Formulation And Evaluation Of Fast Dissolving Tablet: Ibuprofen

Vaishnavi D. Lahane, Vaishali R. Mehetre, Vaishnavi S. Jadhav, Vaishnavi S. Mandave, Tejaswini B. Gawai, Abhaykumar D. Sakhare, R. H. Kale, K. R. Biyani

Anuradha College of Pharmacy, Chikhli, Dist.Buldhana – 443201, Maharashtra, India

*Corresponding Author: Vaishnavi D. Lahane | Email: vaishnavidipaklahane@gmail.com

Abstract

The study focused on developing and evaluating fast-dissolving ibuprofen tablets to address its limitations, including poor solubility, a short half-life, and gastric irritation. Super disintegrants were incorporated to enhance drug dissolution and absorption. Two approaches were used: first, varying concentrations of sodium starch glycolate (2.5–6.25%) were tested, and second, different super disintegrants (sodium starch glycolate, croscarmellose sodium, and crospovidone) were compared at a fixed concentration. Tablets were prepared using direct compression. Results showed that increasing the concentration of sodium starch glycolate improved drug release, with 6.25% giving the best performance. Among the super disintegrants, crospovidone demonstrated the most effective and rapid disintegration, leading to enhanced dissolution.

Keywords: Ibuprofen, Arthritis, Oral Bioavailability, Orally disintegrating tablet, NSAIDs.

Introduction

Fast-disintegrating tablets (FDTs) are an advanced oral solid dosage form designed to disintegrate or dissolve quickly when placed on the tongue, typically within a few seconds, without the need for water. These formulations contain active pharmaceutical ingredients along with excipients that facilitate rapid breakup of the tablet matrix in the presence of saliva, ensuring ease of administration and improved patient convenience. Among the various manufacturing approaches, direct compression is one of the most commonly employed techniques due to its simplicity, cost-effectiveness, and suitability for large-scale production. This method involves the incorporation of specialized excipients known as superdisintegrants, which play a critical role in promoting rapid tablet disintegration.

Superdisintegrants such as croscarmellose sodium, crospovidone (cross-linked polyvinylpyrrolidone), sodium starch glycolate, and microcrystalline cellulose are widely used in FDT formulations. These materials function through mechanisms such as swelling, wicking, and deformation recovery, which collectively enable the tablet to break apart almost instantly upon contact with saliva. As a result, the drug is released quickly in the oral cavity, enhancing the onset of therapeutic action. The use of such excipients has become a fundamental strategy in the development of fast-disintegrating systems.

Difficulty in swallowing, also known as dysphagia, is a common issue observed across various patient populations, particularly among pediatric and geriatric individuals. It is also frequently encountered in patients suffering from conditions such as nausea, motion sickness, neurological disorders, or those who are bedridden or physically impaired. Conventional dosage forms like tablets and capsules often pose challenges for these individuals, leading to poor compliance and incomplete dosing. Fast-disintegrating tablets address these limitations by offering a patient-friendly alternative that does not require water for administration and can be easily consumed, thereby improving adherence to therapy.

In addition to convenience, FDTs are designed to possess adequate mechanical strength to withstand handling while still ensuring rapid disintegration and dissolution in the oral cavity. The quick dispersion of the tablet leads to faster drug dissolution and absorption, which may contribute to a rapid onset of action. Furthermore, partial absorption of the drug in the pre-gastric region (oral cavity and pharynx) can enhance bioavailability and potentially reduce the required dose. These advantages make FDTs particularly beneficial for drugs where rapid therapeutic action is desired.

The formulation of FDTs can be achieved through several techniques; however, direct compression remains highly advantageous, especially for drugs that are sensitive to heat and moisture, as it does not involve harsh processing conditions. In the present work, an attempt was made to develop and evaluate fast-disintegrating tablets of ibuprofen using optimization strategies to enhance drug dissolution and absorption. A novel superdisintegrant, starch tartrate, was explored for its effectiveness in promoting rapid tablet disintegration.

Ibuprofen is a widely used nonsteroidal anti-inflammatory drug (NSAID) that provides relief from pain, inflammation, and stiffness associated with conditions such as rheumatoid arthritis and osteoarthritis, as well as acute and chronic pain. The therapeutic effectiveness of ibuprofen is closely related to its plasma concentration; therefore, rapid absorption is essential for achieving a quick onset of analgesic action. However, ibuprofen presents several formulation challenges, including poor aqueous solubility, limited dissolution in biological fluids, a relatively short half-life of approximately two hours, and the potential to cause gastric irritation.

Due to its hydrophobic nature, ibuprofen exhibits low solubility in gastrointestinal fluids, which can result in reduced absorption and bioavailability. To overcome these limitations, the development of fast-disintegrating tablets using superdisintegrants offers a promising approach. By enhancing the dissolution rate, these formulations can improve drug absorption and therapeutic efficacy. Additionally, since the tablet disintegrates in the oral cavity before reaching the stomach, the exposure of the gastric mucosa to concentrated drug particles may be minimized, potentially reducing gastrointestinal side effects.

Another important advantage of FDTs is their compatibility with existing manufacturing infrastructure, making them economically viable and easy to scale up for industrial production. The rapid disintegration characteristic of these tablets is primarily achieved through the action of superdisintegrants, which rapidly absorb moisture, swell, and create internal pressure within the tablet structure, leading to its immediate breakup.

Ideal Properties of Fast Dissolving Tablets

1. Water is not needed for its administration.
2. It must be sensitive to environmental factors like temperature and humidity.
3. It has enough resilience to endure handling both during and after production procedures.
4. After dissolving, no residue is left in the mouth.
5. It should be adaptable to packing and processing equipment.
6. It should be capable of loading a lot of medication.
7. Its flavor should be pleasing.
8. It ought to be accessible.
9. It must be economical.

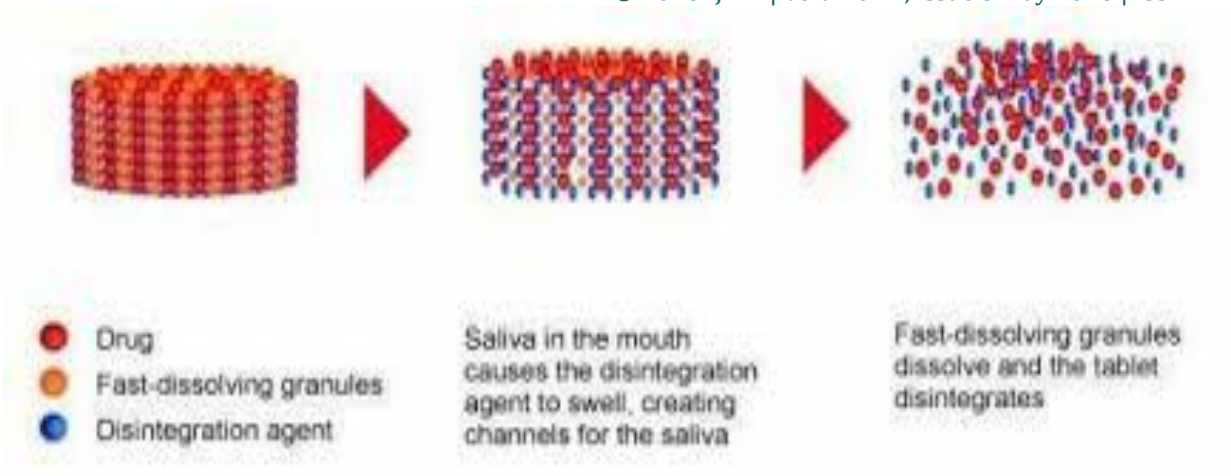


Fig 1: Mechanism of action of superdisintegrant

Criteria for Fast Dissolving Drug Delivery System

The tablets should;

Be compatible with taste masking.
It should not require water for swallowing and should rapidly dissolve or break apart in the mouth within a few seconds.
Be portable without fragility concerns. Have a pleasant mouth feel. It should leave little to no residue in the mouth after administration.
Exhibit low sensitivity to environmental conditions such as temperature and humidity.
Allow the manufacture of the tablet using conventional processing and packaging equipment at low cost.

Need for the Development of Fast-Disintegrating Tablets (FDTs)

The growing interest in fast-disintegrating tablets arises from the need to improve patient convenience, compliance, and therapeutic effectiveness. These dosage forms are particularly valuable in situations where conventional oral tablets and capsules present challenges. FDTs are designed to disintegrate rapidly in the oral cavity without the need for water, making them a practical and patient-friendly alternative to traditional solid dosage forms.

Patient-Related Factors

One of the primary reasons for developing FDTs is to address difficulties associated with swallowing conventional oral medications. A significant proportion of patients, especially pediatric and geriatric populations, experience dysphagia or discomfort when attempting to swallow tablets or capsules with water. For such individuals, fast-disintegrating tablets offer a convenient and stress-free option.

Patients who have trouble chewing or swallowing solid dosage forms benefit greatly from FDTs, as these formulations eliminate the need for mastication and reduce the risk of choking. Fear of choking itself can lead to poor adherence to prescribed therapy, and FDTs help alleviate this concern by dissolving quickly in the mouth. Elderly patients, particularly

those suffering from neurological conditions, depression, or general frailty, may also struggle with conventional dosage forms, making FDTs a more suitable alternative.

In pediatric cases, children often prefer dosage forms that are easy to administer and do not require unpleasant-tasting syrups or large tablets. For example, a young child suffering from allergies may find a fast-dissolving tablet more acceptable than a liquid formulation. Similarly, patients undergoing treatments such as radiation therapy may experience severe nausea and vomiting, making it difficult to swallow traditional medications. In such cases, FDTs provide an effective way to ensure drug intake without inducing further discomfort.

Certain psychiatric patients, including those with conditions such as schizophrenia, may intentionally avoid swallowing tablets by hiding them in the mouth. Fast-disintegrating tablets minimize this risk, as they dissolve rapidly and reduce the possibility of non-compliance. Additionally, individuals who are traveling, experiencing motion sickness, or have limited access to water can conveniently take FDTs without the need for additional fluids, further enhancing their practicality in real-life situations.

Effectiveness-Related Factors

Beyond patient convenience, FDTs also offer pharmacokinetic advantages that can improve drug effectiveness. When these tablets disintegrate in the oral cavity, the drug is released into saliva and can begin to dissolve even before reaching the stomach. This allows for partial absorption through the buccal and pharyngeal mucosa, as well as the upper gastrointestinal tract.

Pre-gastric absorption plays an important role in enhancing drug bioavailability. By allowing a portion of the drug to be absorbed before it passes through the liver, FDTs can reduce the extent of first-pass hepatic metabolism. This is particularly beneficial for drugs that undergo significant metabolic degradation in the liver, as it can lead to higher systemic availability of the active compound.

Furthermore, bypassing or reducing first-pass metabolism may help decrease the formation of potentially harmful metabolites, thereby improving the safety profile of certain medications. Drugs that are well absorbed in the oral cavity or upper gastrointestinal regions especially benefit from this mechanism, as it contributes to a faster onset of therapeutic action.

The rapid disintegration and dissolution characteristics of FDTs ensure that the drug becomes available for absorption quickly, which is crucial in conditions requiring prompt relief, such as pain, allergies, or nausea. Overall, the combination of improved patient compliance and enhanced pharmacokinetic performance makes fast-disintegrating tablets an important advancement in oral drug delivery systems.

Objectives of the Study

The present research was undertaken with the aim of developing an optimized fast- or mouth-dissolving tablet formulation of ibuprofen that can overcome the limitations associated with conventional dosage forms. The study was designed to explore formulation strategies that enhance both patient acceptability and drug performance.

One of the primary objectives was to investigate whether combining different superdisintegrants could improve the overall functionality of the formulation. Superdisintegrants play a crucial role in facilitating rapid tablet breakup, and their

combined use may produce a synergistic effect, leading to faster disintegration and improved drug release compared to using a single agent alone.

Another important goal of the study was to formulate a mouth-dissolving ibuprofen tablet that offers improved patient compliance. This is particularly relevant for individuals who experience difficulty in swallowing traditional tablets or capsules, such as pediatric, geriatric, or bedridden patients. By developing a dosage form that disintegrates quickly in the oral cavity without the need for water, the study aims to provide a more convenient and user-friendly alternative. Additionally, achieving rapid disintegration is expected to enhance the onset of therapeutic action, which is especially beneficial in conditions where quick pain relief is required.

The study also aimed to systematically evaluate the impact of different types and functional properties of superdisintegrants on key performance parameters of the tablets. Specifically, the influence of these excipients on disintegration time and the dissolution profile of ibuprofen was examined. By comparing various superdisintegrants and their mechanisms of action, the research seeks to identify the most effective formulation approach for achieving rapid drug release and optimal tablet performance.

Advantages of FDTs

- Ideal for children, elderly patients, and those with swallowing difficulties (like dysphagia).
- Convenient for on-the-go use or in situations where water isn't available.
- The drug can dissolve and be absorbed faster, sometimes even partly through the oral mucosa.
- Pleasant taste and easy intake increase medication adherence.
- Safer compared to conventional tablets for certain patient groups.
- Provides precise dosage compared to liquids.

Disadvantages of FDTs

- These tablets are often fragile and can break easily during handling or packaging.
- They can degrade quickly in humid conditions, requiring special packaging.
- Not suitable for drugs that require high doses.
- Bitter drugs need effective masking, which can complicate formulation.
- Manufacturing and packaging can be more expensive than conventional tablets.
- Often need controlled environments to maintain stability.

Medications formulated for use in fast-dissolving drug delivery systems.:

Examples: some drugs that are best for FDTs are:

- **Analgesic Andante-Inflammatory drugs**: Mefenamic acid, Ibuprofen, Proxicam.
- **Anti-Bacterials:** Erythromycin, Tetracycline, Doxycycline, and Rifampicin.
- **Anti-Fungals:** Griseofulvin, Miconazole.
- **Anti-Malarials:** Chlorquine, Amodiaquine.

- **Anti-Gout drugs:** Allopurinol, Probenecid.
- **Anti-Hypertensive drugs:** Amlodipine, Nefidipine.
- **Anti-Coagulants:** Tolbutamide, Glipizide.
- **Anti-Protozoals:** Benznidazole, Tinidazole.
- **Anti-Thyroid drugs:** Carbimazole.
- **Cardiac Inotropic drugs:** Digitoxin, Digoxin.
- **Gastrointestinal drugs:** Omeprazole, Ranitidine, Fomotidine.
- **Nutritional Agents:** Vitamin A, Vitamin B, Vitamin D, etc.
- **Oral Vaccines**: Influenza, Hepatitis, Polio, Tuberculosis, etc.

Methods And Materials

List of Materials

Sr no	Ingredients	Use
1.	Ibuprofen	API
2.	Sodium starch glycolate	Superdisintegrant
3.	Croscarmellose sodium	Superdisintegrant
4.	Crospovidone	Superdisintegrant
5.	Mannitol	Diluent
6.	Microcrystalline cellulose	Binder & Diluent
7.	Avicel pH 102 tablet	disintegrant
8.	Talc	Glidant & Lubricant
9.	Magnesium stearate	Lubricant
10.	Vanilla	Flavoring agent

Characteristics of Ibuprofen

1. Rapid Disintegration

- Typically disintegrate within 30–60 seconds when placed on the tongue.
- Achieved using superdisintegrants like croscarmellose sodium or sodium starch glycolate.

2. Improved Patient Compliance

- Ideal for pediatric, geriatric, and dysphagic patients (those with difficulty swallowing).
- No need for water, making them convenient for on-the-go use.

3. Taste Masking

- Since ibuprofen has a bitter taste, FDTs include flavoring agents and sweeteners (e.g., aspartame, mannitol) to enhance palatability.

4. Fast Onset of Action

- Quick disintegration and dissolution may lead to faster absorption compared to conventional tablets, giving quicker pain relief.

5. Porous Structure

- Manufactured using techniques like freeze-drying, direct compression, or sublimation, resulting in a highly porous matrix that promotes rapid water uptake.

6. Adequate Mechanical Strength

- Despite being porous, tablets must have sufficient hardness and low friability to withstand handling and packaging.

7. Enhanced Dissolution Profile

- Increased surface area after disintegration leads to improved dissolution rate of ibuprofen.

8. Low Moisture Sensitivity

- Formulation should minimize sensitivity to humidity, although many FDTs require special packaging (e.g., blister packs).

9. Uniform Drug Content

- Each tablet must maintain dose uniformity, ensuring consistent therapeutic effect.

10. Stability

- Should remain chemically and physically stable throughout shelf life, with no degradation of ibuprofen.

Method for Preparation

The formulation of fast-dissolving tablets (FDTs) largely depends on certain critical factors, among which the selection of an appropriate superdisintegrant and the optimization of its concentration are of primary importance. These components play a decisive role in ensuring rapid tablet disintegration and efficient drug release. An ideal fast-dissolving tablet should disintegrate or dissolve quickly in the oral cavity, typically within 15–60 seconds, without the need for water, while also providing a smooth and pleasant mouthfeel to enhance patient acceptability.

In the present study, fast-dissolving tablets of ibuprofen were developed using the direct compression technique, a widely preferred method due to its simplicity, cost-effectiveness, and suitability for heat- and moisture-sensitive drugs. The formulation incorporated essential excipients such as superdisintegrants to promote rapid disintegration, along with microcrystalline cellulose, which acts as a filler and also contributes to disintegration due to its wicking properties. Croscarmellose sodium was included as a key superdisintegrant because of its ability to rapidly absorb water and swell, thereby facilitating quick tablet breakup.

For the preparation process, ibuprofen equivalent to 100 mg was accurately weighed and blended with mannitol and microcrystalline cellulose in a glass mortar using a pestle to ensure uniform mixing. Mannitol was used not only as a diluent but also to impart a pleasant cooling sensation and improve the overall mouthfeel of the tablet. After achieving a homogeneous mixture, the selected superdisintegrants were added in specific quantities according to the formulation design and thoroughly mixed to ensure even distribution throughout the powder blend.

Subsequently, additional excipients such as aspartame were incorporated as a sweetening agent to enhance palatability, while talc and magnesium stearate were added as glidant and lubricant, respectively, to improve the flow properties of the powder and prevent sticking during compression. The entire blend was then passed through sieve number 80 twice to achieve uniform particle size distribution and ensure proper mixing of all components.

Direct Compression

Direct compression is a tablet manufacturing technique in which the active pharmaceutical ingredient (API) is blended with suitable excipients and compressed directly into tablets without undergoing any prior processing steps such as granulation. This method is widely recognized for its simplicity, efficiency, and cost-effectiveness when compared to conventional techniques like wet or dry granulation. By eliminating intermediate steps, direct compression reduces manufacturing time, minimizes the use of heat and moisture, and lowers the overall production cost, making it particularly suitable for moisture- and heat-sensitive drugs.

For successful tablet formation through direct compression, the powder blend must exhibit good flowability and compressibility. These properties are essential to ensure uniform die filling, consistent tablet weight, and adequate mechanical strength after compression. In this context, excipients are carefully selected not only to act as fillers or binders but also to improve the overall flow and compaction characteristics of the formulation. When the powder mixture inherently possesses these qualities, additional processing steps such as granulation become unnecessary.

In the case of mouth-dissolving or fast-disintegrating tablets, superdisintegrants play a critical role when using the direct compression method. These agents are specifically incorporated to facilitate rapid tablet breakup upon contact with saliva. Their mechanism of action typically involves swelling, wicking, or a combination of both, which accelerates the penetration of fluid into the tablet matrix and promotes quick disintegration. Therefore, the selection of an appropriate type of superdisintegrant, as well as its optimal concentration, is a key factor in achieving the desired disintegration time and dissolution profile.

Moreover, the performance of fast-dissolving tablets can be further enhanced by incorporating additional excipients such as water-soluble diluents or effervescent agents. Water-soluble excipients improve the wettability and dissolution of the tablet, while effervescent components can generate carbon dioxide upon contact with saliva, creating internal pressure that aids in faster tablet disintegration. These formulation strategies contribute to improving both the speed and efficiency of drug release.

The direct compression method, often referred to as disintegrant addition technology in the context of FDTs, is considered one of the most preferred approaches for manufacturing such dosage forms. However, it is important to note that tablet characteristics such as size, hardness, and porosity significantly influence the effectiveness of the disintegrants. Excessive hardness may delay disintegration, while insufficient mechanical strength can compromise tablet integrity during handling.

Therefore, achieving a balance between mechanical strength and rapid disintegration is crucial during formulation development.

Optimal conditions, benefits, and constraints of direct compression

s.no	Ideal requirements	Advantages	Limitations
1	flowability	Cost-effective production	Segregation
2	compressibility	Better stability of the API	Variation in functionality
3	Dilution Potential	Faster dissolution	Low dilution potential
4	Reworkability	Less wear and tear on punches	Reworkability
5	Stability	Simple validation	Poor compressibility of API
6	Control particle size	Low microbial contamination	lubricant sensitivity

Formula

Sr No	Ingredient	F1	F2	F3	F4	F5	F6
1	Ibuprofen	100	100	100	100	100	100
2	Sodium starch glycolate	10	15	20	25		
3	Croscarmellose sodium					25	
4	Crospovidone						25
5	Mannitol	107	102	97	92	92	92
6	Micro crystalline cellulose	80	80	80	80	80	80
7	Avicel pH 102	90	90	90	90	90	90
8	talc	5	5	5	5	5	5
9	Magnesium stearate	5	5	5	5	5	5
10	Flavoring Agent	3	3	3	3	3	3
11	Total weight	400	400	400	400	400	400

Preformulation Studies

Preformulation studies represent an essential initial phase in the development of any pharmaceutical dosage form. These studies involve a detailed evaluation of the physicochemical properties of the drug substance and selected excipients. The information obtained from such investigations plays a crucial role in designing a stable, effective, and manufacturable formulation. By understanding the inherent characteristics of the drug, formulators can anticipate potential challenges

related to stability, compatibility, flow properties, and compressibility, and accordingly select suitable formulation strategies.

Organoleptic Properties

The evaluation of organoleptic characteristics includes the assessment of the drug's color, odor, and taste. These properties, although simple, are important for identification, quality control, and patient acceptability. The color of a drug substance can serve as an indicator of purity and consistency between batches, while any deviation may suggest degradation or contamination. Odor evaluation helps in identifying the presence of volatile impurities, and taste assessment becomes particularly important in formulations such as fast-dissolving tablets, where the drug comes in direct contact with the taste buds. Recording these parameters ensures uniformity and aids in maintaining product quality.

Angle of Repose

The angle of repose is a commonly used parameter to assess the flow properties of powdered or granular materials. It is defined as the maximum angle formed between the surface of a pile of powder and the horizontal plane at which the material remains stable without sliding. A lower angle of repose indicates better flowability, which is essential for uniform die filling during tablet compression. This parameter is typically determined using the fixed funnel method, where the powder is allowed to flow through a funnel to form a conical heap. The height (h) of the pile and the radius (r) of its base are measured, and the angle of repose (θ) is calculated using the equation:

$$\theta = \tan^{-1} (h/r)$$

Where θ represents the angle of repose, h is the height of the powder heap, and r is the radius of the base. This measurement provides insight into interparticle friction and cohesion within the powder blend.

Standards for Angle of Repose

Angle of repose	Flow
25 – 30	Excellent
30 – 35	Good
35 – 40	Fair
40 – 45	Poor
45 – 50	Very poor

Bulk Density

Bulk density is an important parameter that reflects how particles pack together under the influence of gravity. It is defined as the ratio of the mass of the powder to its bulk volume, including the void spaces between particles, and is usually expressed in g/mL. To determine bulk density, a known quantity of powder (for example, 4 g of pre-sieved material) is carefully introduced into a graduated measuring cylinder, and the initial volume occupied by the powder is recorded. The formula for calculating bulk density is:

Bulk Density = Weight of Powder / Bulk Volume

This parameter is useful in determining the packaging requirements and assessing the flow characteristics of the powder.

Tapped Density

Tapped density provides additional information about the packing ability of a powder when subjected to mechanical tapping. In this method, the same powder sample used for bulk density determination is placed in a graduated cylinder and tapped mechanically for a fixed number of times, typically around 500 taps, until a constant minimum volume is reached. This process allows the particles to rearrange and occupy a more compact arrangement. Tapped density is calculated using the formula:

$$\text{Tapped Density} = \text{Weight of powder} / \text{Tapping volume}$$

The comparison between bulk density and tapped density indicates the powder's compressibility and its tendency to consolidate.

Carr's Compressibility Index

Carr's Index, also known as the compressibility index, is derived from bulk and tapped density values and is widely used to evaluate the flowability and compressibility of powders. It provides an indirect measure of interparticle interactions and the ease with which a powder can be compressed. It is calculated using the following expression:

$$\text{Carr's Index (\%)} = (\text{Tapped Density} - \text{Bulk Density}) / \text{Tapped Density} \times 100$$

Carr's Index	Flow
5 – 15	Excellent
12 - 16	Good
18 – 21	Fair
23 – 35	Poor
35 – 38	Very poor
More than 40	More than 40

Table 1: Standards for Carr's index

Hausner's ratio (HR):

It is stated by Hausner. It was calculated as

follow:

Hausner ratio = Tapped density / Bulk density

Table 2: Standards for Hausner ratio

Sr. No	Pre - Compression Parameter	Formulations					
		F1	F2	F3	F4	F5	F6
1	Angle of Repose (°)	25.7	22.1	25.7	25.1	26.4	27.4
2	Bulk Density (gm/cm3)	0.36	0.4	0.41	0.44	0.43	0.4
3	Tapped Density	0.44	0.5	0.51	0.53	0.56	0.51
4	Carr's Index	11.44	14.2	11.51	13.1	13.9	13.7
5	Hausner's Ratio	1.13	1.2	1.19	1.16	1.12	1.13

Pre-evaluation Parameters

Solubility Studies

Solubility studies are an important part of preformulation evaluation, especially for poorly water-soluble drugs such as nonsteroidal anti-inflammatory drugs (NSAIDs). These studies help in understanding how the drug behaves under different physiological conditions, which is essential for predicting its in vivo performance. In the present investigation, the aqueous solubility of the drug was determined as a function of pH using various dissolution media that simulate different regions of the gastrointestinal tract.

The solubility of the drug was evaluated at different pH conditions, including pH 1.2 using 0.1 N hydrochloric acid to simulate gastric fluid, pH 4.5 using acetate/phosphate buffer, pH 6.8 using phosphate buffer to represent intestinal conditions, and pH 7.4 using phosphate buffer to mimic physiological plasma conditions. By studying solubility across this range of pH values, a better understanding of the drug's dissolution behavior in the body can be achieved. This information is particularly useful for predicting absorption characteristics and for selecting appropriate formulation strategies to enhance drug solubility and bioavailability.

H.R.	Flow
1.2 – 1.3	Excellent
1.3 – 1.4	Good
1.4 – 1.5	Fair
1.5 – 1.6	Poor

Evaluation Parameter

Hardness Test

The hardness test is an important quality control parameter used to assess the mechanical strength of tablets. It indicates the ability of a tablet to resist breakage, chipping, or fracture during handling, packaging, transportation, and storage. Adequate hardness is essential to ensure that tablets remain intact until administration, while still allowing them to disintegrate appropriately after ingestion.

In this study, the hardness of the formulated tablets was determined using a Monsanto hardness tester, which measures the force required to break a tablet diametrically. The results are expressed in terms of kilograms per square centimeter (kg/cm^2). During the test, each tablet is placed between two anvils, and increasing pressure is applied until the tablet fractures. The force at which the tablet breaks is recorded as the hardness value.

Formulation	Hardness (kg/cm2)
F1	3.5±0.014
F2	3.6±0.01
F3	4.1±0.015
F4	4.2±0.017
F5	3.3±0.018
F6	4.2±0.011

Uniformity of Weight

The uniformity of weight test is an important quality control parameter used to ensure consistency in tablet manufacturing. It helps in verifying that each tablet contains an accurate and uniform amount of formulation, which is essential for dose accuracy, therapeutic effectiveness, and patient safety. Any significant variation in tablet weight may indicate issues in powder blending, flow properties, or compression efficiency during manufacturing.

In this study, the weight variation test was carried out using a sample of 20 tablets selected randomly from each formulation batch. Each individual tablet was accurately weighed using a calibrated analytical balance, and the average weight of the 20 tablets was then calculated. The individual tablet weights were compared with the calculated average to determine the extent of variation.

Friability:

The friability of tablets was determined using a Roche fribilator. At 25 rpm the tablets were rotated for 4 minutes or up to 100 revolutions. After the removal of fines the tablets were reweighed and the percentage of weight loss was determined.

Formulation	Friability (%)
F1	3.7±0.014
F2	0.72±0.18
F3	0.86±0.08
F4	0.85±0.11
F5	0.74±0.2
F6	0.87±0.12

Thickness and diameter

Tablet thickness should be controlled within 5% or less of a standard value. Mostly tablets have uniform diameter unless they have been prepared by using different dies. Small variation in tablet thickness and diameter significantly affects the hardness and dissolution profile of tablet. The thickness and diameter of the tablets were determined using a vernier caliper.

Formulations	**Thickness (mm**	**Diameter(mm**
F1	2.6±0.013	1.3±0.0012
F2	2.4±0.015	1.3±0.0016
F3	3.2±0.012	1.3±0.0024
F4	3.3±0.014	1.3±0.0018
F5	3.0±0.011	1.3±0.0022
F6	3.0±0.016	1.3±0.0022

Weight Variation Test

20 tablets were randomly chosen, then each was weighed separately as well as collectively using a single-pan balance.. The average weight was noted, and the standard deviation was calculated. IP limit for weight variation in case of tablets weighing up to 120 mg is ± 10%, 120 mg to 300 mg is ± 7.5%, and more than 300 mg is ± 5%.

$$PD = (Wavg) – (W\ initial) / (W\ avg) \times 100$$

Where

PD = Percentage deviation,

Wavg = Average weight of tablet,

Winitial = Individual weight of tablet.

Disintegration Test

The disintegration test is an essential quality control evaluation used to determine the time required for a tablet to break down into smaller particles under specific conditions. This test is particularly important for fast-dissolving or mouth-dissolving tablet formulations, where rapid disintegration is a critical performance characteristic influencing drug release and onset of action.

In the present study, the disintegration time of all formulated batches was determined using a standard tablet disintegration test apparatus. This apparatus consists of a basket-rack assembly with six glass tubes, each containing a mesh at the bottom. For the test, one tablet was placed in each of the six tubes, ensuring that all tablets were individually evaluated under identical conditions.

The apparatus was operated using distilled water maintained at a controlled temperature of 37° ± 2°C, which simulates physiological conditions of the human body. The basket assembly was raised and lowered in the medium at a specified frequency, allowing continuous contact of the tablets with the liquid.

Formulation	Disintegration Time (sec)
F1	91±0.35
F2	83±0.33
F3	75±0.42
F4	62±0.31
F5	46±0.42
F6	49±0.50

Content uniformity

Twenty tablets were powdered, and powder equivalent to 100 mg of Ibuprofen was accurately weighed and transferred into a 100 ml volumetric flask. Initially, 5 ml methanol was added and shaken for 10 min. Then, the volume was made up to 100 ml with 7.2 phosphate buffer. The solution was filtered, diluted suitably and analyzed spectrophotometrically at 221 nm.

Formulation	Uniformity of content (mg)
F1	0.87±0.10
F2	392±0.5
F3	395±0.80
F4	398±0.75
F5	399±0.71
F6	399±0.63

Wetting Time and Water Absorption Ratio

Wetting time and water absorption ratio are important evaluation parameters used to assess the ability of a tablet to take up moisture and initiate rapid disintegration, particularly in fast-dissolving tablet formulations. These tests provide valuable

information regarding the interaction between the tablet and aqueous medium, which directly influences the disintegration and dissolution behavior of the dosage form.

In the wetting time test, a simple method was employed using a Petri dish containing a measured volume (6 ml) of purified water. A piece of tissue paper, folded twice, was placed at the bottom of the Petri dish to serve as a medium for capillary action. To facilitate visual observation, a small amount of amaranth dye was added to the water. A tablet was carefully placed on the surface of the moistened tissue paper, ensuring minimal disturbance.

The water absorption ratio (R) was calculated using the standard formula, which expresses the percentage increase in weight of the tablet due to water uptake. This parameter helps in understanding the swelling behavior of superdisintegrants and their effectiveness in promoting rapid tablet breakup.

$$R = [(Wa - Wb)/Wb] \times 100$$

Formulation	Wetting time (sec)	water absorption ratio (%)
F1	43±0.21	45.31±0.10
F2	52±0.30	53.11±0.10
F3	53±0.37	59.37±0.19
F4	44±0.29	78.89±0.23
F5	37±0.39	88.29±0.16
F6	28±0.45	91.54±0.15

Solubility Studies

The solubility behavior of the drug was systematically investigated in various physiological media to better understand its dissolution characteristics under conditions that simulate the human gastrointestinal environment. All studies were performed at a controlled temperature of 37°C ± 0.5°C to closely mimic normal body temperature, ensuring that the obtained results are relevant to in vivo conditions. Evaluating solubility in different media provides useful insight into the drug's performance across varying pH environments, which is essential for predicting its absorption and bioavailability.

Analysis of Drug

The analytical evaluation of the drug was carried out using spectrophotometric techniques to ensure accurate quantification. Ultraviolet (UV) spectrophotometric analysis was selected due to its simplicity, sensitivity, and reliability for routine drug estimation.

Determination of λmax

The maximum absorption wavelength (λmax) of the drug was determined in phosphate buffer of pH 7.2. The drug exhibited maximum absorbance at 221 nm, which was selected as the analytical wavelength for further quantitative analysis. This λmax value was used for all subsequent absorbance measurements to ensure consistency and accuracy in drug estimation.

Linearity and Calibration Curve

To establish the linearity of the analytical method, a standard calibration curve of the drug was prepared using phosphate buffer of pH 7.2 as the solvent system. Different concentrations of the drug solution were prepared and their absorbance values were recorded at 221 nm using a UV spectrophotometer. The resulting data were plotted to obtain a standard graph, which demonstrated a linear relationship between drug concentration and absorbance within the studied range. The linearity of the calibration curve confirms the suitability of the method for quantitative analysis.

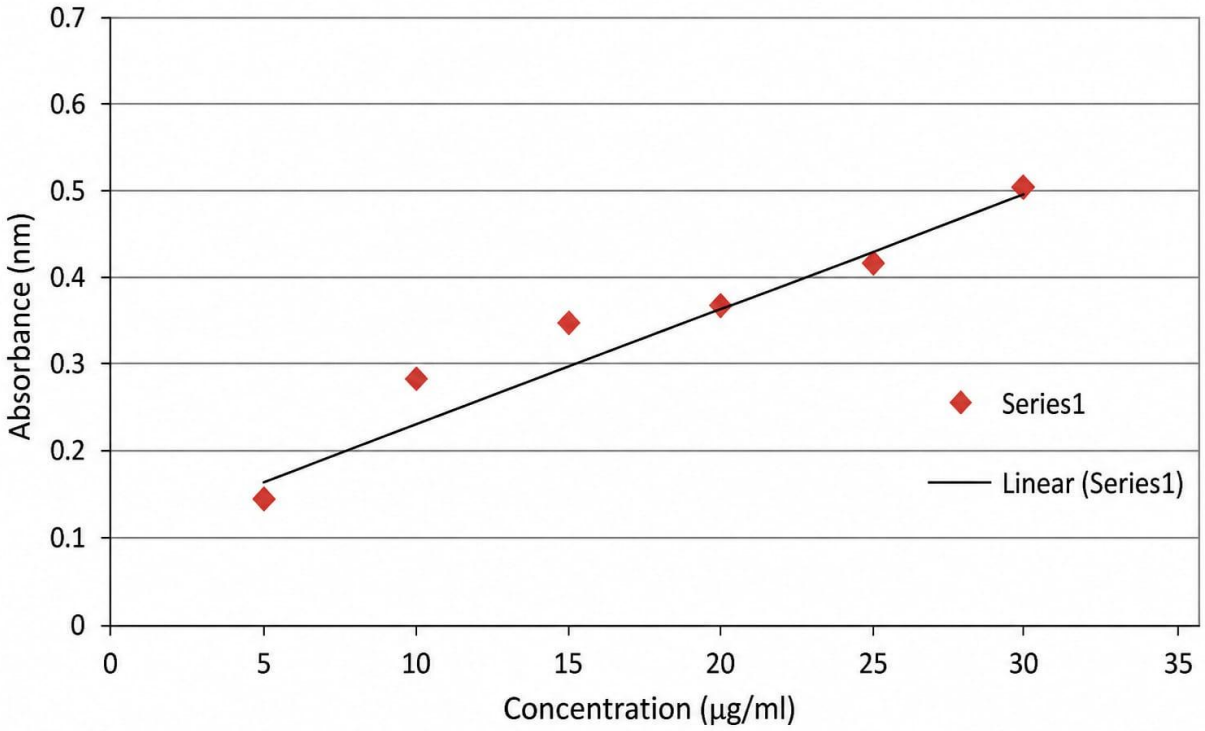
For the preparation of the standard stock solution, accurately weighed 10 mg of the drug was dissolved in the appropriate buffer and the volume was adjusted to obtain a concentration of 100 µg/ml. This stock solution served as the primary standard for preparing further dilutions used in the construction of the calibration curve.

Calibration of Ibuprofen

The calibration of ibuprofen was carried out by constructing a standard calibration curve using phosphate buffer of pH 7.2 as the solvent system. The absorbance of ibuprofen was measured at its predetermined wavelength of 221 nm using a UV spectrophotometer. A series of standard solutions with different known concentrations of ibuprofen were prepared, and their corresponding absorbance values were recorded. These values were then plotted against concentration to obtain the standard calibration curve.

The calibration curve demonstrated a direct and proportional relationship between the concentration of ibuprofen and its absorbance within the studied range. The drug was found to exhibit linearity over a concentration range of 5–30 µg/ml, indicating that it follows Beer–Lambert's law within this interval. This confirms that the absorbance of ibuprofen increases consistently with an increase in concentration, making the method suitable for quantitative analysis.

Concentration(µ/ml)	Absorbance (nm)
5	0.149
10	0.281
15	0.345
20	0.371
25	0.419
30	0.505



Calibration curve of Ibuprofen in phosphate buffer pH 7.2

Results and Discussion

The present study was focused on the formulation and evaluation of fast-dissolving tablets (FDTs) of ibuprofen using the direct compression technique with different types and concentrations of superdisintegrants. The results can be interpreted theoretically by understanding the influence of formulation variables on powder flow, tablet integrity, disintegration behavior, and expected drug release.

The pre-compression studies indicated that all powder blends possessed suitable micromeritic properties for direct compression. The low values of angle of repose, along with acceptable Carr's Index and Hausner's ratio, suggest that the powder mixtures exhibited good flowability and compressibility. Theoretically, this ensures uniform die filling during compression, which is essential for achieving consistent tablet weight and uniform drug content in each dosage unit.

After compression, the tablets demonstrated adequate mechanical strength as indicated by hardness values within an acceptable range. At the same time, friability values remained within permissible limits for most formulations, indicating that the tablets were able to withstand mechanical stress during handling and packaging. This balance between hardness and friability is important in fast-dissolving tablets, since excessive hardness can delay disintegration while low strength may lead to tablet breakage.

The disintegration behavior showed a clear dependence on both the type and concentration of superdisintegrants. As the concentration of sodium starch glycolate increased, a gradual reduction in disintegration time was observed, which can be attributed to increased swelling pressure leading to faster breakup of the tablet matrix. However, formulations containing crospovidone demonstrated the fastest disintegration. Theoretically, this is due to its highly porous structure and wicking

action, which allows rapid penetration of saliva into the tablet without forming a gel barrier, thereby accelerating tablet disintegration more effectively than swelling-based agents.

A similar trend was observed in wetting time and water absorption ratio, where formulations with higher efficiency superdisintegrants showed faster wetting and greater water uptake. This indicates improved hydrophilicity and enhanced capillary action within the tablet structure. From a theoretical standpoint, increased water absorption leads to faster swelling or structural rupture of the tablet, which directly contributes to rapid disintegration.

Although direct dissolution data is not provided, the observed reduction in disintegration time and improved wetting behavior strongly suggest an enhanced dissolution profile. According to fundamental dissolution principles, a reduction in particle size and an increase in surface area after rapid disintegration will enhance the dissolution rate of ibuprofen. Therefore, formulations containing crospovidone are expected to exhibit the fastest drug release and improved bioavailability.

The use of the direct compression method also plays an important role in the performance of the tablets. Theoretically, this method avoids exposure to heat and moisture, thereby maintaining drug stability and simplifying manufacturing. It also allows uniform distribution of excipients, particularly superdisintegrants, which is critical for consistent tablet performance.

Conclusion

The present study successfully demonstrated the formulation and evaluation of fast-dissolving tablets of ibuprofen using different superdisintegrants and their optimized concentrations through the direct compression method. The preformulation studies indicated that the drug and excipients possessed acceptable physicochemical properties, including satisfactory flowability, compressibility, and solubility behavior across different physiological pH conditions, which are essential for developing a stable and effective formulation.

The pre-compression parameters, such as angle of repose, bulk density, tapped density, Carr's index, and Hausner's ratio, confirmed that the powder blends of all formulations exhibited good to excellent flow properties, ensuring uniform die filling and suitability for direct compression. Post-compression evaluation parameters further confirmed the quality of the prepared tablets, as all formulations showed acceptable hardness, uniformity of weight, friability within acceptable limits, and consistent thickness and diameter, indicating good mechanical integrity and manufacturing reproducibility.

Among all formulations, variations in disintegration time, wetting time, and water absorption ratio clearly demonstrated the significant influence of both the type and concentration of superdisintegrants on tablet performance. Increasing the concentration of sodium starch glycolate improved the disintegration and dissolution characteristics, with the highest concentration (6.25% w/w) showing better results compared to lower concentrations. Furthermore, when different superdisintegrants were compared at the same concentration level, crospovidone exhibited superior performance, providing the fastest disintegration, highest water absorption ratio, and most rapid drug release, indicating its greater efficiency as a superdisintegrant.

The content uniformity results confirmed that all formulations contained the desired amount of ibuprofen within acceptable limits, ensuring dose accuracy and reproducibility. The wetting time and water absorption studies further supported the improved performance of formulations containing crospovidone, as they showed faster wetting and higher water uptake capacity, which directly contributed to rapid tablet disintegration.

The spectrophotometric analysis and calibration curve of ibuprofen demonstrated excellent linearity in the concentration range of 5–30 µg/ml at 221 nm, with a high correlation coefficient ($r^2 = 0.9895$), confirming the reliability and accuracy of the analytical method based on Beer–Lambert's law. This validated method was effectively used for drug estimation in formulation studies.

References

1. Kishore VS, Kumar DG, Sudheer D, M Sandeep M. Design and development of fast dissolving tablets of ibuprofen. J Pharm Pharm Sci 2013;2:65-71.
2. Lakshmi AG, Patel R, Kumar DS. Formulation and evaluation of fast-dissolving tablets of the antiemetic drug metoclopramide. World J Pharm Pharm Sci 2014;3:2080-90.
3. Seager H. Drug delivery product and Zydis-fast dissolving dosage form. J Pharm Pharmacol 1998; 50:375-82.
4. Abdelbary G, Prinderre P, Couani C, Taochim J, Reynier JP, Riccerelle P. The preparation of orally disintegrating tablets using a hydrophilic waxy binder. Int J Pharm 2004; 278:423-33.
5. Lachman L, Libermann HA, Kanig JL. The theory and practice of industrial pharmacy. 3rd edition; 1991. p. 233-5.
6. Biradar S, Bhagavati S, Kuppasad I. Fast dissolving drug delivery system: A brief overview. Internet J Pharmacol 2005;4:2. edition; 1991. p. 233-5.
7. Bogner RH, Wilkosz MF. Fast Dissolving Tablets – New Dosage Convenience for Patients, US Pharm 2002; 27:34 - 43.
8. Bandari S, Mittapalli RK, Gannu R, Rao YM. Oral dispersible tablets: an overview. Asian J Pharm 2008;1:2-11.
9. Van SEA, Lechat P, Remmerie BM, Ko G, Lasseter KC, Mannaert E. Pharmacokinetic comparison of fast-disintegrating and conventional tablet formulations of risperidone in healthy volunteers. Clin Ther 2003;25:1687-99.
10. Mukesh P, Ratnaparkhi Mohanta GP, Upadhyay L. Review on: Fast dissolving tablet. J. Pharm Res. 2009; 2(1):5 -12.
11. Liberman, Lachman. Pharmaceutical Dosage Forms: Tablets. Hardcover, Informa Health. 2006; 1(2):195-245.
12. Subramanyam CVS. Textbook of physical pharmaceutics. Vallabh Prakashan: Delhi , 2005.
13. Kumar JS, Meenakshi S, Vivek S. Development and in vitro evaluation of ibuprofen mouth dissolving tablets using solid dispersion technique. Chem Pharm Bulletin 2010;58:1037-42.
14. Mukesh P, Ratnaparkhi Mohanta GP, Upadhyay L. Review on: Fast dissolving tablet. J. Pharm Res. 2009; 2(1):5 -12.
15. Kuchekar BS and Arumugam V, Indian J. Pharm. Edu., 35, 2001, 150.
16. Chang RK, Guo X, Burnside BA, Couch RA. Fast dissolving tablets. Pharm Tech, 2000; 24(6):52-58.
17. Dobetti L. Fast-melting tablets: Developments and technologies. Pharm Technol N Am. 2001; 44–50.