

## FORMULATION AND EVALUATION OF FAST DISSOLVING ORAL FILMS OF SALBUTAMOL SULPHATE

Anupama A. Vardai\*

Department of Pharmaceutics, KLE University, College of Pharmacy J.N.M.C Campus, Nehru Nagar, Belagavi-590010, Karnataka, India.

Received on: 21/03/2021

Revised on: 11/04/2021

Accepted on: 31/05/2021

\*Corresponding Author

Anupama A. Vardai

Department of Pharmaceutics,  
KLE University, College of  
Pharmacy J.N.M.C Campus,  
Nehru Nagar, Belagavi-  
590010, Karnataka, India.

### ABSTRACT

**Background:** Mouth dissolving film becomes a novel approach to oral drug delivery system as it provides convenience and ease of use over other dosage forms such as orally disintegrating buccal tablets and sublingual tablets. Mouth dissolving film was developed on the basis of technology of transdermal patch. These are thin solid dosage forms which when placed in the oral cavity; dissolve within few seconds without chewing and intake of water. The oral buccal mucosa being highly vascularized, drugs can be absorbed directly and can enter the systemic circulation without undergoing first-pass hepatic metabolism. These films offer convenient way of dosing medication to pediatric, geriatric and bedridden patients. The sublingual and buccal delivery of a drug via thin film has the potential to improve the onset of action, lower the dosing and enhance the efficacy and safety profile of medicament. **Material and methods:** Fast dissolving oral films were prepared by solvent casting method using hydroxyl propyl methyl cellulose in varying ratios and evaluated for *in vitro* disintegration/ dissolution time, Tensile strength, Percent of elongation at break (% E), Folding endurance, Thickness of film, Drug content of film, Stability study. Optimized fast dissolving oral films were tested for its *in vitro* drug release study and Stability studies. **Results:** Formulated fast dissolving oral films showed improved bioavailability of salbutamol sulphate when compared to its oral route. **Conclusion:** Salbutamol sulphate loaded fast dissolving oral films could serve as better alternative to existing marketed formulation in terms of bioavailability.

**KEYWORDS:** Salbutamol sulphate, HPMC E4, HPMC E15, Fast dissolving oral films, drug permeated.

### INTRODUCTION<sup>[1-4]</sup>

Oral administration is the most popular route due to ease of ingestion, pain avoidance, versatility (to accommodate various types of drug candidates), and most importantly, patient compliance. But the most evident drawback of oral dosage forms like tablets and capsules is difficulty in swallowing, leading to patient's incompliance particularly in case of pediatric and geriatric. So, fast-dissolving drug-delivery systems came into existence in the late 1970's as an alternative to tablets, capsules and syrups for pediatric and geriatric patients who experience difficulties in swallowing traditional oral solid-dosage forms. Asthma is recognized to be primarily inflammatory condition. Inflammation underlying hyper reaction an allergic basis can be demonstrated in many adult and higher percentages of pediatric patients. The mast cell (Present in lungs) Those cell releases the mediators like histamine, Protease enzyme, TNF $\alpha$  release of phospholipids from cell membrane and those mediator synthesizes PGs, LTs, PAF activation of genes. These mediators together constrict bronchial smooth muscle and also resulting in reversible airway obstruction.

Salbutamol sulphates are mediated by CAMP increase intracellular cyclic AMP increase activity of CAMP dependent protein kin lowers intracellular Ca<sup>2+</sup> concentration and that leads to a smooth muscle relaxation. Salbutamol sulphate, (RS)-1-(4-hydroxy-3-hydroxy-methylphenyl)-2-(tert-butylamino) ethanol sulphate is an anti asthmatic drug and is freely soluble in water and slightly soluble in ether and salbutamol is a short acting beta-2-adrenergic receptors agonist used for the relief of bronchospasm in condition such as asthma and COPD. Systemic absorption is rapid following aerosol administration orally administered salbutamol is well absorbed with peak plasma concentration. 1 to 4 hrs after administration relative bioavailability is 92.2% following inhalation compared with oral administration. The salbutamol sulphate is rapidly distributed from the extra vascular compartment. Plasma protein binding is weak (approximately 36-93%) is negligible. There is very little risk of drug interactions. Salbutamol induces palpitation, restless, nervousness, throat irritation and ankle edema can also occur. Salbutamol undergoes pre systemic metabolism in the gut wall. Oral  $\beta_2$  agonist

therapy is reserved for patients who cannot correctly use inhalers or as alternative drugs in severe asthma.

Mouth dissolving film becomes a novel approach to oral drug delivery system as it provides convenience and ease of use over other dosage forms such as orally disintegrating tablets buccal tablets and sublingual tablets, so mouth dissolving films are gaining the interest of large number of pharmaceutical industries. Mouth dissolving film was developed on the basis of technology of transdermal patch. Mouth dissolving films are thin solid dosage forms which when placed in the oral cavity; dissolve within few seconds without chewing and intake of water. The oral buccal mucosa being highly vascularized, drugs can absorb directly and can enter the systemic circulation without undergoing first-pass hepatic metabolism. This advantage can be exploited in preparing products with improved oral bioavailability of molecules that undergo first pass effect present study is undertaken to overcome the draw backs of fast dissolving tablets. Improved patient compliance is a primary benefit of the fast-dissolving drug delivery systems.

Here in the present research investigation, We have formulated salbutamol sulphate loaded Fast dissolving oral films and finally evaluated for *in vitro* disintegration/ dissolution time, Tensile strength, Percent of elongation at break (% E), folding endurance, thickness of film, Drug content of film, stability study. Optimized fast dissolving oral films were tested for its *in vitro* drug release study, *ex vivo* studies and Stability studies.

## MATERIAL AND METHODS

### Material

Salbutamol Sulphate was obtained as gift sample Empee Medicaments (India) Pvt. Ltd, Belagavi. Sucrose and vanillin was obtained from Himedia Laboratory Pvt. Ltd, Mumbai, India. HPMC E4 and HPMC E15 were obtained Colurcon Asia Pvt. Ltd, Goa, India. Citric acid was obtained from Finar chemical Ltd. Ahmadabad, India. All other chemicals and solvents used were of analytical grade.

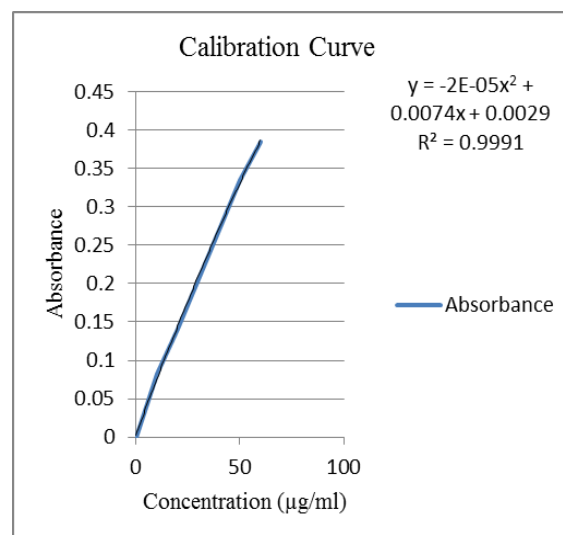
### Method<sup>[5-7]</sup>

#### Preparation of standard calibration curve of salbutamol sulphate in distilled water

Stock solutions were prepared by dissolving 10 mg Salbutamol sulphate in 100 ml of phosphate buffered saline (PBS). Serial dilutions of the stock solutions were prepared using pipettes and their absorbance values were measured using an ultraviolet-visible (UV-VIS) spectrophotometer (Shimadzu, UV-1800 PC, Japan) at  $\lambda_{max}$  275.5 nm. Linearity was observed over a concentration range of 10-120  $\mu\text{g/ml}$ , With an  $R^2 = 0.997$ . The absorbance values of different concentration of Salbutamol sulphate in pH 6.8 buffer solution at 275.5 nm were observed. [Table 2]

**Table 2: Calibration curve of salbutamol sulphate in 6.8 pH buffer solutions at 275.5nm.**

Concentration( $\mu\text{g/ml}$ )	Absorbance
0	0
10	0.082
20	0.141
30	0.206
40	0.271
50	0.335
60	0.385



$\mu\text{g/ml}$ -microgram per milli liter.

#### Preparation of salbutamol sulphate loaded fast dissolving oral films (FDMFS)<sup>[8-9]</sup>

Fast dissolving oral films of Salbutamol sulphate (45.3mg/45.3cm<sup>2</sup>) containing different ratios of hydroxyl propyl methyl cellulose (HPMC E15), hydroxyl propyl methyl cellulose (HPMC E4) were used for preparation of fast dissolving oral film. The required amount of film forming polymer was allowed to hydrate using minimum amount of water for about 3-4 hours and then uniformly dispersed to get clear solution of film forming polymer. After that the required amount of glycerin (10%) was used as plasticizer it was added to film forming solution. Other ingredients including salbutamol sulphate drug, Sweetener as a sucrose(12mg), And citric acid as a saliva stimulating agent (72mg) were dissolved one by one in previously prepared film forming solution with constant stirring to form clear aqueous solution. The aqueous solution was kept in undisturbed condition till the entrapped air bubbles were removed. The solution was casted in a glass petridish having area of 45.3 cm<sup>2</sup> and was dried at room temperature. The dried film was carefully removed from the mould and was cut into size required for testing. The dry films were wrapped in aluminum foil and kept in desiccators. Compositions of prepared formulations were tabulated. [Table 1]

**Table 1: Different formulation of fast dissolving oral films containing salbutamol sulphate.**

Ingredients (mg)	F1	F2	F3	F4	F5	F6	F7	F8	F9
Salbutamol sulphate	45.3	45.3	45.3	45.3	45.3	45.3	45.3	45.3	45.3
HPMC E15	240	300	360	-	-	-	120	150	180
HPMC E4	-	-	-	240	300	360	120	150	180
Citric acid	72	72	72	72	72	72	72	72	72
Sucrose	12	12	12	12	12	12	12	12	12
Vanillin	Q.s	Q.s	Q.s	Q.s	Q.s	Q.s	Q.s	Q.s	Q.s
Glycerin	10%	10%	10%	10%	10%	10%	10%	10%	10%

Mg - milli Grams HPMC-Hydroxy Propyl methyl cellulose Q.s-Quantity sufficient

### Evaluation of Fast Dissolving Oral Films<sup>[5-9]</sup>

#### Physical appearance and surface morphology

This parameter was investigated by visual inspection of films and by scanning electronic microscopy. The samples were mounted on SEM sample slab using a double sided adhesive tape. The samples mounted were coated with gold (200 Å) under reduced pressure (0.001 Torr) for 5 min to improve the conductivity using an ion sputtering device (JEOL, JFC,-1100E, and Japan).

#### Weighing of film<sup>[1]</sup>

The weight of the film was measured by cutting 2X2cm<sup>2</sup> size of the film at 3 different places from the casted film and was weighed on analytical balance and average weight was calculated.

#### Thickness of film

Vernier caliper was used to measure the thickness of film. The thickness was measured at three different spots of the film and average was taken and standard deviation was calculated. This is necessary to ascertain uniformity in thickness of the film as this is directly related to the accuracy of dose in the films.

#### Folding endurance

Folding endurance was determined by repeatedly folding the films (2X2cm<sup>2</sup>) at the same place until the film breaks. The number of the times the films is folded without breaking was computed as folding endurance value.

#### Surface pH

The surface pH of fast dissolving film was determined in order to investigate the possibility of any side effect *in vivo*. As an acidic or alkali pH may cause irritation of mucosa, the films were made slightly wet with the help of water. The pH was measured by bringing electrode in contact with the surface of film. The method was performed in triplicate and the average with standard deviation was reported.

#### Swelling index

The prepared film sample was weighed and placed on a pre-weighed stainless steel wire mesh. The wire mesh was then submerged in Petri dish containing 20ml of distilled water. Increase in weight of the film was determined at regular time interval until a constant weight was obtained and was calculated as difference

between the final weight and initial weight of the film divided by initial weight.

#### Tensile strength

Tensile strength is the ability of the film to withstand a pulling force. It is calculated by applied load at rupture divided by the cross section area of the film in g/cm<sup>2</sup>. The film was held between two clamps wherein the upper clamp was fixed and the lower is variable. The force of tearing and elongation was determined.

#### Percentage elongation

Percentage elongation is the maximum stress applied to appoint at which the film specimen breaks. It is calculated by increase in the length of the film divided by the original length of the film.

#### Drug content of films

The films of 2X2cm<sup>2</sup> from three different places from the casted films were taken and individually dissolved in a beaker containing 50ml of phosphate buffer pH 6.8 using magnetic stirrer. Whatman filter paper was used to filter the solution and was later diluted. After suitable dilutions absorbance was measured at 275.5nm and the drug content was estimated from calibration curve.

#### *In vitro* disintegration study<sup>[10-11]</sup>

*In vitro* disintegration time was determined visually in the Petri dish containing 20ml of phosphate buffer having pH 6.8 with swirling every 10 sec. the disintegration time is the time when the film starts to dissolve. Disintegration time provides an indication about the disintegration characteristics and dissolution characteristics of the film. Time taken by the film to disintegrate was measured as *in vitro* disintegration time.

#### *In vitro* dissolution study<sup>[12]</sup>

*In vitro* drug release studies of salbutamol sulphate fast dissolving oral films were conducted using USP type I (basket type) dissolution test apparatus containing 300ml of phosphate buffer having pH 6.8 as dissolution medium. The stirrer speed was adjusted to rotate at 50rpm. The temperature of dissolution medium was maintained at 37± 0.5°C throughout the experiment. The film specimens were placed in steel basket made up of into of wire mesh. The film sample in the basket was immersed into the dissolution medium. Samples (1ml) were withdrawn at time intervals of 2, 4, 6, 8, 10, 12, 14,

16 min respectively and replaced the same sample with fresh dissolution medium to maintain the constant volume after each sampling. The withdrawn samples were filtered through *whatman* filter paper and were analyzed spectrophotometrically at 275.5nm using UV-visible spectrophotometer.

**Ex vivo permeation study<sup>[9-13]</sup>**

Ex vivo permeation study was carried out using porcine mucosa using modified *Franz* diffusion cell. The dissolution cell consists of donor compartment and receptor compartment, water jacket and sampling port. The receptor compartment of dissolution cell was filled with phosphate buffer pH 6.8 (40ml). Small magnetic bead was placed in the receptor compartment for agitating the buffer solution. Porcine oral mucosa was

used as the model membrane. The mucosa was mounted between the donor & receptor compartments. Formulated optimized film having dimension 2X2cm<sup>2</sup> was placed over the porcine oral mucosal membrane. The donor compartment was then positioned and fixed over it with the help of clamps. The donor compartment was filled with 1ml of phosphate buffer of pH 6.8. The whole assembly was placed on a magnetic stirrer and the solution in the receptor compartment was continuously stirred. The temperature was maintained at 37±2°. Samples of 1ml were withdrawn at suitable time interval of 2,4,6,8,10,12,14 and 16 minutes and were analyzed at 275.5 nm spectrophotometrically by using UV- visible spectrophotometer. Results of Ex-vivo studies of optimized formulation F7 is shown in Figure 2.

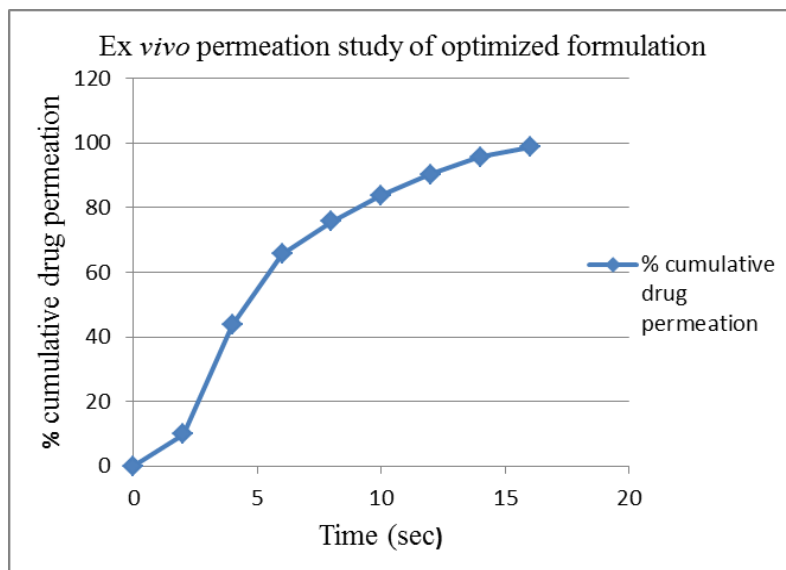


Figure 2: Ex vivo permeation study of optimized formulation F7.

**Stability Study<sup>[14-15]</sup>**

**Procedure**

Films of optimized batches were subjected to stability study. Each film was wrapped in aluminum foil and placed in plastic zip bag. Films were exposed to accelerated condition and humidity (40±2°C and 75±5%

RH).The study was carried out for 1 month. The films were evaluated initially and every 10 days for their physical characteristics, *in vitro* DT, *in vitro* drug release, and drug content uniformity and folding endurance. [Table 5]

Table 5: Stability study result of optimized formulation F7 at 40±2°c and 75±5% RH.

Sampling time	Observation			
	Folding endurance	Disintegration time (sec)	Visual appearance	Drug content (%)
Initial (0 day)	>300	24	Clear	96.25
10 days	>300	26	Homogeneous film	96.07
20 days	>300	28	Slightly hazy film	95.96
30 days	>300	30	Slight recrystallization	95.64

**RESULTS**

**Evaluation of prepared fast dissolving oral films FDMFs**

The present investigation was undertaken to formulate and evaluate fast dissolving oral films of salbutamol sulphate by solvent casting method using citric acid as a

saliva stimulating agent. And to impart pleasant taste and improve mouth feel, sucrose was included as sweetening agent, vanillin as a flavoring agent, and glycerin as a plasticizer was used to enhance flexibility of film. From the evaluation parameters of fast dissolving oral films of salbutamol sulphate, it was observed that 120mg of HPMC E15 and 120 mg of HPMC E4 was the optimum

concentration for fast dissolving oral films on the basis of least disintegration time observed with F7 formulation. HPMC E15 and E4 were resulted in hydrophilicity and swelling which in turn causes rapid disintegration of film. It absorbs saliva rapidly and dissolves in mouth within few seconds. From the evaluation parameters, it was observed that disintegration time of the formulation was decreased and thickness of film, and disintegration time were within the IP limits. The least disintegration time was observed in F7

formulation, optimum polymer concentration selected for final formulation of salbutamol sulphate FDMFs. Improvement in flexibility and physical properties are observed. The films produced were clear and transparent with smooth surface and having better physical properties. The studies revealed that addition of glycerin (10%) was fixed and standardized for formulation F1-F9. All the developed and prepared formulations were smooth, uniform, and flexible films were obtained. (Table 4)

**Table 4: Evaluation parameters of fast dissolving oral films of salbutamol sulphate.**

Formulation code	Swelling index	Disintegration time (sec)	Tensile strength (g/cm <sup>2</sup> )	(%) elongation	(%) Drug content	(%) Drug release
F1	0.031±0.003	28±0.56	0.3±0.76	1.41±0.36	91.66±0.098	92.45±1.8
F2	0.043±0.002	44±1.54	0.43±0.71	2.16±0.087	91.66±0.087	91.94±2.5
F3	0.049±0.005	48±0.03	0.53±0.21	3.1±0.065	95.83±0.065	90.04±1.48
F4	0.026±0.004	37±0.004	0.93±0.05	1.81±1.32	95.83±0.087	92.13±1.68
F5	0.030±1.32	56±0.003	1.39±0.006	2.3±1.42	92.91±0.098	91.76±0.35
F6	0.039±0.02	59±0.008	2.69±0.003	3.74±0.07	91.25±0.32	90.15±0.09
F7	0.019±0.01	24±0.003	0.41±0.001	1.87±0.02	96.25±0.01	95.85±0.03
F8	0.021±0.004	31±0.005	0.6±0.009	1.97±0.007	94.16±0.03	94.78±0.02
F9	0.025±0.008	39±0.007	1.09±0.01	2.02±0.009	94.58±0.06	93.84±0.02

#### Folding Endurance

The folding endurance of the film was found to increase with increase in the concentration of polymer. The values of folding endurance for all the formulations were shown in Table 3.

#### Surface pH

Surface pH of all the films were found to be close to neutral pH indicating that there might be less probability that the films will cause an irritation to the oral mucosa thus promoting patient acceptance. The results were shown in Table 3

**Table 3: Physicochemical properties of fast dissolving oral films of salbutamol sulphate.**

Formulation code	Weight (mg)	Thickness (mm)	Folding endurance	Surface pH
F1	0.26±0.02	0.21±0.03	171±0.05	6.48±0.07
F2	0.28±0.04	0.22±0.04	280±0.06	6.58±0.05
F3	0.31±0.01	0.26±0.02	330±0.05	6.60±0.06
F4	0.25±0.03	0.19±0.01	306±0.01	6.64±0.05
F5	0.30±0.01	0.23±0.05	329±0.06	6.85±0.02
F6	0.32±0.02	0.25±0.06	310±0.01	6.79±0.06
F7	0.21±0.01	0.17±0.01	486±0.02	6.31±0.03
F8	0.22±0.02	0.18±0.05	325±0.03	6.86±0.04
F9	0.24±0.02	0.20±0.03	348±0.02	6.70±0.03

1Mg: milligram

2mm: millimeter

#### Swelling index

The measurement of swelling index indicated that the maximum swelling takes place in the formulations higher proportion of polymer HPMC E 4 and HPMC E15. Swelling index affects the release of drug. Higher the percentage of swelling less the drugs release. The swelling index of all the formulations was shown in Table 4.

#### In vitro disintegration studies

All the formulations showed satisfactory disintegration time. The disintegration time for formulation F7 the least whereas F6 showing maximum disintegration time.

Evaluation of disintegration time showed that disintegration time increases with increase in the polymer concentration. The result were shown in Table 4.

#### Tensile strength

Tensile strength of all formulation was in acceptable range conceding that the films had good flexibility and mechanical strength. The result were shown in Table 4.

#### Percent Elongation at break (%E)

Percentage elongation also contributes an important role in deciding the physical strength and flexibility of the

film. Formulation F6 showing highest elongation among all other films. The results were shown in Table 4.

#### Thickness of film:

Formulation F3 showing highest thickness among all other films. The results were shown in Table 4.

#### Drug content uniformity

The drug content uniformity test was performed to ensure uniformity distribution of drug. Results indicated that was uniformly distributed in all the formulation as shown in Table 4.

#### In Vitro dissolution Studies

The *in vitro* drug release profile of all the nine formulations in pH 6.8 phosphate buffer show different in drug release based on their composition as given in table 1. It was observed that all the prepared films showed more than 90% of drug release in 16 minutes. Study revealed that the drug release from the films containing HPMC E4 as the polymer was more as compared to those containing HPMC E15. The reason behind higher drug release may be due to the lower viscosity of the HPMC E15 polymer. Rapid drug

dissolution was observed in formulations F1, F2, F4, F7, F8 and F9 which released 92.45, 91.94, 92.13, 95.85, 94.78 and 93.84 percent respectively, at the end of 15 minutes. The results are depicted in Table 4 and Figure 1. F7 formulation showed highest drug release of 95.85 percent than other formulations. Slow drug release was observed in F2, F3, F5, F6 and F9 with release of 91.94, 90.04, 91.76, 90.15 and 93.84 percent respectively, at the end of 16 minutes as shown in Table 4, Figure 1. From all the prepared formulations, formulation F7 showed acceptable results having good physical and mechanical properties with optimum percent drug content, lesser disintegration time and maximum *in vitro* drug release of 95.85 percent. Therefore formulation F7 containing lower concentration of HPMC E15 as polymer was considered to be optimized formulation and was chosen for further study. The *ex vivo* permeation study was carried out to check the permeability of the drug through the porcine oral mucosa. From the *ex vivo* study it was found that 97.9 percent of drug permeated through the porcine oral mucosa within 16 minutes from the optimized formulation F7. The optimized formulation also showed better drug release 95.85 percent the results were shown in Figure 1.

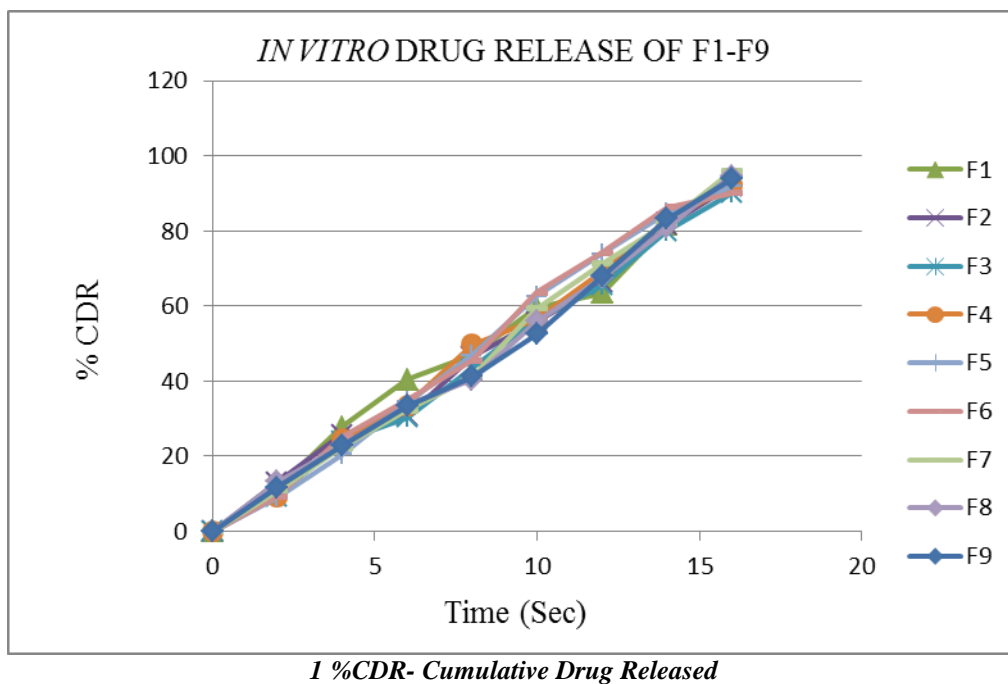


Figure 1. Cumulative amount of drug release of F1-F9 formulations.

#### Stability Study

Stability studies were performed of optimized formulation F7 as per ICH guidelines for 30 days. Optimized formulation showed no major change and revealed that the optimized formulation was stable both at normal and accelerated condition.

#### DISCUSSION

Fast dissolving oral films of salbutamol sulphate were prepared by employing solvent casting method. All the prepared films were smooth surface texture, were

flexibly and good mechanical properties. The thickness of F1 to F9 formulation ranges from 0.21 to 0.2mm. All the films showed the good disintegration time. Formulation F7 showed least disintegration time compared to other films. The percentage of drug content of all the formulations was found to be in the acceptable range of 91.66 to 94.58 percent. *In vitro* drug release study showed that all films released more than 90 percent of drug within 16 minutes.

Formulation F7 was selected as optimized formulation on bases of drug content, in vitro drug release 95.85 percent, DT and folding endurance. The *ex vivo* permeation study showed that 97.9 percent of drug permeated through the porcine mucosa within 16 minutes from optimized formulation F7. Stability study was done for 1month the formulations were stable at room temperature as well as in the accelerated stability conditions. From the studies we can conclude that the fast dissolving oral films of salbutamol sulphate are safe, efficient, effective treatment of asthma to offer a quick relief.

### CONCLUSION

Salbutamol sulphate loaded fast dissolving oral films were formulated by solvent casting method using polymers (HPMC E4, HPMC E15) where the optimized formulation F7 was found to have the best release profile when compared to other films. The results obtained after formulation oral fast dissolving films of salbutamol sulphate clearly indicate that it has improved bioavailability and rapid release rate of formulation is tested for stability and the results are positive hence the formulation is stable.

### ACKNOWLEDGEMENT

The author would like to thank and appreciate Empee medicaments pvt.ltd Belagavi, for helping them in procuring the drug as gift sample for project work.

### Abbreviation Used

Rpm: Rotations per minute; % - Percentage; FT-IR: Fourier Transform Infrared Spectroscopy; UV: Ultraviolet  $\lambda_{\max}$  - Maximum Absorbance; DSC: Differential Scanning Colorimeter; RH: Relative humidity; % CDP: Percentage Cumulative Drug Permeated; CLA: Cumulative loss added; R<sub>2</sub>: Regression coefficients; HPMC: Hydroxy-Propyl-Methyl-Cellulose.

### REFERENCE

1. Siddiquinehal, D, Garg, G. and Sharma, P.A. Short review on a novel approach in oral fast dissolving drug delivery system and their patents advances in biological research, 2011; 291-303.
2. Dixit, R.P, and Puthli, S.P. Oral strip technology overview and future potential: Journal of controlled release, 2009; 139(1): 94-107.
3. Vollmer, U. and Galfetti, P. Rapid film: oral thin films as an innovative drug delivery system & dosage form. Drug development report, 2006; 1-5.
4. Mahajan, A, Chhabra, N. and Agarwal, G. Formulation and characterization of fast dissolving buccal film: A Review for Sinica, 2011; 3(1): 152-165.
5. Suresh, B, Halloran, D. and James, L. Quick dissolving films: A novel approach to drug delivery.

6. Gavaskar, B, Kumar, S.V, Sharan G. and Madhusudan, Y. Overview on fast dissolving films: International journal of pharmacy and pharmaceutical sciences, 2010; 3(2): 29-33.
7. Cilurzo, F, Paola Minghetti, P, Como, A. and Montanari, L. Maltodextrin fast dissolving film: a feasibility study. AAPS journal, 2010; 11: 4.
8. Singh, P, Chauhaniti, K, Verma, M. and Mohd, Y. Formulation preparation techniques: evaluation nagar journal of applied pharmaceutical science, 1(4): 35-45.
9. Alpesh, R, Dharmendra, P and Jignyasha, P. Fast dissolving films (fdfs) as a newer venture in fast dissolving dosage forms: international journal of drug development & research, 2010; 2(2): 232-46.
10. Cilurzo, F, Cupone, I.E, Minghetti, P, Selmin, F, Montanari, L. Fast dissolving films made of maltodextrins. Eur. J. Pharm. Biopharm, 2008; 70(3): 895-900.
11. Corniello, C. Quick dissolving strips: from concept to commercialization. Drug Del. Technol, 2006; 6(2): 68-71.
12. Hariharan, M and Bogue, A. Orally dissolving film strips (ODFS): the final evolution of orally dissolving dosage forms. Drug Del. Technol, 2009; 9(2): 24-9.
13. Frey, Film strips and pharmaceuticals: Pharmaceutical manufacturing and packaging resource, 2006; 4(1): 92-93.
14. Kalyan, S. and Bansal, M. Recent trends in development of oral dissolving Film: international journal of pharm tech research, 2012; 4(2): 725-733.
15. Nagar, P, Chauhaniti, Y. and Asir, M. Insights into polymers: Film formers in mouth dissolving films, 2011; 3(12): 280-289.