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A REVIEW ON FAST DISSOLVING FILMS ALONG WITH THE METHODS OF PREPARATION AND THEIR ASSESSMENT CONSIDERATIONS

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ABSTRACT

Drug delivery plays an important role in delivering the main API to the targeted organ. The delivery of the drug depends on certain factors and one of the important factors is the ease of administration along with overcoming the first-pass metabolism of the drug. The oral route is having a loophole of the first-pass metabolism and to overcome this loophole, fast dissolving oral film (FDF) is an alternative route with respect to the conventional oral dosage form. The FDF can be consumed by pediatric, geriatric and dyphagic patients. The dosage form will give the complete bioavailability of the drug. The dosage form depends on the type of drug candidate, plasticizers, disintegrants, sweeteners, and flavoring agents. The main problem related to the FDF is not to incorporate the drug candidate which cannot withstand the buccal environment. There are several marketed forms that are available for the treatment of hypersensitivity, nausea, and acid reflux. The methods preferred for the preparation of the films are solvent casting, freeze-drying, etc. The main evaluation parameters for the films are disintegrating time, elongation property and wetting time.

KEYWORDS: FDF, dyphagic, drug candidate, buccal, first-pass metabolism.

INTRODUCTION

Fast dissolving oral dosage form is one of the best pharmaceutical dosage forms due to its distinctive characters and beneficial uses.[1] Fast dissolving system came into action in 1970 when there were certain problems arose due to the swallowing of conventional tablets.[2] Fast dissolving film is part of a fast drug delivery system[3] and it consists of hydrophilic polymers along with disintegrating agents that disperse at a fast rate and it goes to the systemic circulation via the buccal route.[2,4,5] FDF is a novel approach because it overcomes one of the loopholes of an oral solid dosage form which is the difficulty to swallow them by geriatric, pediatric and dyphagic patients.[6] FDFis the technique which is based on the release of drug as it is delivered in the transdermal patch.[7] FDF is the novel approach of a solid drug delivery system (DDS) which releases the drug at a rapid rate when it comes in contact with saliva and disintegrates the drug in few minutes due to its flexibility.[2] This is the thin film that is placed over the tongue and there is no need to chew or swallow the strip.[6,7] The film has fast disintegration of API as compared to the tablet.[2]

SALIENT FEATURES OF FDF[3,6-8]

The salient features are shown in figure 1 below

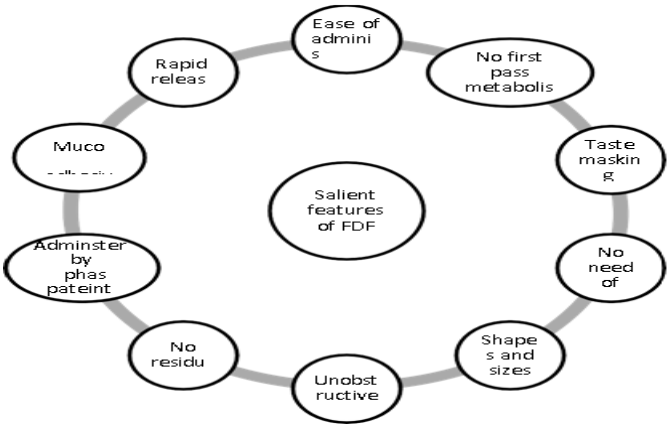

Fig. 1: Salient features of fast dissolving films.

- Ease of administration
- No need of water for swallowing
- No risk of blockage of the throat
- No residue remains in the mouth after administration due to fast disintegration
- High standard of mucoadhesion
- Available in various designs
- Immediate release of drug
- Ease of administering by dyphasic patients
- For those drugs that are highly metabolized by the first-pass metabolism can be taken Taste masking should be excellent

IDEAL CHARACTERISTICS OF DRUG CANDIDATE[1,9,10]

The ideal characteristics are shown in figure 2

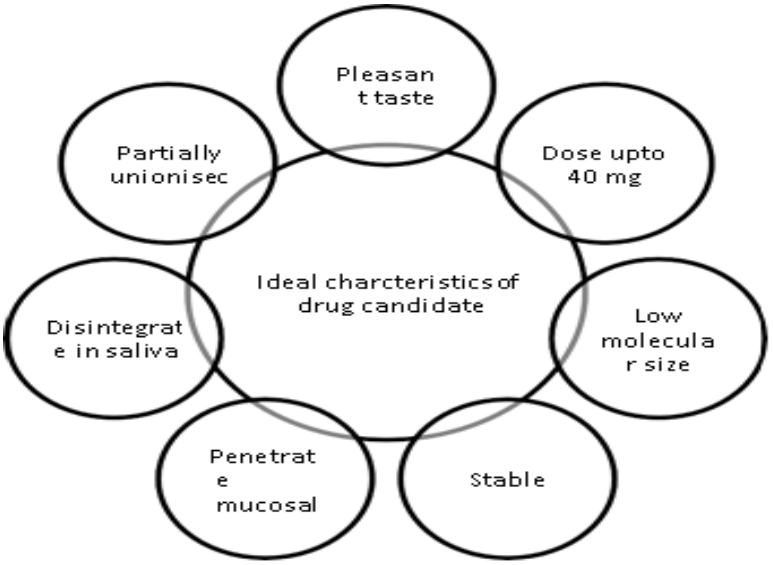

Fig. 2: Ideal characteristics of the drug candidate.

- Pleasant taste
- The dose should be of 40 mg or less but not more than that
- The drug should be of low molecular size
- It should have the ability to dissolve in saliva and also stable enough
- It should have the capacity to cross the mucosal layer
- Partially unionized at oral pH

ADVANTAGES OF FDF[11,12]

- Magnificent stability
- Easy to take
- Convenient dosing
- Rapid onset of action
- No chocking
- Enhanced patient compliance
- Small dose required
- Improved bioavailability of API
- Easy to handle and transport

DISADVANTAGES[6]

- Drugs which are not stable at buccal pH cannot be used
- A low dose is administered due to the small size of the buccal cavity
- On storage, for a long time, it leads to the brittleness of the film
- Drugs which cause irritation to the buccal cavity cannot be given
- Uniformity of dose is difficult
- The packaging is costly

FORMULATIONS CONSIDERATIONS

The formulation of the FDFconsist of various formulations additives[1,13] and they are shown in figure 3 below:

Fig. 3: Formulation additives used in FDF.[14]

The composition of fast dissolving film is shown in table 1[6]

Table 1: Composition Of Fast Dissolving Films.

Ingredients	Amount (w/w)
Drug (API)	5-30%
Plasticizer	0-20%
Film-forming agents	45%
Saliva simulating agent	2-6%
Sweetening agents	3-4%
Surfactant	QS
Coloring and flavoring agents	QS

- **Active pharmaceutical ingredient:** The API used in the films are generally of low dose, approximately 1-30% w/w because it will maintain the uniformity of drug content along with the texture of the film. The different drug categories used are antiemetics, antihypertensive, antitussive, analgesics, NSAIDs, antiallergics, hypnotics, diuretics, expectorants, anti-bacterial, antiallergics, anti asthmatics neuroleptics, antidiarrhoeal, vasodilators.[2]

- **Film-forming agents:** mostly hydrophilic polymers are used as film formers (fat- dissolving). They are the most important part of FDF as when they come in contact withsaliva they release the drug.[15] The polymer contains 40-45% w/w of polymer film so as to maintain the tensile strength of the film.[1,2] With an increase in the molecular weight of the polymer base, there is a decrease in the disintegration rate of the film. The polymer films are of two origin-natural and synthetic and based on the requirement of the film these polymers are used. The examples are given in table 2 along with the reference.

Table 2: Types Of Polymers.

Type of polymer	Name	Reference
Natural	Gelatine, pectin, pullulan, xanthan, polymerized rosin, sodium alginate, maltodextrins	[16]
Synthetic	HPMC, PVA, Polyethylene oxide, kollicoat, sodium carboxymethyl oxidose	[15]

The ideal properties of the film formers are in table 3

Table 3: Ideal Properties Of Film-Forming Agents.[17]

Ideal properties of film-forming agents
Nontoxic
Non-irritant
Shelf life should be sufficient
Good mechanical as well as tensile strength
Easily available
Low molecular weight
Tasteless, colorless
Less costly

- **Plasticizers:** It is an important part of the film so as to maintain tensile strength and elongation of the strip. It ranges from 0-20% w/w concentration of the film. The examples are PG, PEG, phthalate derivative, citrate derivative.[6,18] **Disintegrating agents:** They are added so as to increase the shattering of the film into smaller particles so as to increase the absorption of the drug when com in contact with saliva.[16]
- **Flavoring agents:** They are used to mask the bitter taste as well as make the formulation palatable by the pediatric patients. the flavoring agents used are vanilla, raspberry, orange.[5]
- **Saliva stimulating agents**: The film releases its drug in saliva and the more the amount of saliva the disintegration of the film will be more from the formulation. The film should contain a certain amount of acids so as to increase the disintegration of film and is called saliva simulating fluids. A few examples are citric acid, lactic acid, tartaric acid and ascorbic acid.[3,14]
- **Coloring agents:** The coloring agents used in the preparation of film are FDA approved and it should not more than 1% w/w in the total formulation. The example of these agents is titanium oxide, FD&C colors, and natural colors.[7]
- **Sweetening agents;** They are generally used to maintain the sweet taste as the drug has to disintegrate into the buccal cavity and for this purpose, both natural and artificial sweeteners are used. Natural sweeteners are monosaccharides, polysaccharides, dextrose, sucrose, and artificial sweeteners are saccharin sodium.[19]
- **Cooling agents:** cooling agents are used to increase the flavor as well as the flavor of the formulation so as to provide good effect and fee of formulation while taking. Monomethyl succinate, Utracoll-II are used as cooling agents.[1]
- **Surfactants:** They are used to increase the solubility of the formulation so that it releases the drug in a few seconds and disintegrates fastly. They are used where the water-insoluble drugs are not going to soluble so with their help they disintegrate the film fast.[1]

METHOD OF PREPARATION OF FAST DISSOLVING FILMS

The various methods for the preparation of FDFare:

- Solvent casting
- Semi-solid casting
- Hot-melt extrusion
- Solid dispersion extrusion
- Rolling method
- Freeze-drying method

The methods are shown in figure 4:

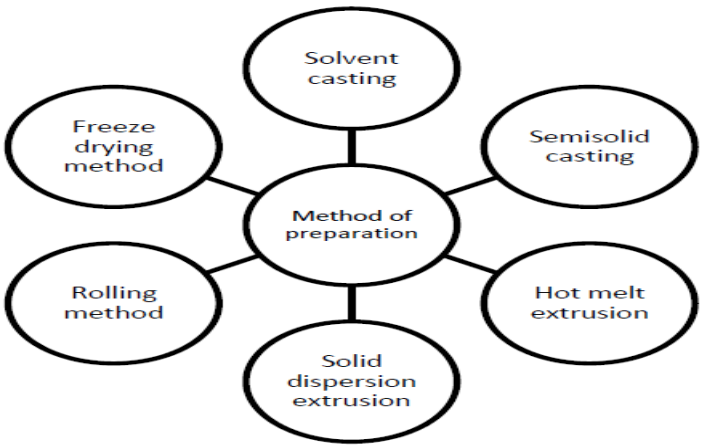

Fig. 4: Method of preparation of FDF.

- **Solvent casting method**

In this method, the excipients are mixed with water which leads to the mixing of water- soluble polymer and then the addition of the drug to make a homogenous mixture after stirring and pour into the Petri plate for casting to occur. After drying film is formed in the Petri plate.[1,20]

This can be explained in figure 5

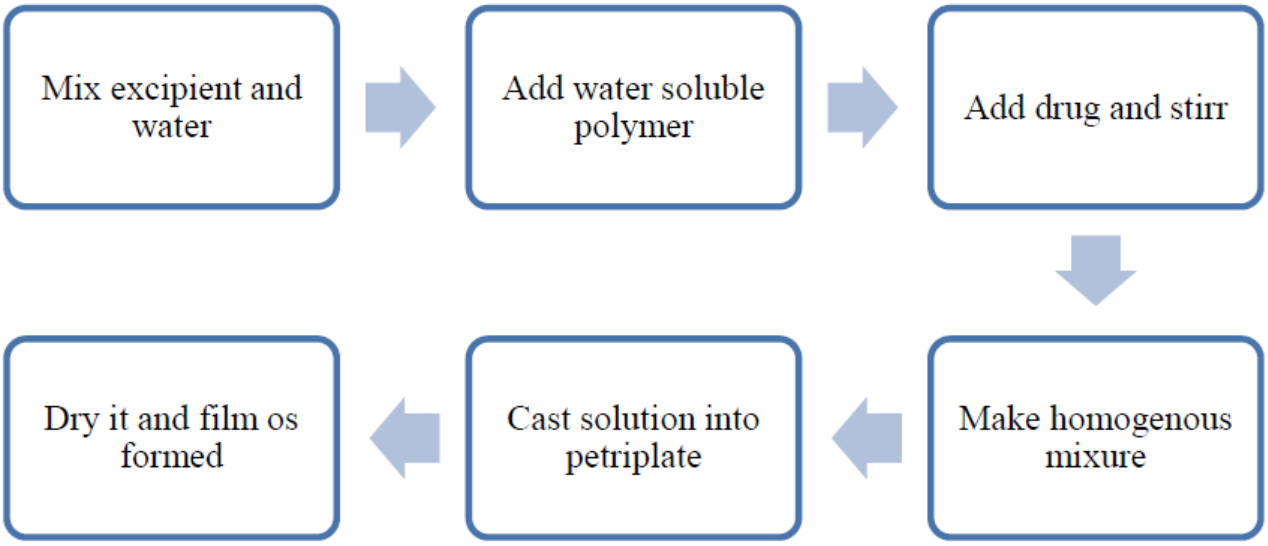

Fig. 5: Solvent casting method.

- **Semi-solid casting**

In this method, the water-soluble polymer is dissolved in water and then it is mixed with acid-insoluble polymers. It is prepared with ammonium and sodium hydroxide and then mixed with plasticizer and gel is cast using heat controlled drums and at last, film is formed. The ratio of acid-insoluble and film-forming polymer is present in the ratio of 1:4.[6] The figure 6 explains it in a better way:

Water soluble polymer is added into water

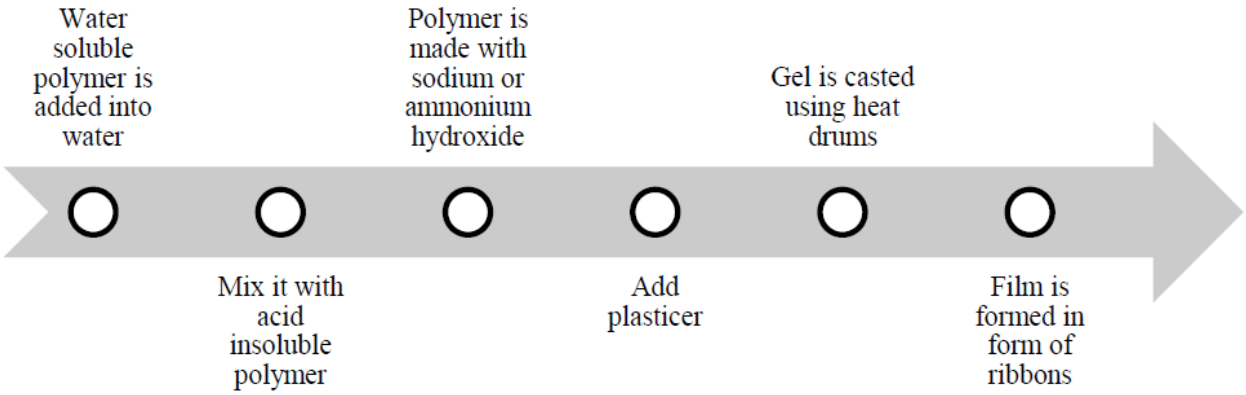

Fig. 6: Semi-solid casting method.

- **Hot melt extrusion**

In this method, the drug is incorporated with carrier and then it is dried granulated in the extruder at a speed of 50 rpm for 3-4 minutes and extrudate then pressed in a cylindrical calendar in order to obtain the film. The advantage of this method is better content uniformity and anhydrous product.[9,21] The process is explained in figure 7 below:

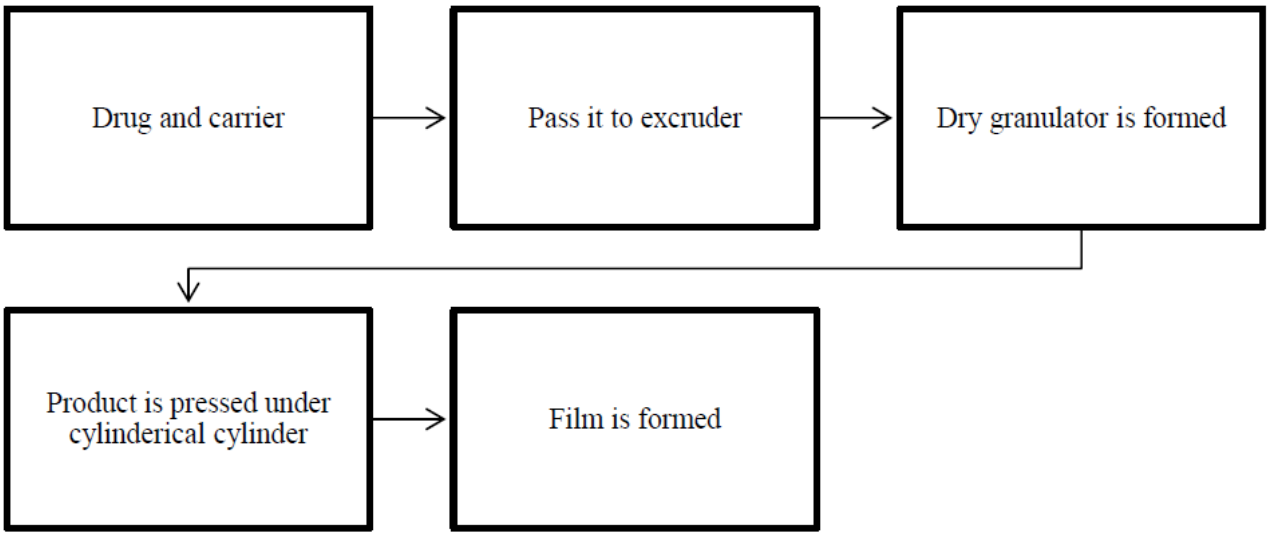

Fig.7: Hot melt extrusion.

- **Solid dispersion extrusion**

This method is applicable for that material which is immiscible with each other. Solid dispersion is prepared by combining one or more API and they are incorporated with inert material in a solid-state using amorphous hydrophilic polymer. The films are formed in the end with the help of dies.[1,3,22] The method is shown n figure 8 below:

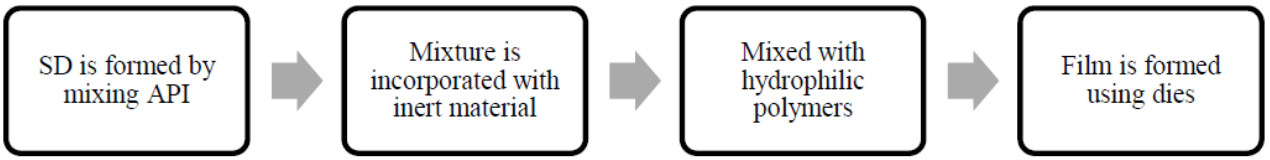

Fig. 8: Solid dispersion method.

- **Rolling method**

In this method a suspension of the drug is prepared with polymer (film making) and is subjected to the roller and the suspension is dried on the hot roller and film is obtained of desired size and shape. The suspension or solution is prepared with alcohol and water so that it evaporates easily.[6] The method of preparation is explained in figure 9 :

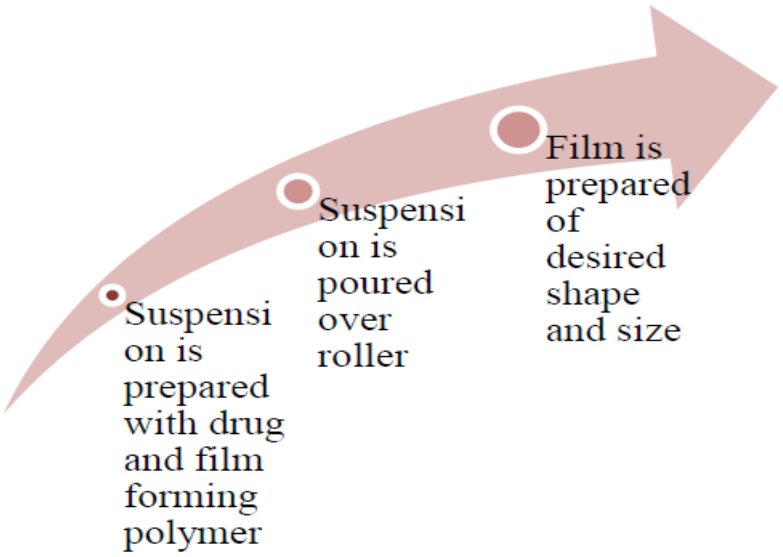

Fig. 9: Method of preparation of film using the rolling method.

- **Freeze-dried method**

In this method, the water is dehydrated under reduced pressure of surrounding so that water is sublime from solid to gaseous state directly results in the preparation of highly porous film which leads to increase the disintegration of film rapidly. This method is also known as lyophilization and cryodessication.[6,23] The method is explained in figure 10 below:

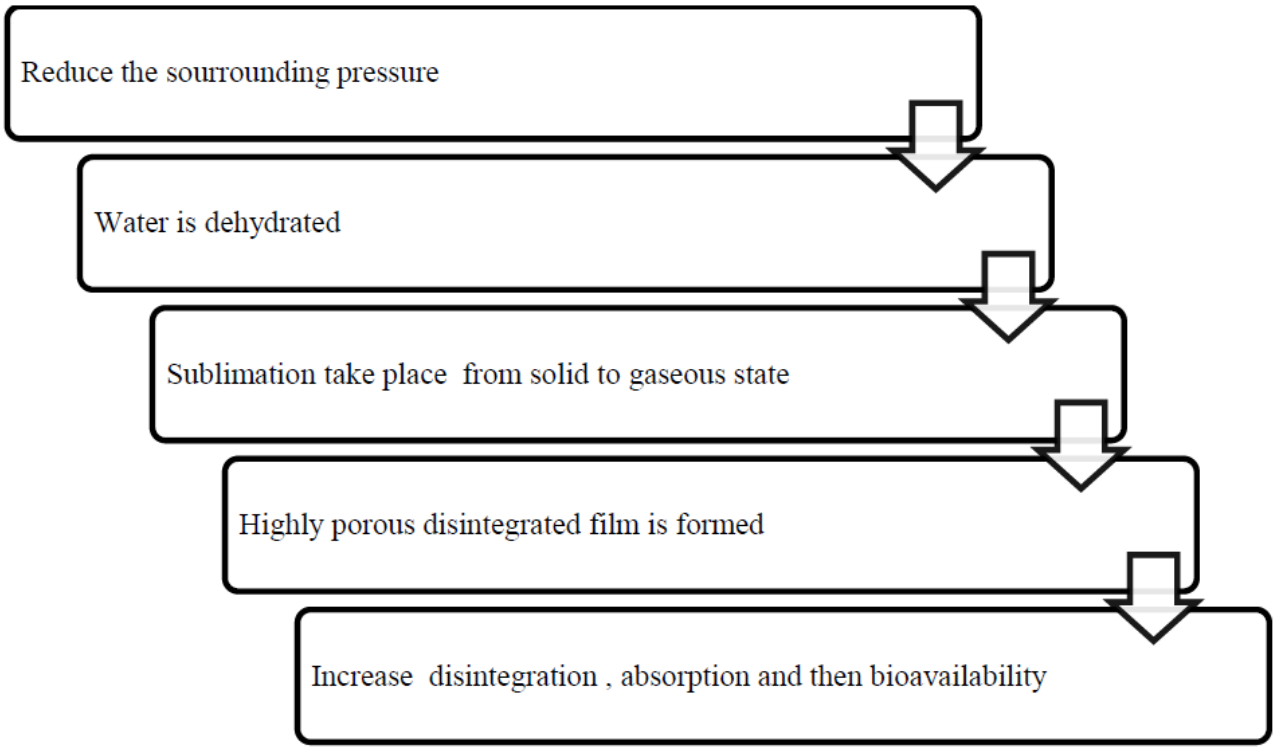

Fig. 10: Cold freeze method.

EVALUATION OF FILMS

Evaluation helps in determining various parameters of the film regarding thickness, tensile strength, drug content, weight variations and so on.[24] These tests are performed to determine the release and stability of the films under ideal conditions and to obtain a suitable film which gives the desired therapeutic action[25]

- **Morphology test:** this test is performed with the help of SEM to check the morphology of the film of specific magnification.[26]
- **Dryness test or tack test:** Tack is the attribute of any film to get adhere to the surface of any paper of surface and dryness refers to the amount of solvent present in any film.[1]
- **Weight variation:** In this method, 10 films are taken randomly and weighed individually. After that average weight is taken and it should not differ from the total weight of the films.[27]
- **Thickness:** It is measured using vernier caliper.[24] The thickness of the film is measured at different positions of film to determine the uniformity of the thickness of the film.[28,29]
- **Drug content:** Assay is performed for the particular film as it is mentioned in particular compendia.[30] The limit of content should be between 85 to 115% in the film.[6]
- **Tensile strength:** While performing this test, stress is applied to the film until it breaks and it is calculated by the given formula[31]:

$$\text{Tensile strength} = \frac{\text{force applied on the film}}{\text{area of film measure initially}}$$

Disintegration test: For this test, the sample film taken in the glass dish and add water 25ml and stir the film every 10 seconds and should start fragmented in 5-30 seconds.[25]

- **Stability test:** this test is performed by keeping the strip under controlled conditions of temperature and relative humidity. The conditions are 25°C/60%RH as well as 40°C/75% for 12 months in a stability chamber. The stability studies are done as per ICH guidelines. After that, the evaluation tests are done on the film.[30,32]

- **Transparency test:** This test is performed by cutting the film into a small rectangle and place then into the inner side of the spectrophotometer cuvette and calculate the transmittance at 600 nm. The transparency is calculated by using the formula:

Transparency = (log T600)/b= -€c

Where,

T600 is transmittance

b is the film thickness

c is the concentration[30]

- **Percentage elongation:** This test is performed to check the elongation parameter of the film and it is directly proportional to the quantity of plasticizer present in the film sample. Stress is employed on the sample and it leads to stretching of the film which is called strain. The strain is the difference of the length before applying stress with respect to the initial length.[24] The formula used is

$$\% \text{ elongation} = \%\text{elongation} = \frac{\text{change in length}}{\text{final length}} \times 100$$

- **Percentage moisture loss:** The film cut and weighed of area 2 cm^2 and placed in the desiccator containing the needed amount of anhydrous calcium chloride for 72 hours. After 72 hours take the film and weighed again and calculate % moisture loss.[33]

=

$$\% \text{ moisture loss} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100$$

- **Folding endurance:** the film is bent again and again in the same position until it breaks. The number of times the film is bent without cracking will give the folding endurance value.[26,34]

- **Surface pH: The** film is kept into a covered Petri plate having 10 ml water in it and allowed to swell. After swelling the pH of the film surface is noted down using electric pH meter.[7]
- **Dissolution test:** the dissolution of the film is done in saliva simulating fluid at 37 ± 0.5^0 C using calculate USP II apparatus and the solution is withdrawn after every 30 seconds and absorbance is determined using UV and % drug release against time is plotted on a graph.[2]
- **Tear resistance:** this is defined as the maximum stress applied until the film gets to tear up and is known as tear resistance value. The value is in newton.[30]
- **Swelling properties:** In this test, the film is kept saliva simulated fluid to check the swelling of films. Mesh wire made up of stainless steel is taken and the film is placed over it and it is kept in saliva simulating fluid after calculating the initial weight. An increase in the weight of the film is noted down until there is no further increase in the film after predetermined time intervals. Calculate the swelling of the film by applying in the formula.[8,35]

$$\text{Degree of swelling} = \frac{\text{final weight} - \text{initial weight}}{\text{final weight}}$$

Where final weight is denoted as w_t and initial weight is denoted as w_0 at time 0

COMMERCIALLY MARKETED FORMULATIONS

There are so many commercial products that are present in the market and are used to treat various diseases and they are enlisted in Table 4 below along with their manufacturing company.[16]

Table 4: Commercially Marketed Formulations.

Product	API	Application	Company
Gas X[28]	Simethicone	Antigas strip	Novartis
Suppress [30]	Dextromethorphan	Suppress cough stri	Innozen
Little colds [28]	Pectin	Sore throat strips	Prestige brands
Ondansetron	Ondansetron	Antiemetic	Labtec GmbH
Triaminic[29]	Diphenhydramine HCl	Long-lasting cough	Novartis
Benadryl[28]	Diphenhyramine HCl	Antihistaminic oral strip	Pfizer

RESEARCHES HAVE DONE SO FAR ON HERBAL EXTRACT FOR FAST DISSOLVING FILMS

Table: 4. Researches Have Done So Far On Herbal Extract.

Sr. no.	Plant used	Dose	Reference
1.	Curcumin	500 mg	[36]
2.	*Geranium palustre*	Not mentioned	[37]
3.	Zingiber officinale	10 mg	[38]
4.	Myrrh	500 g	[39]
5.	Amlodipine Besylate	100mg	[40]

CONCLUSION

The fast dissolving oral films are one of the best delivery systems as they can be consumed by various patients. The herbal extracts should be added in the fast dissolving films as the herbal products lead to eliminating the toxicity of the drug along with various side effects. There are so much researches going on in the field of herbal extract for the preparation of the films. Hot melt extraction and freeze-drying are the two best methods for the preparation of the films. The fast dissolution depends

on the type of ingredients and the drug which is selected for the dosage form.

REFERENCES

1. Sharma PK, Sharma PK, Darwhekhar GN, Shrivastava B. An Overview About Novel Fast Dissolving Oral Films. Int J Drug Regul Aff., 2018; 6(1): 1–7.
2. Sharma G, Wadhani S, Bhadauria RS. An overview on fast dissolving films. Int J Pharm Erud., 2018; 8(1): 45–52.
3. Singh S, Virmani T, Virmani R, Mahlawat G, Kumar P. Fast Dissolving Drug Delivery Systems: Formulation, Preparation Techniques and Evaluation. Univers J Pharm Res., 2018; 3(4): 60–9.
4. Qin Z yu, Jia XW, Liu Q, Kong B hua, Wang H. Fast dissolving oral films for drug delivery prepared from chitosan/pullulan electrospinning nanofibers. Int J Biol Macromol [Internet]. 2019; 137: 224–31. Available from: https://doi.org/10.1016/j.ijbiomac.2019.06.224
5. Yadav G, Kapoor A, Bhargava S. fast dissolving tablets recent advantages: a review. Int J Pharm Sci Res., 2012; 3(03): 728–36.
6. Reddy usha kiran, Reddy sunil kumar, Katta M, Thyagaraju K. A DETAILED REVIEW ON FAST DISSOLVING ORAL FILMS. Indo Am J Pharm reserch., 2018; 8(06): 1351–1326.
7. Arun A, Amrish C, Vijay S, Kamla P. Fast Dissolving Oral Films: An Innovative Drug Delivery System and Dosage Form. Int J ChemTech Res., 2010; 2(1): 576–83.
8. Irfan M, Rabel S, Bukhtar Q, Qadir MI, Jabeen F, Khan A. Orally disintegrating films: A modern expansion in drug delivery system. Saudi Pharm J [Internet]. 2016; 24(5): 537–46. Available from: http://dx.doi.org/10.1016/j.jsps.2015.02.024
9. Kadbhane NS, Shinkar DM, Saudagar RB. An Overview On : Orally Fast Dissolving Film. Int J ChemTech Res., 2017; 10(7): 815–21.
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): 50–7.
11. Bhusnure O, Nandgave A, Gholve S, Thonte S, Shinde C, Shinde N. Formulation & Evaluation of fast dissolving tablet of PGZ. indo Am J Pharm Res., 2015; 5(3): 1092– 104.
12. Balaji A, Poladi KK, Vookanti AR. Fast Dissolving Oral Films for Immediate Drug Release : A Review. World J Pharm Res., 2014; 3(2): 3751–75.
13. Bhattarai M, Gupta AK. Fast Dissolving Oral Films: A Novel Trend to Oral Drug Delivery System. Sunsari Tech Coll J., 2015; 2(1): 58–68.
14. Ghodake PP, Karande KM, Osmani RA, Bhosale RR, Harkare BR, Kale BB. Mouth Dissolving Films : Innovative Vehicle for Oral Drug Delivery. Int J Pharma Res Rev., 2013; 2(10): 41–7.
15. Joshua JM, Hari R, Jyothish FK, Surendran SA. Fast dissolving oral thin films: An effective dosage form for quick releases. Int J Pharm Sci Rev Res., 2016; 38(1): 282–9.
16. Heer D, Aggarwal G, Kumar SLH. Recent trends of fast dissolving drug delivery system - An overview of formulation technology. Pharmacophore., 2013; 4(1): 1–9.
17. Chonkar AD, Bhagawati ST, Udupa N. An Overview on Fast Dissolving Oral Films. Asian J Pharm Technol., 2015; 5(3): 129–37.
18. Meher A, Dighe NS. An Overview of Fast Dissolving Oral Film. J Drug Deliv Ther., 2019; 9(4): 822–5.
19. Jadhav YG, Galgatte UC, Chaudhari PD. Challenges in Formulation Development of Fast Dissolving Oral Films. Indo Am J Pharm Res [Internet]. 2013; 3(8): 6391–407. Available from: http://www.iajpr.com/index.php/en/
20. Kumar R, Rai AK, Kumar N, Vishwakrma DK, Instituteof K, Pradesh U, et al. Fast dissolving drug delivery system : Innova- tive strategies for drug application . Int J Pharm drug Anal., 2017; 5(7): 219–28.
21. Jani R, Patel D. Hot melt extrusion: An industrially feasible approach for casting orodispersible film. Asian J Pharm Sci [Internet]. 2015; 10(4): 1–14. Available from: http://dx.doi.org/10.1016/j.ajps.2015.03.002
22. Patil R shivaji, Kemkar V uddhav, Patil SS. Microsponge drug delivery system: A novel dosage form. Am J PharmTech Res., 2012; 2(June): 2249–3387.
23. Sim KYI, Liew K Bin, Janakiraman AK. Effect of Polymers and Processing Method on Physical Characterization of Orally Disintegrating Film. Int Res J Pharm., 2018; 9(10): 33–8.
24. Abdelbary A, Bendas ER, Ramadan AA, Mostafa DA. Pharmaceutical and Pharmacokinetic Evaluation of a Novel Fast Dissolving Film Formulation of Flupentixol Dihydrochloride. AAPS PharmSciTech., 2014; 15(6): 1603–10.
25. Tomar A, Sharma K, Chauhan NS, Mittal A, Bajaj U. Formulation and Evaluation of Fast Dissolving Oral Film of Dicyclomine as potential route of Buccal Delivery. Int J drug Dev Res., 2012; 4(2): 408–17.
26. Nagendrakumar DD, Gg K, Mogale P, Swami S, Swami H. Formulation and Evaluation of Fast Dissolving Oral Films of Metoprolol Sccinate. Int J Eng Appl Sci [Internet]. 2015; 6(4): 2305–8269. Available from: www.eaas-journal.org
27. Bala R, Sharma S. Formulation optimization and evaluation of fast dissolving film of aprepitant by using design of experiment. Bull Fac Pharmacy, Cairo Univ [Internet]. 2018; 56(2): 159–68. Available from: https://doi.org/10.1016/j.bfopcu.2018.04.002
28. Patil P, Shrivastava SK. Formulation, Evaluation and Optimization of Fast Dissolving Oral Film of Selective Antihypertensive Drug. World J Pharm Pharm Sci., 2014; 3(8): 996–1060.

29. El Nashar NF, Donia AA, Mady OY, El Maghraby GM. Formulation of clarithromycin floating microspheres for eradication of Helicobacter pylori. J Drug Deliv Sci Technol [Internet]. 2017; 41: 213–21. Available from: http://dx.doi.org/10.1016/j.jddst.2017.07.016
30. Thakur N, Bansal M, Sharma N, Yadav G, Khare P. Overview "A Novel Approach of Fast Dissolving Films and Their Patients." Adv Biol Res (Rennes). 2013; 7(2): 50–8.
31. Senthilkumar K, Vijaya C. Formulation Development of Mouth Dissolving Film of Etoricoxib for Pain Management. Adv Pharm., 2015; 2015: 1–11.
32. Allam A, Fetih G. Sublingual fast dissolving niosomal films for enhanced bioavailability and prolonged effect of metoprolol tartrate. Drug Des Devel Ther., 2016; 10: 2421–33.
33. Zaman M, Qureshi S, Sultana K, Hanif M, Mahmood A, Shaheryar ZA, et al. Application of quasi-emulsification and modified double emulsification techniques for formulation of tacrolimus microsponges. Int J Nanomedicine., 2018; 13: 4537–48.
34. Liew K Bin, Odeniyi MA. Application of freeze-drying technology in manufacturing orally disintegrating films. Pharm Dev Technol [Internet]. 2016;21(3):346–53. Available from: http://dx.doi.org/10.3109/10837450.2014.1003657
35. Mahboob MBH, Riaz T, Jamshaid M, Bashir I, Zulfiqar S. Oral Films: A Comprehensive Review. Int Curr Pharm J. 2016; 5(12): 111–7.
36. Sultana S, Rao K, Swati S, Vani T. Formulation and evaluation of herbal fast dissolving buccal film containing curcumin. world J Pharm Pharm Sci., 2018; 7(4): 1617–35.
37. Khavrona M, Benzel I, Fedin R, Pinyazhko O. Application of extract of geranium palustre herb as a dental film in. Int J Pharm Sci Res., 2018; 9(11): 4849–53.
38. Daud AS, Sapkal NP, Bonde MN. Development of Zingiber officinale in oral dissolving films: Effect of polymers on in vitro, in vivo parameters and clinical efficacy. Asian J Pharm., 2011; 5(3): 183–9.
39. Auda SH, Salem-Bekhit MM, Alanazi FK, Alsarra IA, Shakeel F. Antimicrobial evaluation of novel buccoadhesive films containing Myrrh extract. Polym Bull., 2017; 74(10): 4041–54.
40. Maheswari KM, Devineni PK, Deekonda S, Shaik S, Uppala NP, Nalluri BN. Development and Evaluation of Mouth Dissolving Films of Amlodipine Besylate for Enhanced Therapeutic Efficacy. J Pharm., 2014; 2014: 1–10.