	F12	F13	F14	F15	F16	F17	F18
15	31	44	29	54	40	50	30	48	36
30	36	50	35	64	46	56	43	51	42
60	42	56	40	70	51	64	49	59	47
120	51	65	47	77	57	71	54	68	53
180	57	71	53	81	60	79	60	75	57
240	60	76	57	85	64	83	63	80	62
300	62	79	59	87	67	84	65	82	63
360	62	79	59	87	67	85	65	83	63

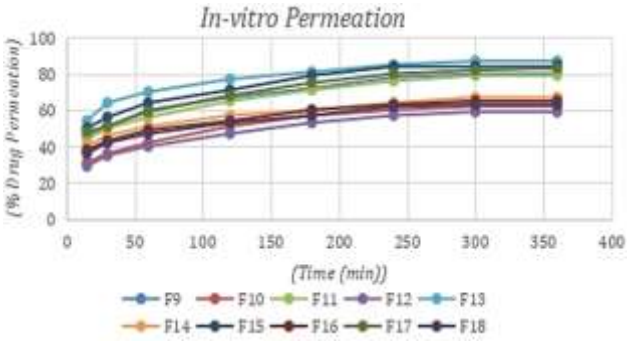

Fig. 12: Graphical representation of % drug permeation from F9, F10, F11, F12, F13, F14, F15, F16, F17 and F18 at 15, 30, 60, 120, 180, 240, 300 and 360 minutes.

Viscosity

The rheological properties of topical preparations are imperative during the process of designing new formulations. Viscosity not only affects the spreadability of gels but also affects their penetration into the skin (Torres *et al*., 2022). In the current study, the viscosity of topical gels (fig. 9) is increased with increasing concentration of the polymers.

Spreadability

The spreadability of a gel is its ability to spread on the skin surface (Nowfia *et al*., 2020). A good spreadability ensures uniform application of gel at the target site. Furthermore, it is also considered an important factor in patient compliance (Kashyap *et al*., 2020). Studies reveal

that gels should possess good spreadability which helps in their even and consistent application on the intended site (Borse *et al*., 2020). The spreadability of all the formulations (fig. 10) was inversely proportional to the concentration of the gelling agent.

In-vitro permeation studies

This study is of utmost importance because it exhibits the behavior of the drug in advance, that is, how this drug will behave in the *in vivo* studies. Therefore, this study minimized the risk of untoward effects of drugs used directly in living systems (Shivalingam *et al*., 2021). Franz diffusion cells are widely used for drug permeation studies through the skin (Kumbhar *et al*., 2021).

In current study the release of curcumin from the formulations containing propylene glycol was found to be between 78-91%. (figs. 11 and 12) The release of curcumin was high when the concentration of the polymer was low as compared to the release from the formulation containing a high polymer concentration. The formulations without propylene glycol exhibited a release profile of 60-70%.

Skin irritation studies

Hypersensitivity test was carried out to determine the skin sensitization or irritation on the volunteer's skin. No irritation or redness was observed in any of the volunteers after the application of the formulations. This shows non-irritant and non-allergic profile for the prepared formulation.

Stability studies

All the prepared formulations were kept for one month, at room temperature, to observe any change in the colour, viscosity, and pH. No significant change was observed in appearance, pH and viscosity of any of the prepared formulations during or after 4 weeks.

DISCUSSION

A number of trials were carried out for the formulation of aloe vera based curcumin topical gels. For this purpose, various gelling agents ranging from natural, synthetic, and semi-synthetic sources were used in varying concentrations. Curcumin is insoluble in water at neutral or acidic pH, but it readily dissolves at an alkaline pH resulting in a distinctive red colour (Yerneni *et al*., 2022). Furthermore, when curcumin was dissolved in dimethyl sulfoxide (DMSO), it undergoes a colour transformation and turned dark red as reported by (Rapalli *et al*., 2020). Therefore, to overcome the solubility challenges of curcumin, it was complexed with β-cyclodextrin. There are numerous variations of cyclodextrins, but the β-form was chosen due to the optimal molecular dimensions of its cavity making it the most favorable option for the inclusion of a complex formation (Niu *et al*., 2019). It was also selected due to its easy availability and being economical as mentioned by Gidwani and Vyas (2015). Curcumin was complexed with β-cyclodextrin in 2 molar ratios of 1:1 and 1:2. The complexes were further studied for their solubility enhancement and as reported in another research, the 1:2 complex showed a better solubility as compared to the 1:1 complex. It has also been stated by (Liu *et al*., 2020) that the 1:2 curcumin β-cyclodextrin complex is more stable. So, a 1:2 complex was used in the formulation of all topical gels.

The calibration curve was obtained by forming a graph. The FTIR spectrum of all the prepared formulations had shown peaks very similar to those of the reported spectrum of pure drug and all of the other chemicals used. All the formulations exhibited uniform drug content with in pharmacopoeial limits. The viscosity of topical gels, in the current study, increased with increasing concentration of the polymers (Andleeb *et al*., 2021). Hence, it can be said that the concentration of the polymer in the formulation is directly proportional to its viscosity. A high concentration forms a highly viscous product resulting in a low spreadability (Shiehzadeh *et al*., 2023). The spreadability of all the formulations was inversely proportional to the concentration of the gelling agent. The viscosity of all formulations increased while the spreadability decreased with the increasing polymer concentration. F1 formulation exhibited the highest permeation of curcumin having a good spreadability of 51mm.

A study revealed an inversely proportional relationship between polymer concentration and drug permeation, requiring the use of permeation enhancers to facilitate drug release from the formulations. Propylene glycol as a permeation enhancer expediting drug release from formulations. In the present study, the release of curcumin from the formulations containing propylene glycol was found to be between 78-91% (table 5 and table 6). The release of curcumin was high when the concentration of the polymer was low as compared to the release from the formulation containing a high polymer concentration. The formulations without propylene glycol exhibited a release profile of 60-70%. F1 showed the highest permeation of 91%. The results of this study demonstrated that all formulated gels were found to be chemically and physically stable.

CONCLUSION

Curcumin is a polyphenolic compound possessing antioxidant and anti-inflammatory properties which is insoluble in water. As per our objective to improve the aqueous solubility of curcumin and to prepare its Aloe vera based topical gel, curcumin was complexed with β-cyclodextrin. After the complexation of curcumin with β-cyclodextrin in a molar ratio of 1:2, the water solubility of

curcumin significantly increased from 9.2µg/ml to 374µg/ml. This enhanced solubility facilitated the utilization of the curcumin-β-cyclodextrin complex in the formulation of topical gels. All the prepared formulations of curcumin β-cyclodextrin complex as an aloe vera based gel were found to be stable possessing drug content ranging from 90-100%. Among the various gels formulated, the Carbopol gels displayed a distinct sparkling appearance, whereas the CMC and guar gum gels had a comparatively darker hue. The viscosity of all gels increased with the increasing concentration of polymer leading to a decrease in the spreadability. Formulations lacking propylene glycol exhibited drug permeation in the range of 60-70%, whereas formulations containing propylene glycol demonstrated enhanced drug permeation ranging from 80% to 91%. F1 showed 91% drug release within 6 hours and a good spreadability of 51mm. F1 aloe vera based formulation containing 1% Carbopol and 10%propylene glycol was considered to be the optimized formulation for the effective delivery of curcumin. Keeping in view the beneficial effects of curcumin and its stability in gel form, further *In-vivo* studies should be conducted.

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