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Formulation, Development and Evaluation of Fast Dissolving Film Containing Niosomes for the Treatment of Psychosis

NIKITA KALE[1]*, SACHIN KUMAR JAIN[1] and SUDHA VENGURLEKAR[2]

Faculty of Pharmacy, Oriental University, Indore (M.P.), India.
*Corresponding author E-mail: nikita.sohaney@gmail.com

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ABSTRACT

The study focused on developing and evaluating sublingual fast-dissolving films incorporating chlorpromazine HCl and haloperidol-loaded niosomes to enhance bioavailability and ensure sustained drug release. Using HPMC E15 and various excipients, films were prepared via solvent casting and exhibited desirable physical characteristics, including smooth texture, transparency, and optimal mechanical strength. *In vitro* and ex vivo results showed high drug release rates for both drugs, with chlorpromazine HCl releasing 90% in 2 h and haloperidol 91% in 24 hours. Among the niosomal formulations, F7 showed the best performance. The findings highlight the effectiveness of the developed films in delivering drugs efficiently through the sublingual route.

Keywords: Niosome, Sublingual film, Cumulative drug release.

INTRODUCTION

FDF technology has been used to market a variety of dosage forms. A number of processes have been used, including FDF tablets, tablet process modifications, centrifugal force application, temperature control, and freeze drying.[1]

Fast Dissolve Technology classification

The following categories comprise Fast Dissolving Technology.

1. Compressed Tablet System
2. Freeze Drying System
3. Film strip/Fast Dissolving Film (FDF)

Fast dissolving film (FDF), commonly referred to as oral wafers, is a collection of thin polymeric films that are now attracting a lot of attention from the pharmaceutical sector. Many clients now embrace this innovative formulation for providing vitamins and self-care goods in particular. It is now being tested for prescription medications and licensed for over-the-counter medications for systemic distribution.[2]

Grouping

Three subtypes of oral patches are available:

1. Instant Disintegration,
2. Dissolution of Mucoadhesive,
3. Extended Release of Mucoadhesive

Benefits

1. The medicine dissolves and disintegrates

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quickly in the oral cavity because of its increased surface area.
2. Administering doses precisely
3. Adherence by patients
4. Secure and effective
5. Suitable and portable without requiring a measurement apparatus or water
6. A decrease in adverse effects due to the avoidance of first-pass hepatic metabolism and the administration of smaller doses.
7. Beneficial for people suffering from mental illnesses, motion sickness, dysphagia, and frequent vomiting.
8. Adaptable[3]

Drawbacks

1. The strip cannot contain a high dosage.
2. The range of acceptable medication goods is restricted.
3. The difficulty in achieving dosage uniformity

Application

1. Treat pain, allergies, sleep issues, and central nervous system diseases that call for quick medication absorption.
2. Breath strips
3. Vitamin and personal care product delivery
4. Topical application: mostly for antibacterial and analgesic ingredients
5. Gastric retentive dosage form: For compounds with a range of molecular weights that are both completely and weakly soluble in water
6. Diagnostic devices: These are used to separate several reagents or to provide an isolation barrier for sensitive reagents that allow regulated release when they come into contact with biological fluid.[1]

METHODS

First, distilled water (DW) was used to dissolve a specified weight of HPMC E15. To the polymeric solution, add FD & C yellow no. 6, citric acid, menthol, and sodium saccharin, in that order.Following levigation with the necessary volume of glycerin, the computed quantity of cross-carmellose sodium was added to the polymeric solutions. Before adding cross-carmellose sodium, the necessary quantity of chlorpromazine hydrochloride was introduced straight to the polymeric solution and thoroughly dissolved in order to create medicated films (which include free medication). The chosen polymeric solution was carefully combined with a predetermined volume of the chosen niosomal dispersion (which corresponds to the necessary maintenance dosage of haloperidol) for the niosomal film. To stop the solvent from evaporating, the beaker was covered with aluminum foil and the final volume was adjusted with distilled water. A magnetic stirrer was used to agitate the distilled water for two hours at 700 RPM. A Petri plate that had been washed and dried was filled with 25 milliliters of distilled water. Before being evaluated, the film was taken off of the Petri plate and allowed to dry in a desiccator for 48 h after the solvent had evaporated for 72 hours. To preserve the integrity and flexibility of the films, the patches were cut into 4 cm^2 pieces and included 5 mg of haloperidol and 35 mg of chlorpromazine hydrochloride. They were then wrapped in aluminum foil and kept at room temperature in a dry location. Within a week of the film's creation, an appraisal was conducted.[4-7]

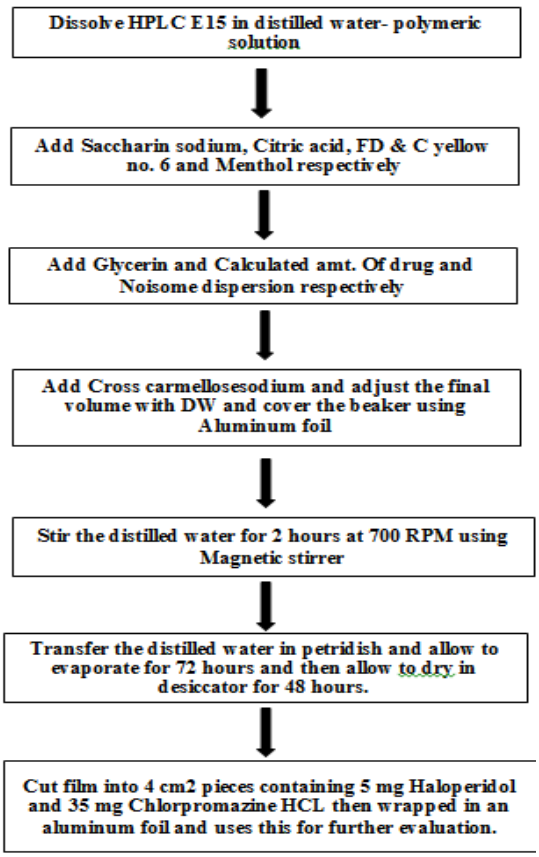

Fig. 1. Process flow chart for formulation of fast dissolving film

Table 1: Formulation of Fast Dissolving film

Sr. No	Ingredients	Formulation Code								
		NF1	NF2	NF3	NF4	NF5	NF6	NF7	NF8	NF9
1	Chlorpromazine HCl (mg)	35	35	35	35	35	35	35	35	35
2	Valsartan niosomal dispersion F7 (equi. mg)	5	5	5	5	5	5	5	5	5
3	HPMC E15 cps (% w/v)	1.75	1.75	1.75	2.25	2.25	2.25	2.75	2.75	2.75
4	Glycerin (% w/w of polymer)	15	20	25	15	20	25	15	20	25
5	Citric acid(%w/v)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	Saccharin sodium (%w/v)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	Cross carmellose sodium(% w/v)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
8	FD &CYellow No. 6	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S
9	Menthol	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S
10	Distilled water	Upto 25 mL								

Evaluation parameters for Medicated film

The film must be flat, rigid, and free of edge crimping. The FDF strip needs to be sturdy enough to be handled by the customer without breaking and to be taken out of the unit-dose package. When inserted into the oral cavity, the film must also breakdown easily to release the active ingredient quickly. The fast-dissolving film's mechanical characteristics are crucial in determining all of these factors. As a result, the rapid dissolving film's mechanical characteristics are just as crucial as its rate of solubility. Thus, the following criteria were used to assess the created mouth dissolving films.[8-10]

Physical appearance

Through visual assessment, the physical appearance was verified.

Texture of surfaces

By touching the surface, the texture was verified.

Evaluation of mechanical properties (MP)

What degree of strain or tension a film can withstand during formulation, packaging, and transportation is determined by its melting point. Additionally, the film's strength and elasticity are demonstrated, as measured by its tensile strength and elasticity upon break. The table that follows distinguishes the kind of polymer.[9]

Table 2: Film's Melting point

Sr. No	Polymer sort	Tensile strength	Elongation
1	Weak, Soft	L	L
2	Brittle, Hard	M	L
3	Soft, Hard	M	H
4	Hard, Tough	H	H

L:Low, M:Moderate, H:High

A low elastic modulus, a high percentage of elongation at break, and moderate TS are characteristics of an acceptable film. Film MP, or film thickness measured with a digital micrometer, Digital Tensile Strength Strengthening Burst A test strip of 10 x 50 mm and devoid of any physical flaws or air bubbles was clamped between two clamps spaced 10 mm apart. The strip was pulled at a rate of 5 mm per minute while being measured. When the film broke, the mechanical property values were noted. Calculations did not include results from film samples that broke at the clamps rather than between them. For every film, measurements were performed three times. Three mechanical characteristics of the films were assessed: their tensile strength, percentage elongation, and folding durability.[11]

Tensile Strength (TS)

The highest stress exerted at the point where the film specimen breaks is known as TS. The TS, which is expressed in force per unit area (N/mm^2), was computed by dividing the greatest load at failure by the film's native cross-sectional area.[10]

Elongation percentage at break (% E)

The extension at the point of rupture of the specimen was divided by the starting gage length of the specimen, and the result was multiplied by 100 to determine the percent elongation at break (%E).

$$\text{Tensile strength} = \frac{\text{Load at failure}}{\text{Strip thickness}} \text{ X Strip width}$$

Folding Endurance(FE)

FE was carried out by repeatedly folding the film at the same spot until it broke. The value of folding endurance is determined by counting the number of times the film can be folded in the same spot without separating.

Study of *in vitro* disintegration

In a glass petridish, 25 milliliters of 67 mM phosphate buffer pH 6.8 were used to quantify the *in-vitro* DT (n=3) for each batch's film. A2 cm × 2 cm film sample was placed in 20 milliliters of artificial saliva. A magnetic stirrer was used to keep the medium somewhat stirred. The moment the film was fully dissolved in the saliva was recorded as DT. Attention was paid to the average of three values.[12]

Thickness of film

A micrometer was used to measure each film's thickness five times (at the center and four corners), and the average thickness was determined.

Uniformity of drug composition

Each cast film was dissolved in 100 mL of 67 mM phosphate buffer pH 6.8 after 4 cm^2 (2 cm × 2 cm) patches were cut from various locations within the film to verify the consistency of the drug content. After filtering the resultant solution and diluting it further with 67 m M phosphate buffer pH 6.8, the absorbance was measured spectrophotometrically to ascertain the drug content %. At least three patches of each formulation underwent the same process, and the mean values and standard deviations were given.[11]

SurfacepH

Three films of each formulation were let to come into contact with one milliliter of distilled water for an hour at room temperature, and the pH was then measured using a pH meter. By placing the electrode on the film's surface and letting it equilibrate for a minute, the surface pH was determined.

Percentage of moisture loss

This test was also used to assess the films' integrity after they were dry. Accurately weighed film was stored in a desiccator with fused anhydrous calcium chloride. The film was taken out and weighed after a day. The percentage of moisture loss was calculated using the formula below.[8-9]

$$\% \text{ Moisture loss} = \frac{\text{Initial wt.} - \text{Final wt.}}{\text{nitial wt.}} \text{ X } 100$$

***In vitro* Drug release study**

The USP dissolution test equipment II (Paddle) was used to perform the in vitro release of chlorpromazine HCl and haloperidol from the prepared film. A stirring rate of 100 rpm and 900 mL of dissolving media kept at 37.0±0.5°C were used. For 24 h, each formulation was tested separately in 900 mL of 67 ml M phosphate buffer with a pH of 6.8. To keep the volume constant, 5 mL samples were taken out of the dissolving media at appropriate intervals and replaced with new medium. The quantity of medicines released in each sample was measuredspectrophotometrically at λmax 280 nm for chlorpromazine HCl and 247.5 nm for haloperidol following filtering and the proper dilution.[13]

Details of Dissolution Test

Device: USP Type II (Paddle)

The medium's volume was 900 milliliters, and its temperature was 37°C ± 0.50.

- 100 rpm paddle speed
- 67 ml of M phosphate buffer pH 6.8 with 0.5% SDS was employed as the dissolution media.
- An aliquot of 5 ml is taken at each time interval.

Permeability investigation *in vivo*

For the improved formulation, permeability tests were conducted using a modified Franz diffusion cell with an internal diameter of 2.5 cm. The model membrane utilized was the sublingual mucosa of goats. Prior to mounting, the membrane was stabilized in order to extract the soluble components. The donor and receptor compartments were separated by the mucosa. 27 mL of 67 mL M Phosphate buffer pH 6.8 was added to the receptor compartment, and the hydrodynamics were maintained by stirring with a magnetic bead at 50 rpm while the temperature was kept at 37°C ± 0.2°C. The mucosal surface that had been wet with a few drops of media was brought into close contact with a previously weighed 2x2 cm film. A single milliliter of 67 mM phosphate buffer (pH 6.8) was added to the donor compartment. To keep the sink condition, samples were taken out at appropriate intervals and replaced with the same volume of fresh medium. For haloperidol and chlorpromazine HCl, the cumulative percentage of drug penetration was measuredspectrophotometrically at 247.5 nm and 280 nm, respectively.[12-13]

Residual solvent analysis

GC often uses the compendial approach to determine residual solvent. However, in our study, Class-3 Diethyl Ether was used to produce a maintenance dose-loaded Haloperidol Niosome. Based on the rationale presented in the Results

and Discussion, this test is unnecessary because the quantity of diethyl ether in the optimized Niofilm formulation C1 was 28127 ppm.

Study of morphology

Surface texture and physical appearance were assessed by touch and eye inspection, respectively.

SEM, or scanning electron microscopy

SEM was used to examine the surface's texture and shape. Cameras also took simple pictures of film. The film formulation was adhered on an aluminum stub using double-sided adhesive tape to create the samples for the SEM. The film samples were then randomly scanned and microphotographs were taken on different magnification and higher magnification was used for surface morphology, homogenicity of polymer and drug distribution and texture of film. The accelerator voltage was set at 30.0KVduringscanning

Separability

The best film from several first trial batches was chosen using *in-vitro* DT, which also assisted in choosing the kind of polymer for further research. The separability of the film was measured by how quickly it detached from the mold.[12]

Table 3: Film separability code

Sr. No	Film separability	Code
1	Good	++
2	Moderate	+
3	Poor	-

RESULT AND DISCUSSION

The results of all evaluation parameters of fast dissolving film formulations were shown in below tables.

Table 4: Evaluation parameter of film formulations

Sr. No	Formulation code	Physical appearance and Surface texture	Tensile strength (N/mm^2)	%Elongation*	Folding endurance*
1	NF1	**	3.55±0.122	56.43±1.20	148±2.34
2	NF2	**	4.19±0.142	89.50±0.88	157±3.35
3	NF3	**	5.10±0.098	92.34±0.14	160±1.87
4	NF4	**	5.01±0.091	98.65±0.29	168±1.45
5	NF5	**	5.53±0.119	176.45±0.45	177±2.04
6	NF6	**	6.20±0.137	201.23±0.30	182±3.22
7	NF7	**	6.27±0.155	102.25±0.75	185±1.23
8	NF8	**	6.45±0.085	189.45±0.81	192±2.77
9	NF9	**	6.76±0.121	208.34±0.91	220±3.78

*All results are shownin mean ± S.D.(n=3)
**Clear trans parent, yellow color, non-sticky with a smooth surface

Table 5: Evaluation parameter of film formulations

Sr. No	Formulation code	*In vitro* Disintegration Time (Sec.)	CU Chlorpromazine HCl (% of label claim)*	CU Haloperidol (% of lael claim)*
1	NF1	28±2.2	94.11±4.02	94.21±0.48
2	NF2	32±1.5	92.77±3.41	96.36±0.21
3	NF3	39±4.5	95.33±4.20	92.37±0.56
4	NF4	37±3.5	95.96±3.51	92.53±0.37
5	NF5	42±3.3	95.60±4.37	95.37±1.25
6	NF6	49±1.9	92.74±6.86	92.25±0.81
7	NF7	45±1.6	94.57±2.29	97.06±0.67
8	NF8	57±2.7	96.80±1.81	91.59±0.26
9	NF9	62±3.4	94.03±4.17	90.43±0.13

CU:Content uniformity
*All results are shownin mean ± S.D.(n=3)

Table 6: Evaluation parameter of film formulations

Sr. No	Formulation Code	Thickness (µm)*	Surface pH*	% Moisture loss*
1	NF1	64.17±4.40	6.23±0.06	1.82±0.05
2	NF2	63.00±4.86	6.38±0.08	2.66±0.15
3	NF3	63.33±2.94	6.43±0.03	3.19±0.09
4	NF4	76.33±3.61	6.50±0.10	2.18±0.22
5	NF5	76.17±5.00	6.38±0.13	2.74±0.34
6	NF6	77.17±3.31	6.51±0.05	3.37±0.37
7	NF7	102.50±5.82	6.46±0.22	2.39±0.59
8	NF8	100.50±7.53	6.53±0.15	2.88±0.67
9	NF9	101.17±6.52	6.72±0.03	3.56±0.59

*All results are shownin mean ± S.D.(n=3)

Table 7: *In-vitro* drug release of Chlorpromazine HCl from film formulations

Sr. No	Time	% Cumulative drug release (Chlorpromazine HCl)								
		NF1	NF2	NF3	NF4	NF5	NF6	NF7	NF8	NF9
1	0	0	0	0	0	0	0	0	0	0
2	5	47.06	49.1	49.56	48.65	50.13	50.87	50.98	51.36	52.98
3	10	55.84	54.71	53.12	51.23	56.41	57.41	56.84	57.86	59.64
4	15	59.7	60.12	57.41	56.21	62.24	63.59	60.27	64.51	65.24
5	20	65.48	66.41	64.1	63.54	69.55	70.12	68.34	72.36	73.02
6	25	72.54	73.64	70.33	70.98	74.68	75.65	73.1	76.99	79.35
7	30	78.98	81.12	79.58	78.66	82.54	81.26	80.67	83.54	85.21
8	35	89.54a	88.96	90.32	85.94	89.03	90.23	89.64	89.14	92.35
9	40	96.47	97.13	95.64	93.15	94.21	95.64	93.55	96.55	98.81

Table 8: *In-vitro* drugreleaseof Haloperidolfromfilmformulations

Sr. No	Time (Min)	%Cumulative drug release (Haloperidol)								
		NF1	NF2	NF3	NF4	NF5	NF6	NF7	NF8	NF9
1	0	0	0	0	0	0	0	0	0	0
2	15	28.65	27.41	30.12	26.74	29.56	30.14	31.25	28.32	30.96
3	30	32.45	30.14	32.74	30.98	33.41	34.55	35.74	33.56	29.84
4	45	41.63	42.37	46.29	41.02	45.9	44.52	43.58	42.09	41.65
5	60	49.6	51.23	50.88	48.61	50.64	51.63	52.9	51.96	50.98
6	120	51.56	54.63	52.61	52.35	55.03	56.47	53.61	54.61	51.86
7	240	59.84	58.2	61.84	58.96	61.25	63.59	60.95	62.9	61.27
8	360	65.53	68.41	69.56	63.87	68.58	69.21	68.83	69.15	70.33
9	480	71.29	73.64	75.26	69.82	71.69	71.68	74.62	73.64	74.91
10	600	79.83	81.23	81.42	74.96	75.82	80.35	81.39	81.63	79.1
11	720	82.36	85.41	85.63	79.16	80.31	86.23	85.64	85.94	84.28
12	1080	92.24	89.67	94.57	88.54	86.54	91.54	95.63	90.87	92.34
13	1440	99.57	93.72	102.3	97.68	91.62	96.55	103.3	95.39	100.2

Table 9: Ex-vivo permeability results of Chlorpromazine HCl and Haloperidol from Optimized formulation NF9

Time (Min)	%Cumulative amount of drug permeated		Cumulative amount of drug permeated per cm^2 (mg)	
	Chlorpromazine HCl	Haloperidol	Chlorpromazine HCl	Haloperidol
0	0	0	0	0
5	48.59	-	0.662	-
10	52.65	-	0.717	-
15	60.21	25.61	0.82	5.122
20	69.85	-	0.951	-
25	73.96	-	1.007	-
30	80.24	30.47	1.093	6.094
35	85.67	-	1.167	-
40	90.12	-	1.227	-
45	-	39.65	-	7.93
60	-	46.18	-	9.236
120	-	51.96	-	10.392
240	-	59.12	-	11.824
360	-	62.59	-	12.518
480	-	69.75	-	13.95
600	-	72.83	-	14.566
720	-	79.91	-	15.982
1080	-	86.54	-	17.308
1440	-	91.27	-	18.254

Inference

Physical appearance and Surface texture

The physical characteristics of all trial batches were clear, transparent, yellow, non-sticky, and smooth.

Strength in tensile

A representation of film strength is provided by the tensile strength. Tensile strength readings come in a range of 3.55 ± 0.122 N/mm^2 to 6.76 ± 0.121 N/mm^2. According to the findings, the film's tensile strength increased as the polymer concentration increased.

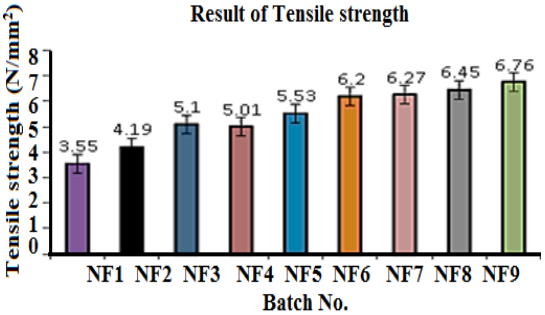

Fig. 2. Histogram of Tensile strength of formulations

%Elongation

The film's elasticity is indicated by the percentage elongation. Tensile strength findings vary from 56.43 ± 1.20% to 208.34 ± 0.91%. According to the findings, the percentage of film elongation increased as the polymer concentration increased.

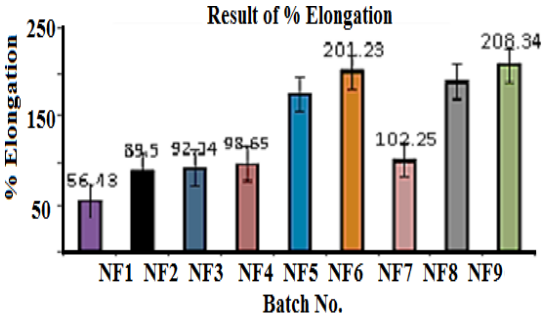

Fig. 3. Histogram of %Elongation of formulations

Folding endurance

The film's brittleness is shown by folding endurance. Folding endurance results vary from 148 ± 2.34 to 220 ± 3.78. According to the findings, folding endurance rises with increasing polymer and plasticizer concentrations.

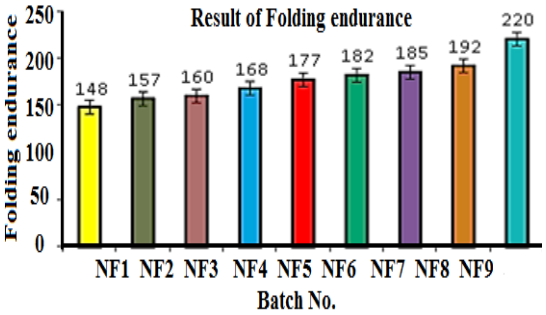

Fig. 4. Histogram of Folding endurance of formulations

In-vitro disintegration time

The primary determinant of the amount of medication release in a shorter amount of time and a quicker commencement of effect is the in vitro disintegration time. The in vitro disintegration time values vary from 28 ± 2.2 seconds to 62 ± 3.4 seconds. The findings showed that, as the amount of polymer grew, the *in-vitro* disintegration time increased as well because the film became thicker. Because glycerin is hydrophilic, it slows down the wetting process, which eventually causes the in-vitro disintegration time to decrease as the amount of glycerin rises.

Thickness

The thickness measurements vary from 63.00 ± 4.86µm to 102.50 ± 5.82µm. The findings showed that when the amount of polymer grew, thickness rose as well. The relationship between thickness and polymer is linear. Polymer optimization results in thickness control, which has an indirect impact on in vitro disintegration time. Glycerin and thickness do not appear to be correlated in any way.

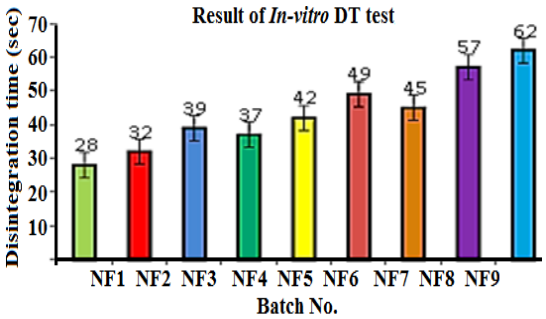

Fig. 5. Histogram of *In-vitro* Disintegration time of formulations

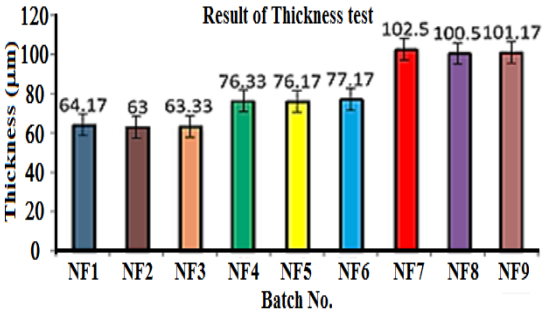

Fig. 6. Histogram of Thickness of formulations

Contentuniformity(CU)

CU is also predominant parameter for administration of precise dose inpatient. CU is solely dependent on the formulation process. There sults of CU ranges between 92.74 ± 6.86% of label claimto 96.80 ± 1.81% of label claim for Chlorpromazine HCl and 90.43 ± 0.13% of label claimto 97.06 ± 0.67% of label claim for Haloperidol. From the results it was observed that all the formulation had >90 %CU which does not leads to any problem. There were no any significant changes perceived with respect to polymer and plasticizer informulations.

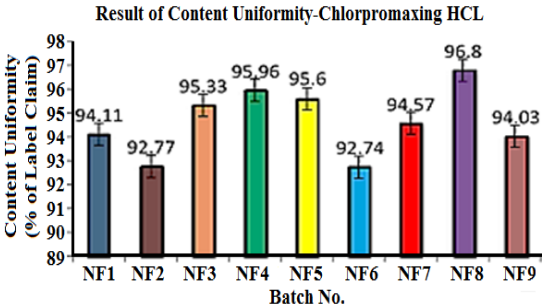

Fig. 7. Histogram of Content uniformity-Chlorpromazine HCl of formulations

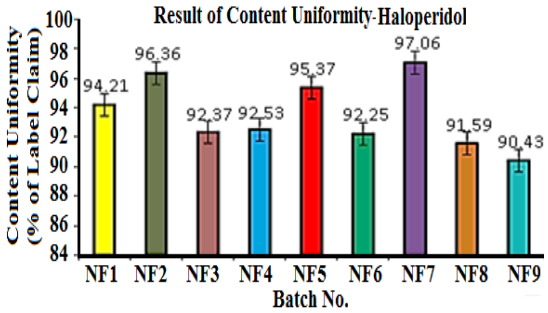

Fig. 8. Histogram of Content uniformity-Haloperidol of formulations

Surface pH

The surface pH was determined to be near neutral, ranging from 6.23 ± 0.06 to 6.72 ± 0.03. This suggests that films may be more pleasant because they are less likely to irritate the sublingual mucosa.

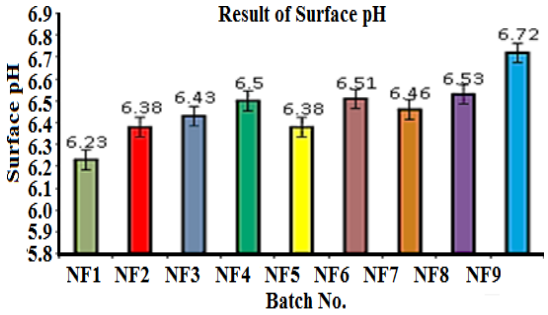

Fig. 9. Histogram of Surface pH of formulations

% Moisture loss

The purpose of this test was to assess the films' integrity when they were dry. The percentage of moisture loss ranged from 1.82 ± 0.05% to 3.56±0.59%.

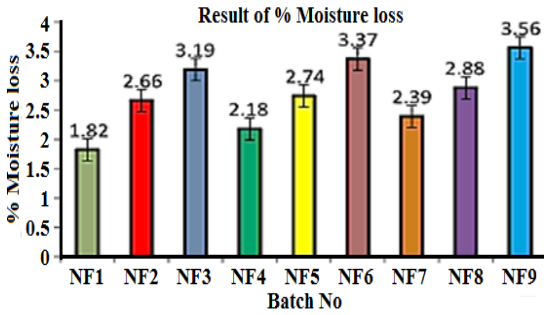

Fig. 10. Histogram of %Moisture loss of formulations

CONCLUSION

In the current study, fast-dissolving films containing chlorpromazine HCl and niosomes loaded with haloperidol were made and assessed. While the films were employed to improve the drug's bioavailability through the sublingual route, niosomes were used to enable a prolonged release of the medication. Both the film and the niosomewere assessed independently using their own assessment criteria. First, nine batches of niosomes were prepared and assessed; of those nine batches, F7 was determined to be the optimum formulation. Tensile strength ranged from 3.55 to 6.76 N/mm^2, while elongation percentage ranged from 56 to 208%. folding endurance between 148 and 220. Haloperidol and chlorpromazine HCl both had 94% and 96% *in vitro* drug release, respectively. The film's thickness ranged from 64 to 101 µm. Haloperidol 100.2 percent and chlorpromazine HCl98.81% had the largest cumulative drug release, whereas surface PH ranged from 6.23 to 6.72 percent and moisture loss from 1.82 to 3.56 percent. These assessment parameters showed that the maximum ex-vivo permeability and percentage cumulative drug release were for chlorpromazine HCl 90% in 2 h and haloperidol 91% in 24 hours. The improved formulation was identified as the ninth formulation with code NF9, and it was investigated for an ex-vivo permeability investigation.

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Conflict of Interest

There is no conflict of interest.

REFERENCES

1. Kumar L. Rapidly dissolving felodipine nanoparticle strips-formulation using design of experiment and characterisation., *Journal of Drug Delivery Science and Technology*., **2020,** *60*, 1-5.
2. Bharti K.; Mittal P.; Mishra B. Formulation and characterization of fast dissolving oral films containing buspirone hydrochloride nanoparticles using design of experiment., *Journal of Drug Delivery Science and Technology*., **2019,** *1*(49), 420-32.
3. Lai KL.; Fang Y.; Han H.; Li Q.; Zhang S.; Li HY.; Chow SF.; Lam TN.; Lee WY. Orally-dissolving film for sublingual and buccal delivery of ropinirole. Colloids and Surfaces B: *Biointerfaces*., **2018,** *1*(163), 9-18.

4. Mohapatra S.; Ranjan S.; Dasgupta N.; Thomas S.; Mishra RK, editors. Nanocarriers for drug delivery: Nanoscience and nanotechnology in drug delivery. *Elsevier*., **2018,** *5*.
5. Ali MS, Vijendar C, Kumar SD, Krishnaveni J. Formulation and evaluation of fast dissolving oral films of diazepam., *J. Pharmacovigil*., **2016,** *28*, 4(3).
6. Irfan M.; Rabel S.; Bukhtar Q.; Qadir MI.; Jabeen F.; Khan A. Orally disintegrating films: A modern expansion in drug delivery system., *Saudi Pharmaceutical Journal*., **2016,** *1;24*(5), 537-46.
7. Kumar GP.; Phani AR.; Prasad RG.; Sanganal JS, Manali N.; Gupta R.; Rashmi N.; Prabhakara GS.; Salins CP.; Sandeep K.; Raju DB. Polyvinylpyrrolidone oral films of enrofloxacin: Film characterization and drug release., *International Journal of Pharmaceutics*., **2014,** *25;471*(1-2), 146-52.
8. Chaudhary H.; Gauri S.; Rathee P.; Kumar V. Development and optimization of fast dissolving oro-dispersible films of granisetronHCl using Box–Behnken statistical design., Bulletin of Faculty of Pharmacy, Cairo University., **2013**, *1;51*(2), 193-201.
9. Choudhary DR.; Patel VA.; Chhalotiya UK.; Patel HV.; Kundawala AJ. Development and characterization of pharmacokinetic parameters of fast-dissolving films containing levocetirizine., *Scientia Pharmaceutica*., **2012,** *80*(3), 779.
10. Bhyan B.; Jangra S.; Kaur M.; Singh H. Orally fast dissolving films: innovations in formulation and technology., *Int J Pharm Sci Rev Res*., **2011,** *9*(2), 9-15.
11. Yellanki SK.; Jagtap S.; Masareddy R. Dissofilm: a novel approach for delivery of phenobarbital; design and characterization., *J. of Young Pharmacists*., **2011,** *1;3*(3), 181-8.
12. Liang AC.; Chen LL. Fast-dissolving intraoral drug delivery systems. *Expert Opinion on Therapeutic Patents*., **2001,** *1;11*(6), 981-6.
13. Liu C.; Chang D.; Zhang X.; Sui H.; Kong Y.; Zhu R.; Wang W. Oral fast-dissolving films containing lutein nanocrystals for improved bioavailability: formulation development, *in vitro* and *in vivo* evaluation. Aaps Pharmscitech., **2017,** *18*, 2957-64**.**