Original Research Article

Comment [n1]: Journal writing rules should be revised.

Mouth Dissolving Tablets of Favipiravir using superdisintegrants for the treatment of Covid-19: Preparation, Optimization and *In-Vitro* Evaluation

Comment [n2]: Super disintegrants

ABSTRACT:

Comment [n3]: ABSTRACT
To formulate and evaluate the mouth dissolving tablet dosage forms of favipiravir using various super disintegrants by using wet granulation technique.
Batches of favipiravir Mouth dissolving tablets were formulated by using wet granulation technique. The formulated granules were evaluated for their flow properties as a pre-compression parameter and the friability, hardness, disintegration, wetting ratio, wetting time, dissolution, and drug release parameters were evaluated as post-compression parameters. The effect of the varying concentrations of super disintegrants on the formulation for disintegration time was ascertained and the results were compared.
The tablet had friability and hardness values ranging from 0.60±0.04 to 0.68±0.04%, and 3.9±0.057 to 4.3±0.21(kg/cm^2). Tablet weights did not vary significantly but the disintegration time varied from 44.66±057 to 142.66±2.51min and the wetting time varied from 45.33±0.57 to 144±3.06 min and the optimal batch of tablets shows a drug release of 98.8% within 60 min and first-order release kinetics of the formulations are compared.

AIM:

To formulate and evaluate the mouth dissolving tablet dosage forms of favipiravir using various super disintegrants by using wet granulation technique.

METHOD:

Batches of favipiravir Mouth dissolving tablets were formulated by using wet granulation technique. The formulated granules were evaluated for their flow properties as a pre-compression parameter and the friability, hardness, disintegration, wetting ratio, wetting time, dissolution and drug release parameters were evaluated as post-compression parameters. The effect of the varying concentrations of super disintegrants on the formulation for disintegration time was ascertained and the results were compared.

RESULT:

The tablet had friability and hardness values ranging from 0.60±0.04 to 0.68±0.04% and 3.9±0.057 to 4.3±0.21(Kg/cm^2). Tablet weights did not vary significantly but the disintegration time varied from 44.66±057 to 142.66±2.51min and the wetting time varied from 45.33±0.57 to 144±3.06 min and the optimal batch of tablets shows a drug release of 98.8% within 60 min and first-order release kinetics of the formulations are compared.

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Keywords: Favipiravir, Super disintegrants, crospovidone, croscarmellose sodium, sodium starch glycolate, wetting time, wetting ratio, disintegration time.

1.INTRODUCTION:

Comment [n8]: 1. INTRODUCTION

The US FDA, Centre for Drug Evaluation and Research (CDER) defines an orally Disintegrating tablet as an "a solid dosage form containing medicinal substances, which disintegrates rapidly, usually within a matter of seconds, when placed upon tongue" [1]. The European Pharmacopeia defines a similar term, orodisperse, a tablet that can be placed in the mouth where it disperses rapidly before swallowing. [2]

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Recent market studies indicate that more than half of the patient prefer ODT. As of 2020 analytics, north America is having a consumption market share value of nearly40.5%, Europe is having a market share of 31.6%, China, South America, Asia-pacific, middle east Asia and

Comment [n12]: patients

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Africa are also a major market for oral disintegrating tablets. The expected market for ODT will reach21300 million USD by 2024 from 11200million USD in 2019. [3]

The extent of the solubility of drug influences the rate of absorption of the drug. The quicker the drug dissolves into the solution, the faster the absorption and faster the onset of clinical action of the drug. [4][5] the medicament should readily dissolve or disintegrate in the saliva within or less than a minute. A very little amount of saliva is sufficient for the oral disintegration of the medicament in the oral cavity and the drug is then absorbed partially or entirely into the systemic circulation from the blood vessels of the sublingual mucosa or it can be swallowed as a solution into the GIT. [4] The sublingual route produces a faster onset of action orally ingested tablets and surpasses the hepatic first-pass metabolism.[6]

Fast dissolving drug delivery system is quickly picking up acceptance in this pandemic as a significant novel drug delivery system. the fast-dissolving formulation is so popular since they are easy in administration for better patient compliance. Pediatric and geriatric patients have difficulty in swallowing the conventional dosage forms where fast dissolving tablets shows great feasibility to them in accepting the medication easily by placing the tablet on the tongue and it dissolves or disintegrates in the oral cavity. [4][7]

ODT is formulated by a various process, which differs in the methodologies and finds differences in the various physical and chemical properties of the tablet such as Mechanical strength, taste, swallowability, drug dissolution, bioavailability and stability of the drug. ODT's can be formulated by various methodologies such as Freeze-Drying or Lyophilization, Cotton candy process, moulding, spray drying, mass extrusion and mass extrusion and compaction (wet granulation, dry granulation, direct compression). [4]

1.1DRUG PROFILE:

In the trend of drug repurposing for the treatment of the COVID-19, favipiravir has shown a quick service in treating the pandemic before the vaccine. Favipiravir (T-705; 6-fluoro-3-hydroxy-2-pyrazine carboxamide) is an antiviral agent that selectively inhibits the RNA-dependent RNA polymerase (RdRp) of RNA viruses. It is a synthetic prodrug which was initially used in the treatment of the influenza infections. [8-10]

It is having good bioavailability (97.6%), 54% protein binding and a low apparent volume of distribution(15-20L).

The C_{max} is attained after 2Hrs of administration. Both T_{max} and half-life increases after multiple doses. It having a very short half-life of 2.5-5 h which is rapidly eliminated in the hydroxylated from. Favipiravir shows both dose-dependent and time-dependent pharmacokinetics. [9]

Favipiravir undergoes ribosylation and phosphorylation intracellularly to become the active favipiravir RTP. The active form binds to and inhibits RNA dependent RNA polymerase (RdRp), which in turn prevents viral transcription and replication of the viral genome and also there are several hypotheses in the mechanism of action of favipiravir like incorporated in the viral RNA strand and preventing it from further extension and also hypothesis was that it induces

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Comment [n26]: 1.1 DRUG PROFILE

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lethal mutagenesis in vitro during the influenza viral infection. [9,10]

In the present research work, a wet granulation method was employed in the manufacture of ODT considering the pre-compression studies of the excipients and the hardness of the tablet.

2.MATERIALS AND METHODS:

2.1Matrials:

Favipiravir API was received as a gift sample from Biophore limited. Hyd. Mannitol is used as a diluent. Starch paste has used a binder for the granulation process. Sodium starch Glycolate, Croscarmellose sodium USP-NF (AC-Di- Sol) (from FMC biopolymer), Crospovidone(from FMC biopolymer) were used as super disintegrants. Aspartame (Loba chemicals) is used as a sweetening agent, Magnesium stearate and talc (from Ferro industries) were used as glidant and lubricant.

Various equipment was used for the preparation of the mouth dissolving tablets such as Electronic balance (Essae digi), UV-Visible Spectrophotometer (UV-1700 Shimadzu), Hot Air Oven(Centex), Sieve shaker(Ganson), Vernier Callipers (Mitutoyo), Glassware(Borosil), Digital pH meter(Susima Technologies Ltd), Friabilator(EF-2, Electro lab, Mumbai, Hardness tester, Dissolution apparatus(Lab India Disso 8000), Disintegration Apparatus(Lab India), Bulk density apparatus(Electrolab) and tablet punching machine(VJ Instruments).

2.2FORMULATION AND PREPARATION OF ODT TABLETS BY WET GRANULATION METHOD:

Favipiravir, other excipients were accurately weighed and mixed in geometric proportion as shown in the table 1. The starch paste of 5% was prepared and added to the mixture as a binder to prepare a wet mass. Granules were prepared by passing the wet mass through the sieve no.#16. Granules were dried at 60 C for 45 mins. Granules were then mixed with talc, magnesium stearate as shown in the table. granules were evaluated for the pre-compression studies.

Table 1. Formulation table

S.No	Ingredients	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
1	Favipiravir	200	200	200	200	200	200	200	200	200	200
2	Mannitol	80	65	50	80	65	50	80	65	50	56
3	Sodium Starch Glycollate	15	30	45	-	-	-	-	-	-	15
4	CCS	-	-	-	15	30	45	-	-	-	15
5	Cross povidone	-	-	-	-	-	-	15	30	45	15
7	Aspartane mg	1	1	1	1	1	1	1	1	1	1
8	Magnesium Stearate	3	3	3	3	3	3	3	3	3	3
9	Talc	1	1	1	1	1	1	1	1	1	1

Table -1: Formulation table

Comment [n33]: 2. MATERIALS AND METHODS

Comment [n34]: 2.1 Matrials

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Comment [n37]: 60 °C

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Comment [n39]: Table 1. Formulation table

10	Starch Paste (5%w/v)	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s

Table -1: Showing the formulations and PREPARATION of TABLETS

2.3 EVALUATION:

2.3.1 DRUG EXCEPIENT COMPATIBILITY:

The compatibility between the excipients and the drug was done using the FTIR pellet press technique using potassium bromide and the obtained graphs were observed for their spectra wavelengths.

2.3.2 PREPARATION OF STANDARD GRAPH OF FAVIPIRAVIR:

10mg of favipiravir was dissolved in 10ml of water using cyclo mixer. This solution is referred to as a standard solution. From the standard solution make 10µ/ml stock solution was made and measured for the maximum wavelength obtained using UV-VIS spectrophotometer. The obtained wavelength is selected as λmax. The obtained spectrum is 235nm. Different stock solutions of 3,6,9,12,15µg/ml were prepared and observed for their linearity. The standard curve was plotted.

Comment [n40]: 10 mg

Comment [n41]: a cyclo

Comment [n42]: 10 µ/ml

Comment [n43]: 235 nm

Comment [n44]: 3,6,9,12,15 µg/ml

2.3.3 EVALUATION OF THE GRANULES:

2.3.3.1 The angle of repose:

The angle of repose was evaluated by using the funnel method. The granules were poured through the funnel that can be raised vertically until a maximum cone height (h) was obtained. The radius of the heap (r) was measured and the angle of repose was calculated using the below formula:[6]

Comment [n45]: Formula [6].

$$Tan\ \theta = h/r$$

Where θ is the angle of repose.

2.3.3.2 Tapped density:

Tapped density is determined by placing a graduated cylinder containing a known mass of granules and mechanical tapper apparatus, which is operated for an affixed number of times until there is no more change in the volume was attained. Using the formula, the tapped density was calculated:[6]

Comment [n46]: Calculated [6].

Tapped density =Weight of the granules/ tapped volume of the granules

2.3.3.3 Carr's compressibility index:

The Bestway for finding out the free flow of the granules is compressibility index; it is the indication for the ease of flow of the granules it is calculated by the given formula: [11]

$$\textbf{Carr's Index (\%)} = \frac{\textit{Tapped Density} - \textit{Bulk Density}}{\textit{Tapped density}} \times 100$$

2.3.3.4 Hausner's ratio:

It is the indirect index for the ease of powder flow. It is calculated by the following formula:[11]

$$\textbf{Hausner's ratio} = \frac{\textit{Tapped Density}}{\textit{Bulk density}}$$

2.3.4 EVALUATION OF POST COMPRESSION PARAMETERS OF TABLETS:

The formulations were evaluated for the hardness, weight variation, tablet size and thickness, friability, disintegration time, in-vitro dispersion time, wetting time and water absorption ratio, assay, content uniformity and in vitro dissolution.

2.3.4.1APPEARANCE: The general appearance characteristics of the tablet was evaluated such as tablet size, shape colour, presence or absence of the odor, taste, surface texture.

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2.3.4.2HARDNESS:

The hardness of the tablet was measured by diametric compression using a Monsanto Hardness Tester. Tablet was placed between the two anvils, force to the anvils and the crushing strength that causes the tablet to break was recorded. A tablet hardness of about 2-4 Kg/cm^2 is taken as adequate for mechanical stability of the ODT [12]

Comment [n49]: kg/cm^2

Comment [n50]: ODT [12].

2.3.4.3Weight variation:

Twenty tablets were selected randomly during compression and the mean weight was measured. Then individual tablets were weighed was compared with the mean weight and none of the tablets should deviate from the mean weight by more than $\pm$10%.[12]

2.3.4.4THICKNESS:

The thickness of the tablets from each of the formulation was measured using vernier callipers by placing the tablet between two arms of the vernier callipers, which is measured in mm.

Comment [n51]: calipers

Comment [n52]: calipers

2.3.4.5FRIABILITY:

It is performed to measure the effect of friction and shock, which may cause the tablet to chip, cap, or break. The friability of the tablet was measured in a Roche friabilator. This device subjects several tablets to the combined effect of abrasion and shock by using a plastic chamber that revolves at 25 rpm/min for 4 min dropping the tablet at a distance of 6inches with each revolution. Pre weighed tablets were placed in the friabilator and after de-dusting, the tablets are reweighted.[13]

The per cent friability was measured using the formula:

Comment [n53]: percent

Friability (%) = [(Initial Weight-Final weight)/ (Initial weight)] ×100

2.3.4.6UNIFORMITY OF DRUG CONTENT: The drug content uniformity test was used to determine the uniform amount of active ingredient present in all formulations. The tablets are selected randomly and pulverized to a fine powder. the powder equivalent to 100mg of favipiravir was taken and dissolved in 10ml of distilled water in a volumetric flask, the volume was adjusted to 100ml with phosphate buffer pH 6.8 and the solution was filtered an aliquot of 1.0ml of solution were diluted to 10ml phosphate buffer pH 6.8 in a separate volumetric flask. The drug content in all the formulations was estimated spectrophotometrically using UV Spectrophotometer with λ max at 235nm [13-14]

2.3.4.7In-Vitro Disintegration Time:

The test was performed using disintegration apparatus. A tablet was placed in each of the six tubes of the apparatus the basket with the bottom surface made of a stainless-steel screen was immersed in a water bath at 37±2^{o} C and one perforated disc was placed on each of the tubes. The time in seconds was recorded for completed disintegration of the tablet with no remnants of the palpable mass in the apparatus.[15]

2.3.4.8In Vitro Dispersion Time:

In vitro dispersion time was measured by dropping a tablet in 10ml measuring cylinder containing 6ml

of buffer solution simulating the saliva fluid. (pH 6.8).[16]

2.3.4.9WETTING TIME AND WATER ABSORPTION TEST: Wetting time is used to test the inner porosity of the tablet and the hydrophilicity of the excipients. The pore size decreases and the wetting time increases with an increase in the compression force. A linear relationship exists between the wetting time and the disintegration time. A piece of the tissue paper folded twice was placed in a small Petri dish of an internal diameter of 6.5cm containing 6ml of distilled water. A tablet was placed on the paper, and the time for complete wetting of the tablet was measured in seconds.

The same procedure was repeated for determining the water absorption ratio. The wetted tablet was then weighed. Water absorption ratio, r, was determined according to the following equation.[17]

R={(Wa-Wb)/Wa} *100

Wa=weight of the tablet before the study

Wb= weight of the tablet after study

R= water absorption ratio.

***2.3.4.10In-Vitro* DRUG RELEASE STUDIES:**

The release rate of Favipiravir from the fast-dissolving tablet was determined by using the USP dissolution testing apparatus II (Paddle type). The dissolution test was performed using 900ml of

Comment [n54]: 100 mg

Comment [n55]: 1.0 ml

Comment [n56]: **2.3.4.6 UNIFORMITY OF DRUG CONTENT**
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Comment [n57]: 2.3.4.7 *In-Vitro* Disintegration Time

Comment [n58]: *2.3.4.7 In-Vitro Disintegration Time*

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Comment [n62]: **2.3.4.8 *In Vitro* Dispersion Time**

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Comment [n64]: In vitro dispersion time was measured by dropping a tablet in 10 ml measuring cylinder containing 6 ml of buffer solution simulating the saliva fluid. (pH 6.8) [16].

Comment [n65]: *2.3.4.9 Wetting Time And Water Absorption Test*

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Comment [n69]: *2.3.4.10 In-Vitro Drug Release Studies*

phosphate buffer pH-6.8 as dissolution medium at50rpm and temperature 37+0.5 C. at predetermined time intervals, 5ml of the sample was withdrawn using the syringe fitted to a free filter, the volume withdrawn at each interval was replaced with the same quantity of fresh medium. the resultant samples were filtered through watmann filter paper no.41 and analyzed for the presence of the drug release by measuring the absorbance at 235 nm (from graph-4) using UV visible spectrophotometer after suitable dilutions. [18-20]

Comment [n70]: 37+0.5°C

3.RESULTS AND DISCUSSIONS:

3.1 RESULTS:

3.1.1 STANDARD CALIBRATION GRAPH: The prepared stock solutions were observed for absorbance at wavelength 235nm shown in the Graph a and Graph b was plotted using excel.

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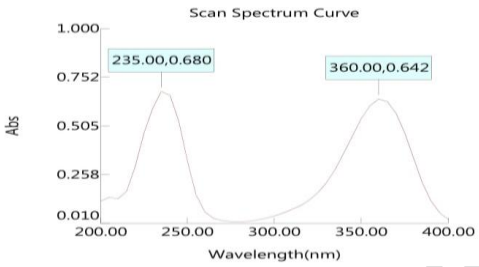
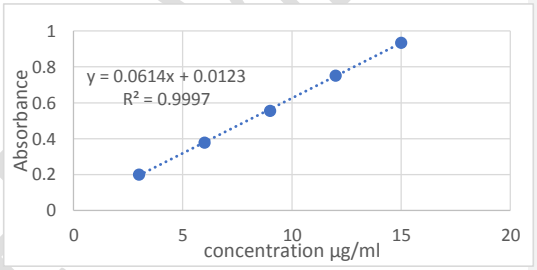


Graph a : UV spectrum Standard graph



Graph b: Standard calibration Graph of Favipiravir

3.1.2 GRANULES PROPERTIES:

The physical properties were evaluated for the prepared granules of all the formulation from-1 to F-10 as shown in Table no.2. Results of the bulk density were in the ranged of 1.17±0.01 to 1.23±0.02, the tapped density ranged from 1.38±0 to 1.48±0.02, the angle of repose ranged from 20.95±0.71 to 29.85±0.71,% of compressibility ranged from 13.50±1.42 to 17.51±0.26, and the Hausner's ratio ranged from 1.15±0.02 to 1.19±0.02.

Comment [n72]: 29.85±0.71, Not %

Table 2. Precompression parameters of the formulations; n=3

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Formulation code	Angle of repose	Bulk density	Tapped density	% of compressibility	Hausner's Ratio
F1	24.54±1.84	1.23±0.02	1.45±0.02	14.87±2.85	1.174±0.03
F2	23.78±1.46	1.21±0.03	1.40±0.02	13.50±1.42	1.15±0.02
F3	25.68±1.66	1.25±0.02	1.48±0.02	17.51±0.26	1.19±0.02
F4	28.64±0.43	1.23±0.02	1.45±0.02	14.91 ± 0.10	1.17±0.02
F5	29.85±0.71	1.22±0.01	1.38±0.02	11.34±1.66	1.12±0.02
F6	29.16±2.73	1.18±0.01	1.36±0.01	13.22±1.20	1.14±0.01
F7	22.63±1.23	1.18±0.01	1.39±0.02	15.29±1.33	1.17±0.02
F8	22.55±3.5	1.17±0.01	1.34±0.05	15.21±1.25	1.17±0.01
F9	23.14±0.60	1.19±0.01	1.40±0.02	15.17±1.67	1.17±0.02
F10	20.95±0.71	1.19±0.01	1.39±0.02	14.08±1.96	1.16±0.02

Table -2: Pre compression parameters of the formulations; n=3

3.1.3 TABLETS PROPERTIES:

Table 3 shows the tablet properties of all the prepared formulations were evaluated as the post-compression parameters, the hardness of the tablet ranged from 3.9±0.057 to 4.3±0.21, the thickness of the tablet ranged from 3.5±0.1 to 3.73±0.115, the Percent friability ranged from 0.60±0.04 to 0.68±0.04 and all the formulations pass the % weight variation and % drug content. Where all the formulations are suitable for the compression of the tablet.

Formulation code	Hardness (Kg/cm^2)	Thickness (mm)	Friability (%)	% weight variation	Drug content(%)
F1	4.0± 0.152	3.4±0.208	0.62±0.07	Pass	198.6±0.76
F2	4.1±0.057	3.5±0.10	0.60±0.04	Pass	197.8±1.04
F3	4.0±0.208	3.6±0.152	0.65±0.09	Pass	198.16±1.15
F4	4.3±0.210	3.73±0.115	0.68±0.04	Pass	199.16±1.04
F5	4.2±0.251	3.6±0.115	0.66±0.02	Pass	199.33±1.15
F6	3.9±0.057	3.5±0.057	0.64±0.01	Pass	199.66±0.57
F7	3.9±0.152	3.5±0.057	0.64±0.02	Pass	199.16±1.04
F8	4.06±0.115	3.5±0.120	0.63±0.02	Pass	199.83±0.28
F9	4.16±0.152	3.7±0.115	0.62±0.01	Pass	199.66±0.28
F10	4.15±0.13	3.7±0.057	0.63±0.01	Pass	199.83±0.28

Comment [n74]: kg/cm^2

Table -3: Post compression parameters of the formulations; n=3

Table4 shows the disintegration properties of all the formulations, disintegration time ranges from 44.66±0.57 to 142.66±2.51 minutes, wetting time ranges from 45.33±0.57 to 144±3.060 minutes and water absorption ratio ranges from 21.75±2.17 to 71.5±2.27. where F10 has shown good disintegration properties suitable for fast MDT.

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FORMULATION CODE	DISINTEGRATION TIME	WETTING TIME	WATER ABSORPTION RATIO
F1	75.66±1.52	77.33±2.08	52.1±0.13
F2	66.66±2.72	73.33±1.15	45.31±0.81
F3	59.66±2.08	60.66±2.30	33.21±1.52
F4	76.66±2.08	77.66±2.30	48.68±0.57
F5	71.33±1.04	73.66±1.52	43.21±1.52
F6	62.23±2.60	64.33±1.15	36. 16 ± 0.56
F7	128.33±1.5	131.66±1.5	24.28±0.24
F8	138.66±2.04	134.33±2.04	22.57±1.33
F9	142.66±2.51	144. 25 ± 3.06	73.75±2.17
F10	44.66±0.57	45.33±0.57	71.50 ± 2.27

Table -4: Post compression parameters of the formulations; n=3

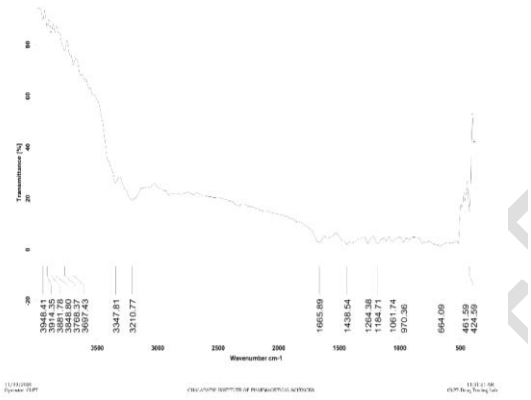


Fig:1 FR-IR of pure drug (Favipiravir)

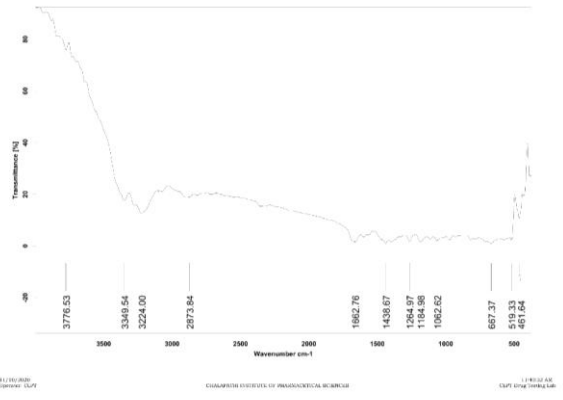


Fig:2 FR-IR of pure drug and CCS

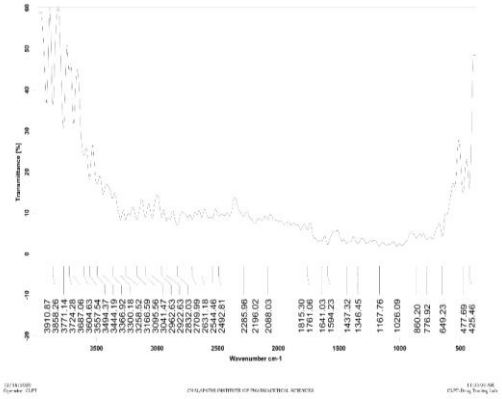


Fig:3 FR-IR of pure drug and SSG

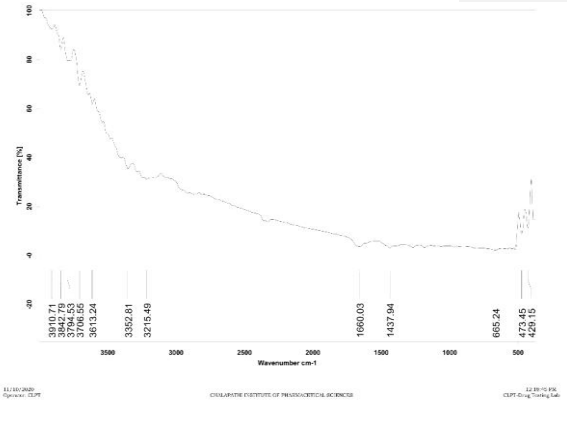


Fig:4 FR-IR of pure drug and CPV

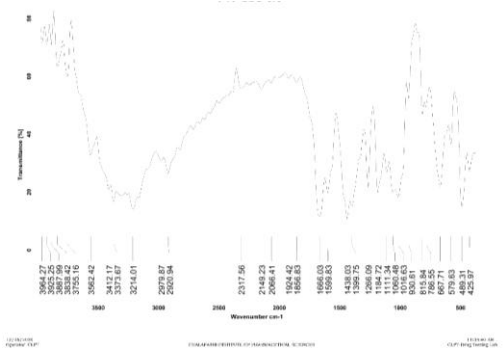
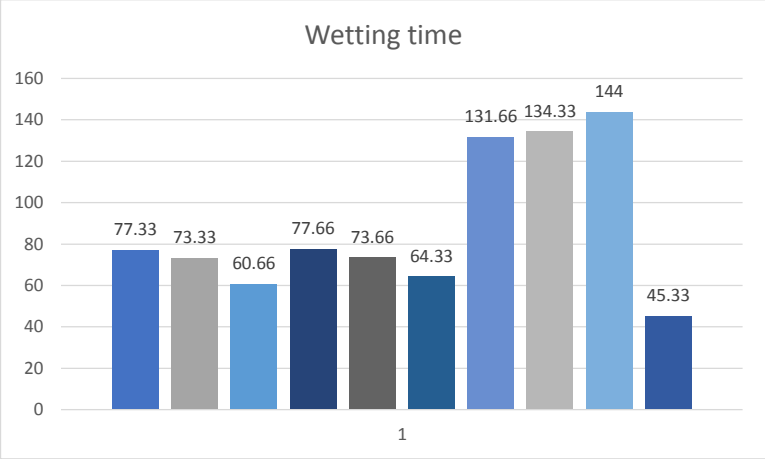
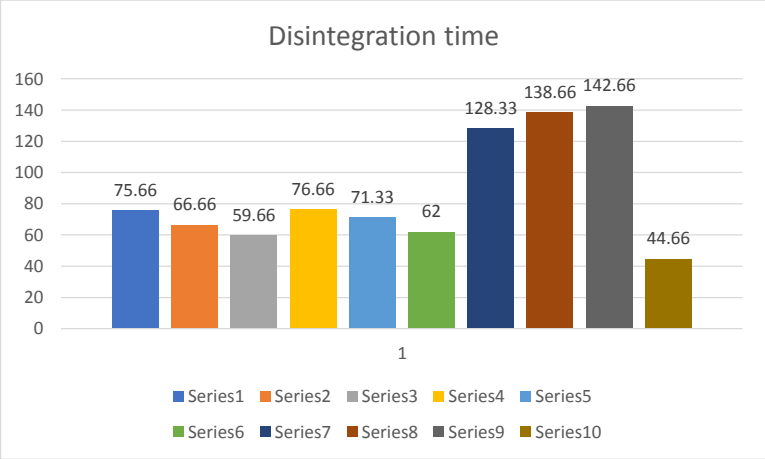


Fig:5 FR-IR of F-10 formulation



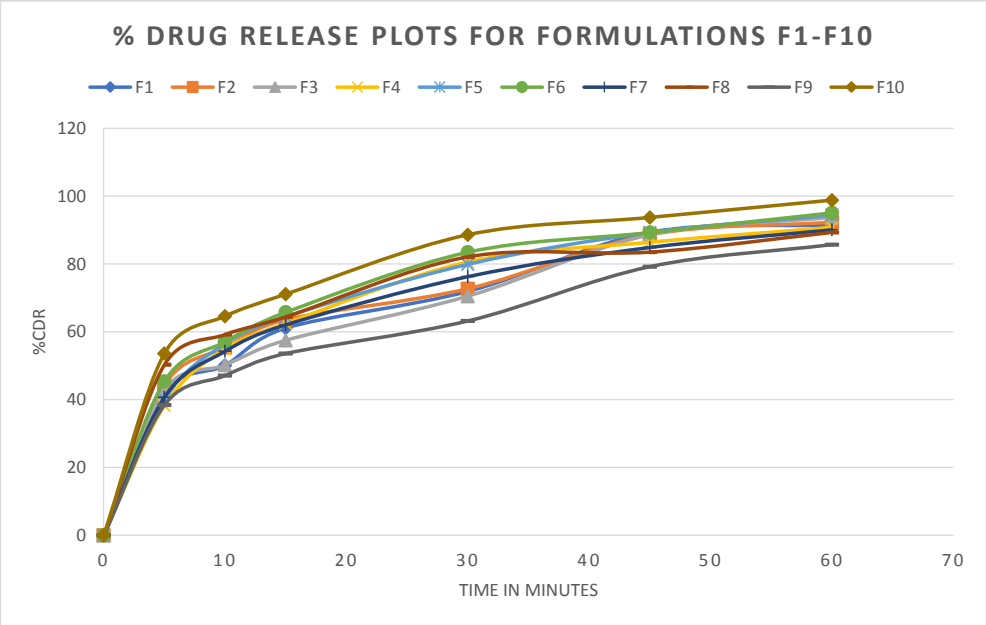
Graph 1: Wetting time for formulations F1-F10

Comment [n77]: Graph 1. Wetting time for formulations F1-F10

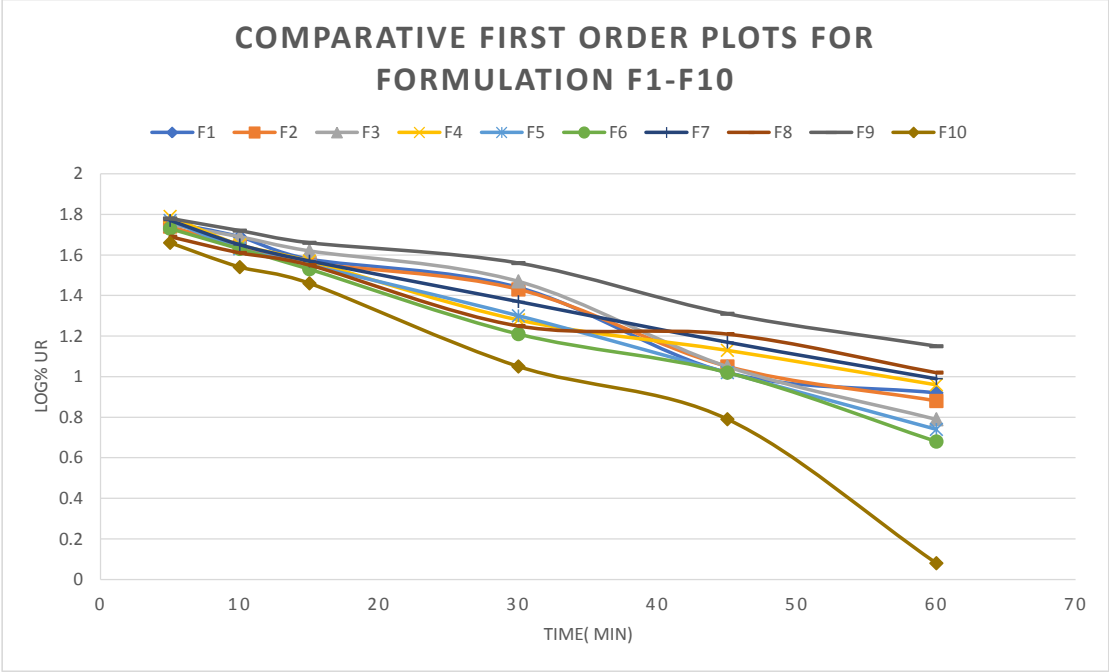


Graph 2: Disintegration time for formulations F1-F10

Comment [n78]: Graph 2.



Graph 3: % drug release plots for formulations F1-F10



Graph 4: First order release plots for formulations F1-F10

3.2 DISCUSSIONS:

The FT-IR images in the figure1 to figure5 shows no interactions between the drug and the excipients used in the formulation.

From the obtained results it was very clear that all the pre-compression parameters of the granules were suitable for the compression of the tablet which is in the good range. The hardness of the tablets are in the considerable range of which F1 shows less hardness, the thickness is within the range, the friability of all the tablets was less than 1% which is a permissible limit.

the disintegration time is directly proportional to the wetting time, On comparison of Disintegration and wetting time (from graph 2,1) F10 has given good results which get disintegrates in less than a minute and suits the pharmacopeial definition. The dissolution studies mentioned in the Graph -3, F- 10 has shown more than 50% drug release within 5 minutes and 98.8% drug release in 60 minutes at pH6.8 buffer solution. From the Graph-4 the optimized

Comment [n79]:

Comment [n80]: Not the

Comment [n81]: have

Comment [n82]: pH 6.8
gap

Comment [n83]: not the

formulation F10 has shown regression of 0.9714 which concludes that it follows first-order release kinetics.

4.CONCLUSION:

The present research work predicts the applicability of various super disintegrants such as Croscarmellose sodium, crospovidone, and sodium starch glycolate in the formulation and the development of the mouth dissolving tablet formulations of favipiravir. The tablets were successfully prepared using Wet Granulation technique using various concentrations of different super disintegrants and from the results, it was clearly understood that the formulation containing 5%of crospovidone, 5%croscarmellose sodium and 5% Sodium starch Glycolate as super disintegrants were found to be the best formulation in terms of the disintegration and the rate of dissolution.

Comment [n84]: the wet

Comment [n85]: 5% croscarmellose gap

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Comment [n86]: REFERENCES

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