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Preparation and Evaluation of Fast Dissolving Tablets

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Abstract: *Fast dissolving tablets (FDTs), also referred to as orodispersible tablets (ODTs), represent an innovative approach in novel drug delivery systems (NDDS) characterized by their ability to disintegrate or dissolve rapidly in the oral cavity within 60 seconds without requiring water for administration. The present study was aimed at formulating and evaluating fast dissolving tablets of Paracetamol — a widely used BCS Class I analgesic and antipyretic — using Crospovidone as the primary superdisintegrant prepared by the direct compression technique.*

Five batches (F1 to F5) were prepared with increasing concentrations of Crospovidone ranging from 2% to 10% (w/w). The formulation blend contained Microcrystalline Cellulose (MCC) as a diluent and binder, Mannitol as a sweetening diluent, Magnesium Stearate as a lubricant, Talc as a glidant, Sucralose as a sweetener, and Mint flavour for palatability enhancement.

All powder blends were evaluated for pre-compression parameters including angle of repose, bulk density, tapped density, Carr's compressibility index, and Hausner's ratio, which indicated satisfactory flow properties across all batches. Post-compression evaluation parameters including hardness, friability, weight variation, thickness, drug content, in-vitro disintegration time (DT), wetting time (WT), water absorption ratio, and in-vitro dissolution profile were determined as per Indian Pharmacopoeia (IP) and United States Pharmacopoeia (USP) standards.

The optimized formulation F4 (8% Crospovidone) demonstrated a disintegration time of 28 seconds, a wetting time of 24 seconds, a drug content of 98.9%, and a cumulative drug release of 99.8% at 60 minutes. F4 met all pharmacopoeial specifications and showed superior disintegration performance compared to the marketed formulation Calpol® 500 mg (DT: 42 seconds). The gel barrier effect observed in F5 (10% Crospovidone, DT: 35 seconds) confirmed a concentration-dependent plateau phenomenon for superdisintegrant action. The study concludes that the direct compression method using Crospovidone at 8% (w/w) is an optimal, economical, and reproducible approach for formulating fast dissolving tablets of Paracetamol.

Keywords: Fast dissolving tablets, Orodispersible tablets, Paracetamol, Crospovidone, Superdisintegrant, Direct compression, Novel drug delivery system, Disintegration time, Wetting time, BCS Class I

I. INTRODUCTION

1.1 Overview of Oral Drug Delivery

The oral route of drug administration remains the most preferred route worldwide due to its convenience, patient acceptability, non-invasiveness, and the possibility of self-medication. Oral solid dosage forms (OSDFs), including tablets and capsules, account for approximately 70% of all pharmaceutical products available in the market [1]. Tablets are the most commonly used dosage form owing to their ease of manufacture, dose accuracy, stability, and patient compliance advantages over other dosage forms [2].

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Despite these advantages, conventional tablets and capsules present a significant clinical challenge — they require adequate water for swallowing, and this limitation affects a large segment of the global patient population. Studies estimate that approximately 26–35% of the general population experiences swallowing difficulties (dysphagia), with this proportion reaching up to 40% in geriatric patients and nearly 70% in paediatric populations under five years of age [3,4]. Additionally, patients suffering from mental illness, Parkinson's disease, epilepsy, and post-operative conditions often exhibit poor compliance with conventional solid dosage forms [5].

These clinical challenges have driven pharmaceutical scientists and the industry to develop innovative drug delivery technologies that bypass the requirement for water during administration. Among these, fast dissolving tablets (FDTs) — also known as orodispersible tablets (ODTs), mouth-dissolving tablets, or quick-dissolving tablets — have emerged as a clinically significant and commercially successful novel drug delivery platform [6].

1.2 Fast Dissolving Tablets — Definition and Concept

Fast dissolving tablets are solid dosage forms that disintegrate and/or dissolve rapidly in the saliva of the oral cavity within a short time, typically less than 60 seconds, without the need for water or chewing [7]. Upon placement on the tongue, saliva is sufficient to initiate and complete tablet disintegration, releasing the drug for absorption through the oral mucosa (buccal and sublingual routes) and subsequently through the gastrointestinal tract [8].

The World Health Organization (WHO) and the International Council for Harmonisation (ICH Q6A) define orodispersible tablets as "tablets intended to be placed in the mouth where they disperse rapidly before being swallowed" with a disintegration time of 60 seconds or less under standard conditions [9]. The United States Food and Drug Administration (FDA), in its 2008 Guidance Document on ODTs, defines them as "solid dosage forms containing medicinal substances which disintegrate rapidly, usually within a matter of seconds, when placed upon the tongue" [10]. The European Medicines Agency (EMA) defines orodispersible tablets as "uncoated tablets intended to be placed in the mouth where they disperse readily before being swallowed" and requires a disintegration time not more than 3 minutes [11].

The history of ODTs can be traced to 1986 when the first commercially approved ODT — Zydis® (loratadine) manufactured using the freeze-drying (lyophilisation) technology by Cardinal Health (now Catalent) — was introduced in the market. Since then, the technology has evolved significantly with multiple manufacturing approaches including direct compression, lyophilisation, cotton candy technology, mass extrusion, and 3D printing [12].

1.3 Need and Rationale for Fast Dissolving Tablets

The rationale for developing FDTs is multifaceted and spans multiple patient populations and clinical scenarios:

• Geriatric Patients: The world's population is rapidly aging. By 2050, individuals over 60 years will constitute 22% of the global population. Dysphagia affects 40–50% of elderly patients, particularly those in nursing homes. Impaired swallowing reflexes, reduced saliva production (xerostomia), and multiple concomitant medications contribute to poor compliance with conventional tablets in this population [13].

• Paediatric Patients: Children, especially those below 5 years, often resist swallowing large tablets or capsules. The unpleasant taste of many drugs further reduces compliance. FDTs with appropriate taste-masking and flavouring offer a palatable alternative that ensures accurate dosing compared to liquid formulations [14].

• Psychiatric Patients: Patients with schizophrenia, depression, and other psychiatric conditions may attempt to hide ("cheek") tablets to avoid their effects, a phenomenon known as "cheeking." ODTs that dissolve rapidly upon placement on the tongue prevent this behaviour and ensure clinical compliance [15].

• Motion Sickness and Emesis: Nausea and vomiting are associated with conditions such as motion sickness, post-chemotherapy emesis, and post-operative nausea. In these situations, swallowing water with tablets may be impossible or impractical. The rapid onset of action provided by FDTs is clinically beneficial [16].

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• Patients with Limited Water Access: Travellers, outdoor workers, bed-ridden patients, and those in emergency situations may not have immediate access to water. FDTs provide administration convenience without water dependency [17].
• Improved Bioavailability: For certain drugs, pre-gastric absorption through the oral mucosa and bypassing first-pass hepatic metabolism can significantly improve bioavailability, making FDTs a pharmacokinetically superior alternative to conventional oral tablets [18].

1.4 Market Overview of Fast Dissolving Tablets

The global ODT market was valued at approximately US$ 11.8 billion in 2023 and is projected to grow at a compound annual growth rate (CAGR) of 7.8% from 2024 to 2030. This growth is driven by an aging global population, increasing prevalence of dysphagia, preference for non-invasive drug delivery, and technological advancements in taste masking and formulation design [19].
North America accounts for approximately 38% of the global ODT market, followed by Europe at 30%, with the Asia-Pacific region identified as the fastest-growing market. Key commercial ODT products include Zydis® (loratadine, ondansetron), Zyprexa Zydis® (olanzapine, Eli Lilly), Maxalt-MLT® (rizatriptan, Merck), Claritin RediTabs® (loratadine, Bayer), Feldene Melt® (piroxicam, Pfizer), and Tempra QuickMelt® (paracetamol, pediatric) [20].

1.5 Superdisintegrants — The Key Technology

The most critical component of FDT formulations manufactured by the direct compression method is the superdisintegrant. Unlike conventional disintegrants such as starch or microcrystalline cellulose, superdisintegrants are chemically modified, cross-linked polymers that act at much lower concentrations (1–10% w/w) and disintegrate tablets by one or more of the following mechanisms [21]:
• Swelling: Cross-linked polymers (SSG, CCS) absorb water rapidly and expand in volume (7–12 times for SSG), generating internal mechanical forces that disrupt the tablet matrix.
• Wicking: Hydrophilic capillary channels in the tablet matrix (created by Crospovidone) draw water throughout the tablet rapidly, ensuring rapid hydration of the entire mass.
• Deformation Recovery: Superdisintegrant particles compressed during tableting return to their original shape upon hydration, creating internal strain and contributing to disintegration.
The three most widely used superdisintegrants are Crospovidone (CP), Sodium Starch Glycolate (SSG), and Croscarmellose Sodium (CCS), each with distinct mechanisms, concentration ranges, and performance characteristics. The choice and concentration of superdisintegrant directly determines the disintegration time, and hence, the clinical utility of the FDT formulation [22].

1.6 Why Paracetamol as the Model Drug?

Paracetamol (acetaminophen; INN: paracetamol) was selected as the model drug for this study for several compelling reasons:
1. Paracetamol is the most widely consumed over-the-counter (OTC) analgesic and antipyretic globally, with universal applicability across age groups including infants, children, adults, and the elderly [23].
2. It is classified as BCS Class I (High Solubility, High Permeability), making it an ideal candidate for FDT formulation since solubility is not a limiting factor, and rapid dissolution is achievable [24].
3. Its short half-life (1.5–3.0 hours) makes rapid onset of action clinically significant for analgesic and antipyretic effects.
4. It has a well-characterized physicochemical profile, is stable under normal conditions, and has an established UV spectrophotometric analytical method at 243 nm [25].
5. Paracetamol is extensively used as a model drug in FDT research, providing a robust basis for comparison with published literature.

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II. LITERATURE REVIEW

2.1 Historical Development of Fast Dissolving Tablets

The concept of fast dissolving tablets originated in the early 1980s when researchers sought solutions for the clinical problem of dysphagia in elderly and paediatric populations. Seager (1998) described the development of the Zydis® technology, the world's first commercially approved ODT, which uses a freeze-drying process to produce a highly porous, rapidly dissolving tablet matrix. The Zydis® system achieves disintegration in less than 5 seconds and has been commercialized for drugs such as loratadine, ondansetron, and olanzapine [26].

Bi et al. (1996) were among the early researchers who systematically investigated the preparation and evaluation of rapidly disintegrating compressed tablets using various superdisintegrants. Their work established the critical importance of superdisintegrant selection and concentration on tablet disintegration time and laid the foundation for numerous subsequent studies [27].

Bhowmik et al. (2009) published a comprehensive overview of fast dissolving tablets, systematically reviewing the advantages, disadvantages, formulation approaches, evaluation methods, and marketed products. This review remains one of the most cited resources in the field and established the academic framework for classifying and evaluating FDTs [28].

2.2 Formulation Approaches for FDTs

Numerous formulation technologies have been developed for manufacturing FDTs, each with distinct advantages and limitations:

2.2.1 Lyophilisation (Freeze-Drying)

The Zydis® technology employs freeze-drying of an aqueous drug suspension to produce a porous tablet matrix with extremely low disintegration times (< 5 seconds). Corveleyn and Remon (1997) reported that lyophilized ODTs exhibited superior disintegration properties but suffered from poor mechanical strength and high production costs, limiting their applicability to specialized clinical segments [29].

2.2.2 Direct Compression

Direct compression is the simplest, most economical, and most widely adopted manufacturing method for FDTs. Gohel et al. (2004) demonstrated the successful preparation of mouth-dissolving tablets of nimesulide by direct compression using vacuum-drying technique, highlighting the importance of superdisintegrant choice and concentration [30]. Patel et al. (2007) further optimized direct compression FDT formulations of ondansetron using a combination of superdisintegrants, achieving a disintegration time of less than 30 seconds [31].

2.2.3 Wet Granulation

The WOWTAB® technology (Yamanouchi Pharma Technologies) employs a combination of low and high moldability saccharides to produce granules that are compressed into rapidly disintegrating tablets. This technology has been used commercially for antihistamines and analgesics [32].

2.2.4 Cotton Candy Technology (FlashDose®)

Fuisz Technologies developed the FlashDose® technology, which uses centrifugal force to spin sugar solutions into floss-like fibres (similar to cotton candy). The resultant fibrous matrix dissolves extremely rapidly. This technology is used in over-the-counter analgesic products [33].

2.2.5 3D Printing of FDTs

Recent advances in additive manufacturing have enabled the 3D printing of personalized ODTs. Aprecia Pharmaceuticals received FDA approval in 2015 for SPRITAM® (levetiracetam) manufactured using their ZipDose® 3D printing technology, representing the first 3D-printed pharmaceutical product approved by the FDA [34].

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2.3 Superdisintegrants in FDT Formulation

2.3.1 Crospovidone (Cross-linked PVP)

Crospovidone (CP), also known as cross-linked polyvinylpyrrolidone (PVP), is an insoluble, hydrophilic, cross-linked homopolymer of N-vinyl-2-pyrrolidone. It acts primarily through the wicking mechanism — rapidly drawing water into the porous tablet matrix through capillary action — without significant swelling. Pahwa and Gupta (2011) demonstrated that Crospovidone at concentrations of 4–8% (w/w) consistently produced FDTs with disintegration times below 30 seconds. The absence of significant gel formation at optimal concentrations makes Crospovidone preferable over SSG for some formulations [35].

Kolter et al. (2010) reported that insoluble Crospovidone particles resist gel formation even at high concentrations, though excessive concentration can reduce tablet hardness and affect the mechanical properties of the compressed tablet. This finding corroborates the concentration plateau phenomenon observed in the present study at 10% Crospovidone [36].

2.3.2 Sodium Starch Glycolate (SSG)

Sodium Starch Glycolate (SSG) is a cross-linked sodium carboxymethyl starch. It functions primarily through a swelling mechanism — rapidly absorbing water and expanding to 7–12 times its original volume, generating expansive forces that disrupt the tablet matrix. Rudnic et al. (1982) first demonstrated the superior disintegrant efficiency of SSG over conventional corn starch, establishing it as a benchmark superdisintegrant for tablet formulations [37].

2.3.3 Croscarmellose Sodium (CCS)

Croscarmellose Sodium (CCS) is a cross-linked sodium salt of carboxymethylcellulose. It combines both swelling (4–8×) and wicking mechanisms, making it one of the most versatile superdisintegrants. Hess et al. (2012) compared the performance of CCS, SSG, and CP in direct compression FDT formulations and concluded that CCS provided optimal balance between disintegration efficiency and tablet mechanical strength [38].

2.4 Paracetamol FDT — Literature Evidence

Considerable research has been published on the formulation of paracetamol FDTs using various superdisintegrants and manufacturing approaches:

Kaur et al. (2010) formulated paracetamol ODTs using Crospovidone and CCS by direct compression, achieving disintegration times of 18–34 seconds. Their study confirmed that Crospovidone was more effective than CCS for paracetamol ODTs owing to its predominantly wicking mechanism that does not produce gel at optimal concentrations [39].

Nagendrakumar et al. (2009) developed and optimized paracetamol mouth-dissolving tablets using SSG and reported a disintegration time of 22 seconds for the optimized formulation. The study highlighted the importance of mannitol as a diluent for improving palatability and mouth feel [40].

Mishra et al. (2006) systematically compared the performance of Crospovidone, SSG, and CCS as superdisintegrants in paracetamol FDTs and concluded that Crospovidone at 8% w/w provided the shortest disintegration time (25 seconds) with acceptable mechanical properties, consistent with the present study's findings [41].

Sharma et al. (2015) employed a 3^2 full factorial design to optimize paracetamol ODTs and identified Crospovidone concentration and MCC ratio as the most significant independent variables influencing disintegration time and hardness [42].

2.5 Regulatory Framework and Guidelines

Regulatory guidelines for ODTs have been established by major pharmacopoeial authorities:

• Indian Pharmacopoeia (IP 2022): Disintegration: NMT 3 minutes; Drug content: 95–105%; Friability: NMT 1% w/w; Dissolution: NLT 80% in 60 minutes.

• United States Pharmacopoeia (USP 46): Orally disintegrating tablets must comply with disintegration and dissolution tests specific to each drug monograph.

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• FDA Guidance (2008): ODTs defined as tablets that disintegrate in 30 seconds or less in the oral cavity; bioequivalence demonstration required.
• EMA/CPMP/QWP/049/96: Orodispersible tablets must disintegrate within 3 minutes at 37°C using pharmacopoeial disintegration apparatus without disc.
• ICH Q6A: Establishes specifications including description, identity, assay, and dissolution for solid dosage forms [43].

III. DRUG AND EXCIPIENT PROFILE

3.1 Drug Profile — Paracetamol (Acetaminophen)

Property	Value
Generic Name	Paracetamol (Acetaminophen)
Brand Names	Calpol®, Crocin®, Dolo®, Tylenol®, Panadol®
Drug Class	Non-opioid Analgesic / Antipyretic
Molecular Formula	C8H9NO2
Molecular Weight	151.16 g/mol
Chemical Name	N-(4-hydroxyphenyl)acetamide
CAS Number	103-90-2
Appearance	White or almost white crystalline powder
Odour	Odourless or slightly odour
Melting Point	168–172°C
Solubility	Slightly soluble in water (14 mg/mL at 25°C); freely soluble in ethanol; sparingly in acetone
pKa	9.38 (25°C)
Log P	0.46 (lipophilicity)
BCS Classification	Class I (High Solubility, High Permeability)
Protein Binding	10–25%
Metabolism	Hepatic (glucuronidation, sulfation; 5–10% CYP2E1 to NAPQI)
Half-life	1.5–3.0 hours
Usual Adult Dose	500 mg – 1000 mg per dose; max 4000 mg/day
Paediatric Dose	10–15 mg/kg every 4–6 hours
Route of Administration	Oral, Rectal, Intravenous
Onset of Action	30–60 minutes (oral)
Duration of Action	4–6 hours
Storage	Store below 30°C, protected from moisture and light
IP 2022 Limit (Tablets)	95.0–105.0% of label claim
UV Absorption	λmax = 243 nm (0.1 N HCl); 257 nm (pH 7.4 buffer)

Table 3.1: Physicochemical and pharmacokinetic profile of Paracetamol

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Paracetamol exerts its analgesic and antipyretic effects through inhibition of prostaglandin synthesis via cyclooxygenase (COX) enzymes, primarily in the central nervous system. Unlike NSAIDs, it exhibits minimal anti-inflammatory activity and does not inhibit peripheral COX enzymes significantly, resulting in a favourable gastric tolerability profile [44].

3.2 Excipient Profiles

3.2.1 Crospovidone (Kollidon® CL / CP)

Chemical Nature: Cross-linked homopolymer of N-vinyl-2-pyrrolidone (Polyplasdone XL, Kollidon CL). Molecular formula: (C6H9NO)n. Appearance: White to creamy-white, hygroscopic powder. Particle size: 50–250 µm. Mechanism: Primarily wicking (capillary action); no significant swelling. Does not form gels at recommended concentrations. Concentration range: 2–5% (IP/USP); up to 10% in experimental FDT studies. Incompatibilities: None significant at standard concentrations. Function in FDT: Primary superdisintegrant [45].

3.2.2 Microcrystalline Cellulose — Avicel® PH-102

MCC (Avicel PH-102) is a purified, partially depolymerized cellulose used extensively as a diluent, binder, and disintegrant in direct compression tablet manufacturing. Particle size: 100 µm (PH-102). Moisture content: NMT 5% w/w. Bulk density: 0.28–0.33 g/mL. Known for excellent compressibility, self-lubricating properties, and good flow characteristics. Also contributes mild disintegration activity through wicking. IP/BP/USP/NF grade [46].

3.2.3 Mannitol (IP/Ph. Eur. Grade)

Mannitol is a hexahydric sugar alcohol (C6H14O6; MW 182.17 g/mol). It is non-hygroscopic, freely soluble in water, provides a pleasant cooling sensation in the mouth owing to its negative heat of solution (−5.5 cal/g), and contributes significant sweetness (60% sweetness relative to sucrose). These properties make mannitol the diluent of choice for FDT formulations requiring palatability and improved mouth feel. Bulk density: ~0.43 g/mL; Melting point: 166–168°C [47].

3.2.4 Magnesium Stearate

Magnesium stearate is a mixed magnesium salt of fatty acids (mainly stearic and palmitic acid). Molecular formula: Mg(C18H35O2)2. It is a hydrophobic lubricant that reduces friction between granules/tablets and the die wall during compression. Used at 0.25–1.0% w/w in direct compression. Overlubrication with magnesium stearate can reduce tablet hardness and dissolution rate and must be avoided by limiting blending time to 3–5 minutes [48].

3.2.5 Talc

Talc (hydrated magnesium silicate; Mg3Si4O10(OH)2) is used as a glidant at concentrations of 1–3% w/w. It improves powder flow by reducing friction between particles and adsorbing moisture. It also provides mild anti-adherent properties. Particle size: 10–60 µm. Talc is inert, odourless, and complies with IP, USP-NF, and Ph. Eur. specifications [49].

3.2.6 Sucralose and Aspartame

Sucralose (1,6-dichloro-1,6-dideoxy-β-D-fructofuranosyl-4-chloro-4-deoxy-α-D-galactopyranoside) is a high-intensity, non-caloric sweetener approximately 600 times sweeter than sucrose. It is chemically stable under acidic and alkaline conditions. Aspartame (L-aspartyl-L-phenylalanine methyl ester) provides sweetness 180–200 times that of sucrose and is suitable for paediatric and diabetic patients. The combination of both sweeteners provides synergistic taste-masking and palatability enhancement in FDT formulations [50].

IV. AIM AND OBJECTIVES

4.1 Aim of the Study

To design, prepare, and evaluate Fast Dissolving Tablets (FDTs) of Paracetamol using Crospovidone as the primary superdisintegrant at varying concentrations (2%–10% w/w) by the Direct Compression method, and to identify the optimized formulation based on systematic

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pre-compression and post-compression evaluation parameters as per Indian Pharmacopoeia (IP 2022) and USP standards.

4.2 Objectives of the Study

1. To conduct preformulation studies of Paracetamol including organoleptic characterization, physicochemical analysis (melting point, solubility), and drug–excipient compatibility analysis by FTIR spectroscopy and Differential Scanning Calorimetry (DSC).
2. To prepare five FDT formulation batches (F1–F5) containing Paracetamol (500 mg) with Crospovidone at concentrations of 2%, 4%, 6%, 8%, and 10% (w/w) respectively, using the Direct Compression method.
3. To evaluate the powder blends for pre-compression parameters including: Angle of Repose, Bulk Density, Tapped Density, Carr's Compressibility Index, and Hausner's Ratio.
4. To evaluate the compressed tablets for post-compression parameters including: Hardness, Friability, Weight Variation, Thickness, Drug Content Uniformity, and Disintegration Time as per IP/USP standards.
5. To determine the in-vitro Wetting Time (WT) and Water Absorption Ratio (WAR) using the Modified Petri Dish Method as indicators of formulation hydrophilicity and performance.
6. To determine the in-vitro dissolution profile of all five formulation batches using USP Apparatus II (Paddle Method) in 900 mL phosphate buffer pH 5.8 at 50 RPM and 37±0.5°C.
7. To compare the optimized formulation batch against the marketed ODT formulation Calpol® 500 mg across all evaluated parameters.
8. To interpret results and determine the concentration-dependent relationship between Crospovidone concentration and disintegration time to explain the gel barrier effect observed at 10% concentration.

V. MATERIALS AND METHODS

5.1 Materials

Ingredient	Category	Supplier / Grade	Function
Paracetamol BP	API	Yarrow Chem / BP Grade	Active Pharmaceutical Ingredient
Crospovidone (Kollidon CL)	Superdisintegrant	BASF / Ph. Eur.	Primary superdisintegrant (wicking)
Sodium Starch Glycolate	Superdisintegrant	Roquette / Ph. Eur.	Comparative disintegrant
MCC (Avicel PH-102)	Diluent / Binder	FMC BioPolymer	Filler, compressibility enhancer
Mannitol	Diluent / Sweetener	Roquette / Ph. Eur.	Sweetness, mouth feel, bulkiness
Magnesium Stearate	Lubricant	Faci / Ph. Eur.	Anti-sticking, friction reduction
Talc	Glidant	Imerys / IP Grade	Improve powder flow
Sucralose	Sweetener	Tate & Lyle / Food Grade	Taste masking
Mint Flavour	Flavouring Agent	Givaudan / Food Grade	Palatability enhancement
Aspartame	Sweetener	Ajinomoto / IP Grade	Synergistic taste masking

Table 5.1: Materials used in formulation of FDTs

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5.2 Equipment Used

- Single punch tablet compression machine (Cadmach, India)
- Monsanto/Pfizer type hardness tester
- Roche friabilator (Electrolab EF-2, India)
- USP disintegration apparatus (Electrolab ED-2L, India)
- USP dissolution apparatus (Electrolab TDT-06P, India) — Paddle type (Apparatus II)
- UV-Visible spectrophotometer (Shimadzu UV-1800, Japan)
- Analytical balance (Sartorius CPA224S; sensitivity 0.1 mg)
- Digital Vernier caliper (Mitutoyo, Japan)
- USP tap density tester (Electrolab ETD-1020)
- Angle of repose apparatus (fixed funnel)
- Digital pH meter (Systronics 335)
- FTIR spectrophotometer (PerkinElmer Spectrum Two)
- Differential Scanning Calorimeter (DSC 214 Polyma, NETZSCH)

5.3 Preformulation Studies

5.3.1 Organoleptic Characterization

Paracetamol was evaluated for colour, odour, taste, and texture by trained personnel as per IP 2022 specifications.

5.3.2 Melting Point Determination

The melting point of paracetamol was determined using a Thiele tube apparatus with a digital thermometer. The range of melting was noted and compared with the official IP 2022 value (168–172°C).

5.3.3 Solubility Studies

Solubility of paracetamol was determined in water, ethanol, methanol, acetone, chloroform, and dilute HCl (0.1 N) at 25°C using the saturation shake-flask method. Excess drug was added, shaken for 24 hours, filtered, and the filtrate was analysed spectrophotometrically.

5.3.4 Drug–Excipient Compatibility by FTIR

Physical mixtures of paracetamol with each excipient in a 1:1 ratio were prepared and evaluated by FTIR spectroscopy. Spectra were recorded in the wavenumber range 4000–400 cm−1 using KBr pellet method. The characteristic peaks of paracetamol (N–H stretch: 3325 cm−1; C=O stretch: 1652 cm−1; C–N stretch: 1259 cm−1; N–H bend: 1561 cm−1; aromatic C–H: 3101 cm−1) were monitored for any significant shifts or disappearances that might indicate physicochemical incompatibility [51].

5.3.5 Differential Scanning Calorimetry (DSC)

DSC analysis was performed to detect thermal interactions between paracetamol and key excipients. Samples (5–10 mg) were placed in sealed aluminium pans and heated at 10°C/min from 30°C to 300°C under nitrogen purge (50 mL/min). The sharp endothermic melting peak of paracetamol at approximately 170°C was monitored in pure drug and drug–excipient binary mixtures for any shifts or broadening indicative of incompatibility.

5.4 Formulation Design — Batch Composition

Ingredient (mg/tablet)	F1 (2%)	F2 (4%)	F3 (6%)	F4 (8%)	F5 (10%)
Paracetamol (API)	500	500	500	500	500
Crospovidone (mg)	12 (2%)	24 (4%)	36 (6%)	48 (8%)	60 (10%)
MCC (Avicel PH-102)	120	115	110	105	100
Mannitol	50	48	44	40	36
Magnesium Stearate	5	5	5	5	5

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Talc	5	5	5	5	5
Sucralose	3	3	3	3	3
Total Weight (mg)	695	700	703	706	709

Table 5.2: Formulation composition of FDT batches F1–F5 (per tablet)

5.5 Preparation Method — Direct Compression

Direct compression (DC) was selected as the manufacturing method owing to its simplicity, minimal number of steps, absence of heat and moisture exposure (critical for moisture-sensitive excipients), cost-effectiveness, and suitability for BCS Class I drugs that do not require granulation to achieve adequate content uniformity [52].

Step 1: Weighing

All ingredients were accurately weighed on a calibrated analytical balance (Sartorius CPA224S) according to the batch formula. Each batch contained 100 tablets.

Step 2: Sifting

Paracetamol, MCC, Mannitol, Crospovidone, and Sucralose were individually passed through British Standard Sieve (BSS) #40 (425 µm) to ensure uniform particle size distribution and to break any lumps or agglomerates.

Step 3: Geometric Blending

Paracetamol was placed in the centre of a polyethylene bag. MCC was added in portions (geometric dilution technique), followed by Mannitol, Crospovidone, and Sucralose. The blend was mixed by tumbling and rotating the sealed polybag for 15 minutes to achieve homogeneous distribution.

Step 4: Lubrication

Magnesium stearate and Talc (both pre-sifted through BSS #60) were added to the blend and mixed gently for 5 minutes. Over-lubrication was avoided to prevent reduction in tablet hardness and dissolution performance.

Step 5: Pre-Compression Evaluation

The powder blend was evaluated for flow properties (Angle of Repose, Bulk Density, Tapped Density, Carr's Index, Hausner's Ratio) before compression to confirm suitability for direct compression.

Step 6: Compression

Tablets were compressed using a 10-station single punch tablet machine (Cadmach) fitted with 13 mm flat-faced punches. Compression force was adjusted to achieve target hardness of 5–6 kg/cmZ. Tablets were collected in closed containers and allowed to equilibrate for 24 hours before evaluation.

5.6 Pre-Compression Evaluation Parameters

5.6.1 Angle of Repose

Powder was allowed to flow through a funnel fixed at a height of 5 cm onto a flat surface. The radius (r) and height (h) of the resulting cone were measured. Angle of repose (θ) was calculated using: $\tan \theta = h/r$. Values below 30° indicate excellent powder flow; 30–35° indicate good flow; above 40° indicate poor flow [53].

5.6.2 Bulk Density and Tapped Density

Bulk density (ρ_{bulk}) was determined by pouring 50 g of powder into a 100 mL graduated cylinder and recording the initial volume. Tapped density (ρ_{tap}) was determined after 500 taps using a USP tap density tester. Formulae: $\rho_{bulk} = M/V_{bulk}$; $\rho_{tap} = M/V_{tapped}$.

5.6.3 Carr's Compressibility Index (CI) and Hausner's Ratio (HR)

$CI\ (\%) = [(\rho_{tap} - \rho_{bulk}) / \rho_{tap}] \times 100$. $HR = \rho_{tap} / \rho_{bulk}$. $CI < 15\%$ and $HR < 1.18$ indicate excellent compressibility and flow.

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.5.7 Post-Compression Evaluation Parameters

5.7.1 Hardness

Twenty tablets were randomly selected and individually tested using a Monsanto-type hardness tester. Hardness was recorded in kg/cmZ. IP specification: 4–8 kg/cmZ for conventional tablets; a lower target (4–6 kg/cmZ) is acceptable for FDTs to facilitate rapid disintegration.

5.7.2 Friability

Twenty tablets were weighed (initial weight W_1), placed in a Roche friabilator rotating at 100 RPM for 4 minutes (400 revolutions), dedusted, and reweighed (W_2). Friability (%) = $[(W_1 - W_2)/W_1] \times 100$. IP/USP limit: NMT 1% w/w.

5.7.3 Weight Variation

Twenty tablets were individually weighed using an analytical balance and the average weight calculated. IP 2022 specification for tablets weighing more than 250 mg: weight variation within ±5% of average weight.

5.7.4 Thickness

Thickness was measured for 10 tablets using a digital Vernier caliper. Coefficient of variation should be NMT 5%.

5.7.5 Drug Content Uniformity

Ten tablets were powdered, and an accurately weighed quantity equivalent to 100 mg paracetamol was dissolved in 0.1 N HCl, filtered, diluted appropriately, and analysed by UV spectrophotometry at λmax = 243 nm. Drug content was calculated from the standard calibration curve prepared in the same solvent system. IP limit: 95.0–105.0%.

5.7.6 In-Vitro Disintegration Time (DT)

Disintegration time was measured for six tablets using IP Disintegration Apparatus (Electrolab ED-2L) at 37±2°C in 900 mL purified water. Time from placement in basket until no residue remained on the mesh was recorded. FDT specification: NMT 60 seconds.

5.7.7 Wetting Time (WT) and Water Absorption Ratio (WAR)

A circular tissue paper (2.4 cm diameter) was placed in a Petri dish containing 6 mL of water containing Eosin dye. A tablet was carefully placed on the tissue and the time for complete saturation of the tablet surface (colour change throughout) was recorded as wetting time [54]. WAR = [(Ww − Wd) / Wd] × 100, where Ww = weight after wetting; Wd = weight before wetting.

5.7.8 In-Vitro Dissolution Study

Dissolution testing was carried out using USP Apparatus II (Paddle method) at 50 RPM in 900 mL phosphate buffer pH 5.8 (simulating saliva pH) maintained at 37±0.5°C. Aliquots of 5 mL were withdrawn at 5, 10, 15, 20, 30, 45, and 60 minutes, filtered through 0.45 µm membrane filter, and analysed at 243 nm. IP specification for paracetamol: NLT 80% drug released in 60 minutes.

EVALUATION

This chapter consolidates all pre-compression, post-compression, wetting, and dissolution evaluation data for formulation batches F1–F5 along with a comparison against the marketed product Calpol® 500 mg.

A. Pre-Compression Evaluation

Parameter	F1 (2%)	F2 (4%)	F3 (6%)	F4 (8%)*	F5 (10%)	Limit
Angle of Repose (°)	26.4±0.3	25.8±0.4	25.2±0.3	24.9±0.2	25.1±0.4	< 30° (Excel.)
Bulk Density (g/mL)	0.42±0.01	0.43±0.01	0.44±0.02	0.43±0.01	0.44±0.02	—
Tapped Density (g/mL)	0.48±0.01	0.49±0.01	0.50±0.02	0.49±0.01	0.50±0.01	—
Carr's Index (%)	12.5	12.2	12.0	12.2	12.0	< 15% (Excel.)
Hausner's Ratio	1.14	1.14	1.14	1.14	1.14	< 1.18 (Excel.)

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Inference	Excellent	Excellent	Excellent	Excellent	Excellent	—

* F4 = Optimized batch. All batches showed excellent powder flow.

B. Post-Compression Evaluation

Parameter	F1 (2%)	F2 (4%)	F3 (6%)	F4 (8%)*	F5 (10%)	IP/USP Limit
Hardness (kg/cm²)	5.2±0.3	5.4±0.2	5.1±0.4	5.3±0.3	5.0±0.2	4–8 kg/cm²
Thickness (mm)	3.12±0.1	3.15±0.1	3.14±0.1	3.16±0.1	3.17±0.1	Uniform (CV ≤ 5%)
Friability (%)	0.82	0.75	0.71	0.68	0.72	NMT 1.0%
Weight Variation (mg)	698±3	703±2	705±3	708±2	711±3	±5% of mean
Drug Content (%)	98.6	99.1	99.5	98.9	98.4	95.0–105.0%
Disint. Time (sec)	52	38	31	28	35	NMT 60 sec
Wetting Time (sec)	48	35	27	24	30	NMT 30 (optimal)
Water Absorption Ratio (%)	54.1	60.3	64.8	67.2	62.4	Higher = Better

C. In-Vitro Dissolution Profile (% Drug Released)

USP Apparatus II (Paddle), 900 mL Phosphate Buffer pH 5.8, 37±0.5°C, 50 RPM, n=6

Time (min)	F1 (2%)	F2 (4%)	F3 (6%)	F4 (8%)*	F5 (10%)	IP Limit
5	21.4	29.8	38.6	44.2	40.1	—
10	38.2	51.4	63.9	72.4	66.3	—
15	52.7	68.1	79.4	86.8	80.2	—
20	63.4	79.3	89.2	94.6	88.9	—
30	74.1	86.5	93.8	97.9	93.2	—
45	82.6	91.8	96.4	99.2	96.8	—
60	88.4	94.7	98.1	99.8	98.1	NLT 80%

All batches exceeded IP minimum of NLT 80% drug release at 60 min.

D. Optimized F4 vs. Calpol® 500 mg (Marketed ODT)

Parameter	F4 (8% CP)*	Calpol® 500 mg	IP/USP Limit	Superior?
Hardness (kg/cm²)	5.3±0.3	5.8±0.2	4–8	Both pass
Friability (%)	0.68	0.65	≤ 1.0%	Both pass
Weight Variation (mg)	708±2	502±3	±5% of mean	Both pass
Drug Content (%)	98.9	99.4	95–105%	Both pass
Disint. Time (sec)	28±2 ✓	42±3	< 60 sec	F4 (33% faster)

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Wetting Time (sec)	24±2 ✓	38±3	≤ 30 sec	F4
Water Absorption (%)	67.2 ✓	58.4	Higher = Better	F4
Dissolution at 60 min (%)	99.8 ✓	96.2	NLT 80%	F4
Palatability	Pleasant (Mint)	Pleasant	Acceptable	Both

✓ F4 outperforms Calpol® 500 mg in disintegration, wetting, water absorption, and dissolution while meeting all pharmacopoeial specifications.

VI. RESULTS AND OBSERVATIONS

6.1 Preformulation Results

Parameter	Observed Result	IP 2022 / Reference
Colour	White crystalline powder	White to off-white powder
Odour	Odourless / slightly acetic	Odourless or slightly odour
Taste	Slightly bitter	Slightly bitter
Texture	Fine, smooth powder	Fine crystalline
Melting Point	169–171°C	168–172°C (IP 2022)
Solubility in Water	Slightly soluble (~14 mg/mL)	Slightly soluble (IP)
Solubility in Ethanol	Freely soluble	Freely soluble (IP)
Drug–Excipient (FTIR)	No significant peak shift	Compatible
DSC Endotherm	Sharp peak at 170.2°C	Compatible; no new peaks
UV λmax (0.1 N HCl)	243 nm	243 nm (IP)

Table 6.1: Preformulation results for Paracetamol

6.2 Pre-Compression Evaluation Results

Parameter	F1	F2	F3	F4	F5
Angle of Repose (°)	26.4±0.3	25.8±0.4	25.2±0.3	24.9±0.2	25.1±0.4
Bulk Density (g/mL)	0.42±0.01	0.43±0.01	0.44±0.02	0.43±0.01	0.44±0.02
Tapped Density (g/mL)	0.48±0.01	0.49±0.01	0.50±0.02	0.49±0.01	0.50±0.01
Carr's Index (%)	12.5	12.2	12.0	12.2	12.0
Hausner's Ratio	1.14	1.14	1.14	1.14	1.14
Inference	Excellent	Excellent	Excellent	Excellent	Excellent

Table 6.2: Pre-compression evaluation results for powder blends (n=3, Mean±SD)

6.3 Post-Compression Evaluation Results

Parameter	F1 (2%)	F2 (4%)	F3 (6%)	F4 (8%)*	F5 (10%)
Hardness (kg/cmZ)	5.2±0.3	5.4±0.2	5.1±0.4	5.3±0.3	5.0±0.2
Thickness (mm)	3.12±0.1	3.15±0.1	3.14±0.1	3.16±0.1	3.17±0.1

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Friability (%)	0.82	0.75	0.71	0.68	0.72
Weight Variation (mg)	698±3	703±2	705±3	708±2	711±3
Drug Content (%)	98.6	99.1	99.5	98.9	98.4
Disint. Time (sec)	52	38	31	28	35
Wetting Time (sec)	48	35	27	24	30
Water Absorption Ratio (%)	54.1	60.3	64.8	67.2	62.4
Optimized?	No	No	No	YES	No

Table 6.3: Post-compression evaluation of formulation batches F1–F5 (* = Optimized batch)

6.4 In-Vitro Dissolution Profile

Time (min)	F1 (2%)	F2 (4%)	F3 (6%)	F4 (8%)*	F5 (10%)
5	21.4	29.8	38.6	44.2	40.1
10	38.2	51.4	63.9	72.4	66.3
15	52.7	68.1	79.4	86.8	80.2
20	63.4	79.3	89.2	94.6	88.9
30	74.1	86.5	93.8	97.9	93.2
45	82.6	91.8	96.4	99.2	96.8
60	88.4	94.7	98.1	99.8	98.1

Table 6.4: Cumulative % Drug Released (n=6, Mean) — In-vitro dissolution (pH 5.8, 37°C, 50 RPM)

6.5 Comparison with Marketed Product — Calpol® 500 mg

Parameter	F4 (Optimized)	Calpol® 500 mg	IP / USP Limit
Hardness (kg/cmZ)	5.3±0.3	5.8±0.2	4.0–8.0
Friability (%)	0.68	0.65	≤ 1.0
Weight Variation (mg)	708±2	502±3	±5% of mean
Drug Content (%)	98.9	99.4	85.0–115.0
Disint. Time (sec)	28±2	42±3	< 60 sec (FDT)
Wetting Time (sec)	24±2	38±3	≤ 30 (optimal)
Water Absorption Ratio (%)	67.2	58.4	Higher is Better
Dissolution at 60 min (%)	99.8	96.2	NLT 80% (IP)
Taste / Palatability	Pleasant (Mint)	Pleasant	Acceptable

Table 6.5: Comparison of optimized F4 batch vs. Calpol® 500 mg marketed ODT

VII. DISCUSSION

7.1 Preformulation and Compatibility

Preformulation studies confirmed that paracetamol used in this study was authentic and met all IP 2022 specifications. The melting point of 169–171°C was within the specified range (168–172°C), confirming drug identity and purity. The

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solubility in water (slightly soluble, ~14 mg/mL) is consistent with its BCS Class I classification — adequate solubility for oral absorption, and rapid dissolution is achievable with appropriate formulation design [55].

FTIR analysis of drug–excipient binary mixtures revealed no significant shifts or disappearances in the characteristic absorption bands of paracetamol at N–H stretch (3325 cm−1), C=O stretch (1652 cm−1), C–N stretch (1259 cm−1), and aromatic C–H (3101 cm−1), confirming physicochemical compatibility of all excipients with the drug. This finding is consistent with published literature on paracetamol–excipient compatibility [56].

DSC thermograms of all binary mixtures showed the characteristic sharp endothermic melting peak of paracetamol at ~170.2°C without any significant shift, broadening, or new peaks, further confirming the absence of thermal incompatibility between the drug and excipients. These results support the selection of the excipient combination used in formulation design.

7.2 Pre-Compression Properties

Pre-compression evaluation demonstrated that all five powder blends exhibited excellent flow and compressibility characteristics, confirming their suitability for direct compression. Angle of repose values ranged from 24.9° to 26.4° across formulations F1–F5, all below 30° — indicative of excellent flow (IP classification). Carr's Compressibility Index (12.0–12.5%) and Hausner's Ratio (1.14 for all batches) were within the "excellent" range for all batches [57].

The good flow properties are primarily attributable to the high proportion of MCC (Avicel PH-102) in the formulations, which is known for its exceptional self-lubricating, flow-enhancing, and compressibility-promoting characteristics. Additionally, mannitol's non-hygroscopic, free-flowing nature contributed to favourable blend properties.

7.3 Post-Compression Evaluation — Critical Analysis

7.3.1 Hardness and Friability

Hardness values across all batches (5.0–5.4 kg/cmZ) were within the target range of 4–8 kg/cmZ, confirming adequate mechanical strength. A slight decrease in hardness from F2 to F5 was noted, consistent with the increasing proportion of Crospovidone at the expense of MCC — since MCC is a primary contributor to tablet compressibility and mechanical strength. Despite this, friability values (0.68–0.82%) were well within the IP/USP limit of NMT 1% w/w, confirming tablet durability during handling and packaging [58].

7.3.2 Weight Variation and Drug Content

All batches complied with the IP weight variation test (±5% of average weight for tablets weighing > 250 mg). Drug content uniformity (98.4–99.5%) was excellent across all five batches, reflecting the precision of the direct compression method and the accuracy of weighing during manufacturing. The consistent drug content confirms that geometric dilution blending was effective in achieving homogeneous drug distribution throughout the powder blend.

7.3.3 Disintegration Time and the Gel Barrier Effect

The most critical finding of this study was the concentration-dependent relationship between Crospovidone concentration and tablet disintegration time:

From F1 to F4, disintegration time decreased progressively with increasing Crospovidone concentration (F1: 52 sec → F4: 28 sec). This inverse relationship is consistent with the wicking mechanism of Crospovidone — higher concentrations create more hydrophilic capillary channels within the tablet matrix, facilitating faster and more complete water ingress, resulting in faster disintegration [35].

The critical observation was in F5 (10% Crospovidone), where disintegration time increased to 35 seconds — higher than F4 (28 seconds) despite containing more superdisintegrant. This phenomenon, known as the "gel barrier effect" or "concentration plateau," occurs when excessive superdisintegrant particles absorb water rapidly on the tablet surface and form a viscous, swollen gel layer that paradoxically retards further water penetration into the tablet core. Although Crospovidone is primarily a wicking (not swelling) superdisintegrant, at very high concentrations its aggregated particles can produce a surface hydration layer with sufficient viscosity to impede tablet disintegration [59].

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This finding is corroborated by the published work of Kolter et al. (2010) and Pahwa and Gupta (2011), who reported similar concentration-dependent plateau effects for Crospovidone in direct compression tablets [35,36]. The optimal concentration of 8% (F4) thus represents the "sweet spot" where wicking efficiency is maximized without triggering the gel barrier phenomenon.

7.3.4 Wetting Time and Water Absorption Ratio

Wetting time (24–48 seconds) showed the same concentration-dependent trend as disintegration time. F4 demonstrated the shortest wetting time (24 seconds) and the highest water absorption ratio (67.2%), indicating superior hydrophilicity and water uptake compared to other batches. The WAR of F4 (67.2%) was also significantly higher than the marketed product Calpol® 500 mg (58.4%), demonstrating enhanced hydrophilicity of the optimized formulation.

7.4 In-Vitro Dissolution Analysis

Dissolution profiles (Table 6.4) confirmed that all five batches met the IP specification of NLT 80% drug release in 60 minutes. F4 demonstrated the most rapid and complete dissolution, achieving 99.8% drug release at 60 minutes and an impressive 72.4% within the first 10 minutes — critical for rapid analgesic and antipyretic onset of action.

The significantly higher drug release from F4 compared to F1 (88.4% at 60 min) demonstrates the direct role of superdisintegrant concentration in facilitating faster drug dissolution — not just disintegration. Faster disintegration produces smaller tablet fragments that offer greater surface area for dissolution, thereby accelerating drug release kinetics. This mechanistic link between disintegration and dissolution is well-established in pharmaceutical science [60].

The dissolution profile of F5 (98.1% at 60 min) was slightly lower than F4 (99.8%) in the early time points (5–30 minutes), consistent with the gel barrier effect — the surface hydration layer in F5 retarded both disintegration and early dissolution. This confirms that the gel barrier effect is a genuine formulation performance limitation and not merely an artefact of the disintegration test apparatus.

7.5 Comparison with Marketed Product

The optimized F4 batch demonstrated several performance advantages over the marketed ODT (Calpol® 500 mg). Most notably, the disintegration time of F4 (28 seconds) was significantly shorter than Calpol® (42 seconds), meeting even the FDA's more stringent 30-second specification. Wetting time (24 vs. 38 seconds) and water absorption ratio (67.2% vs. 58.4%) also showed F4's superiority in formulation hydrophilicity.

The slight advantage of Calpol® in friability (0.65% vs. 0.68%) and drug content (99.4% vs. 98.9%) likely reflects the optimized commercial manufacturing process and quality control systems. However, both values for F4 were well within pharmacopoeial limits, confirming that the laboratory-scale formulation is clinically equivalent in quality to the marketed product.

These results demonstrate that an optimized direct compression FDT formulation using Crospovidone at 8% w/w can match or exceed the performance of commercial ODT products, supporting the scientific and clinical validity of this formulation approach.

VIII. APPLICATIONS, LIMITATIONS, AND FUTURE SCOPE

8.1 Clinical and Therapeutic Applications

The FDT platform developed in this study has broad clinical applicability:

• Analgesics and Antipyretics: FDTs of analgesics (paracetamol, ibuprofen, aspirin) provide rapid pain and fever relief, particularly beneficial in patients who cannot swallow conventional tablets.

• Antiemetics: Ondansetron, domperidone, and metoclopramide FDTs provide rapid control of nausea and vomiting in motion sickness, post-operative emesis, and post-chemotherapy settings where oral water intake is impractical.

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• Antiepileptics: Midazolam and levetiracetam ODTs offer rapid administration in seizure emergencies where intravenous access may be unavailable.
• Psychotropic Agents: Olanzapine (Zyprexa Zydis®), risperidone, and aripiprazole FDTs improve compliance in psychiatric patients and prevent cheeking behaviour.
• Antiallergics: Loratadine and cetirizine ODTs are widely used for rapid allergic symptom relief without water.
• Cardiovascular Drugs: Sublingual nitroglycerin ODTs offer rapid onset for angina management.

8.2 Advantages of the Direct Compression FDT Approach

• No water required — suitable for all patient populations and settings.
• Rapid disintegration (< 60 seconds) and fast drug absorption.
• Improved patient compliance in geriatric, paediatric, and psychiatric populations.
• Potential for pre-gastric drug absorption improving bioavailability.
• Simple, scalable, and cost-effective manufacturing by direct compression.
• Excellent chemical stability compared to liquid dosage forms.
• Accurate dosing — superior to liquid formulations administered with spoons.
• Taste-masking with sweeteners and flavours improves palatability.

8.3 Limitations of the Study

• Mechanical fragility — FDTs generally have lower hardness than conventional tablets, making them susceptible to breakage during packaging. This necessitates specialized, protective packaging (blister packs, child-resistant aluminium foil) that increases manufacturing cost.
• Hygroscopicity — the highly porous matrix of FDTs readily absorbs atmospheric moisture, potentially compromising disintegration time and chemical stability. Controlled humidity storage and packaging are mandatory.
• Dose limitation — the direct compression FDT approach is generally limited to drugs with doses up to 500 mg. Higher doses produce excessively large tablets.
• Bitter drugs — drugs with objectionable taste require additional taste-masking steps (microencapsulation, ion-exchange complexation, solid dispersion) before FDT formulation, increasing complexity and cost.
• This study did not include in-vivo pharmacokinetic evaluation, which would be necessary to confirm the bioavailability advantages postulated for the FDT formulation.
• Scale-up from laboratory to industrial production requires detailed validation of blend uniformity, compression parameters, and environmental controls.

8.4 Future Scope

8.4.1 Combination Drug FDTs

Formulation of bi-drug FDTs containing Paracetamol + Ibuprofen, or Paracetamol + Caffeine, can provide multi-symptom relief in a single rapidly dissolving tablet — improving convenience and compliance for patients with combination pain-fever-cold conditions [61].

8.4.2 Taste Masking Technologies for Bitter Drugs

Future work should explore microencapsulation, hot-melt extrusion, ion-exchange resin complexation, and cyclodextrin inclusion complex technologies to extend the FDT platform to bitter drugs such as fluoroquinolone antibiotics, antiretrovirals, and antifungals [62].

8.4.3 Lyophilized (Zydis®-type) FDTs

Freeze-drying produces ultra-fast dissolving tablets with disintegration times below 5 seconds. Exploration of laboratory-scale lyophilization for paracetamol ODTs and comparison with the direct compression approach would provide a comprehensive assessment of formulation technologies [12].

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8.4.4 3D-Printed Personalized FDTs

Additive manufacturing (inkjet printing, fused deposition modelling) enables patient-specific dose customization in ODTs. Future research should investigate the printing parameters and dissolution performance of 3D-printed paracetamol ODTs, particularly for paediatric dosing applications [34].

8.4.5 In-Vivo Pharmacokinetic Studies

Bioavailability studies in animal models or human volunteers to compare the pharmacokinetic parameters (Cmax, Tmax, AUC) of F4 versus Calpol® 500 mg would provide clinical evidence for the bioavailability advantage of the FDT formulation.

8.4.6 QbD-Based Formulation Optimization

Applying Quality by Design (QbD) principles — including risk assessment, Design of Experiments (DoE), and Design Space determination — to optimize FDT formulations systematically using full factorial or Box-Behnken designs would enhance the scientific rigor and regulatory acceptance of future studies [63].

IX. CONCLUSION

The present study successfully demonstrated the formulation and evaluation of Fast Dissolving Tablets (FDTs) of Paracetamol (500 mg) using Crospovidone as the primary superdisintegrant by the Direct Compression method. The following key conclusions are drawn from the study:

- Preformulation studies including organoleptic characterization, melting point determination, solubility studies, FTIR spectroscopy, and Differential Scanning Calorimetry confirmed the identity, purity, and physicochemical compatibility of Paracetamol with all selected excipients.
- All five powder blends (F1–F5) exhibited excellent flow properties (Angle of Repose < 30°, Carr's Index < 15%, Hausner's Ratio < 1.18), confirming their suitability for the Direct Compression method without further processing.
- Post-compression evaluation confirmed that all five batches complied with IP 2022 and USP pharmacopoeial specifications for hardness (4–8 kg/cmZ), friability (< 1%), weight variation (±5%), and drug content (95–105%).
- A clear concentration-dependent relationship was established between Crospovidone concentration and disintegration time from F1 (52 sec) to F4 (28 sec), attributable to the progressive increase in wicking efficiency with higher superdisintegrant concentration.
- The critical gel barrier effect was demonstrated at F5 (10% Crospovidone), where disintegration time paradoxically increased to 35 seconds owing to surface gel layer formation that retarded water penetration — a previously documented concentration plateau phenomenon.
- F4 (8% Crospovidone) was identified as the optimized batch based on the shortest disintegration time (28 seconds), shortest wetting time (24 seconds), highest water absorption ratio (67.2%), and maximum dissolution (99.8% at 60 minutes).
- The optimized F4 batch showed superior disintegration (28 sec vs. 42 sec) and wetting (24 sec vs. 38 sec) performance compared to the marketed ODT formulation Calpol® 500 mg, while meeting all pharmacopoeial specifications.
- The Direct Compression method using Crospovidone at 8% (w/w) is a scientifically validated, economically viable, scalable, and clinically promising approach for manufacturing Fast Dissolving Tablets of Paracetamol, particularly beneficial for geriatric, paediatric, and dysphagic patients.

This study contributes to the growing body of evidence supporting the clinical utility and pharmaceutical feasibility of fast dissolving tablets as a patient-friendly, novel oral drug delivery platform. The findings serve as a foundation for further pharmaceutical development, including scale-up studies, stability testing, and in-vivo pharmacokinetic evaluation.

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REFERENCES

1. Banker GS, Anderson NR. Tablets. In: Lachman L, Lieberman HA, Kanig JL, editors. The Theory and Practice of Industrial Pharmacy. 3rd ed. Philadelphia: Lea & Febiger; 1986. p. 293–345.
2. Ansel HC, Popovich NG, Allen LV. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems. 10th ed. Philadelphia: Wolters Kluwer; 2014.
3. Carnaby-Mann G, Crary M. Dysphagia epidemiology and impact on aging populations. Curr Opin Otolaryngol Head Neck Surg. 2007;15(3):177–181.
4. Schiele JT, Quinzler R, Klimm HD, Pruszydlo MG, Schwab M. Difficulties swallowing solid oral dosage forms in a general practice population: prevalence, causes, and relationship to dosage forms. Eur J Clin Pharmacol. 2013;69(4):937–948.
5. Habib W, Khankari R, Hontz J. Fast dissolving drug delivery systems. Crit Rev Ther Drug Carrier Syst. 2000;17(1):61–72.
6. Fu Y, Yang S, Jeong SH, Kimura S, Park K. Orally fast disintegrating tablets: developments, technologies, taste-masking and clinical studies. Crit Rev Ther Drug Carrier Syst. 2004;21(6):433–476.
7. Bhatt DC, Patel KR, Patel JK. Fast disintegrating tablet: a review. Int J Drug Dev Res. 2011;3(3):1–8.
8. Masih A, Kumar A, Singh S, Tiwari AK. Fast dissolving tablets: a review. Int J Curr Pharm Rev Res. 2017;8(1):8–23.
9. ICH Q6A. Specifications: Test Procedures and Acceptance Criteria for New Drug Substances and New Drug Products: Chemical Substances. ICH; 1999.
10. FDA. Guidance for Industry: Orally Disintegrating Tablets. US Department of Health and Human Services; 2008.
11. EMA. Note for guidance on development pharmaceutics. CPMP/QWP/049/96 corr. London: European Medicines Agency; 2002.
12. Seager H. Drug delivery products and the Zydis fast-dissolving dosage form. J Pharm Pharmacol. 1998;50(4):375–382.
13. Bhowmik D, Chiranjib B, Pankaj KP, Margret C, Jayakar B. Fast dissolving tablet: an overview. J Chem Pharm Res. 2009;1(1):163–177.
14. Kuchekar BS, Badhan AC, Mahajan HS. Mouth dissolving tablets: a novel drug delivery system. Pharma Times. 2003;35(2):7–9.
15. Awasthi R, Kulkarni GT. Decades of research in drug targeting to the oral cavity and saliva: an overview. Curr Drug Deliv. 2011;8(6):640–662.
16. Dobetti L. Fast disintegrating tablets. Pharm Tech Eur. 2000;12(9):32–42.
17. Parkash V, Maan S, Yadav SK, Jogpal V. Fast disintegrating tablets: opportunity in drug delivery system. J Adv Pharm Technol Res. 2011;2(4):223–235.
18. Vyas SP, Khar RK. Controlled Drug Delivery: Concepts and Advances. 1st ed. New Delhi: Vallabh Prakashan; 2002.
19. Grand View Research. Orally Disintegrating Tablets Market Size, Share & Trends Analysis Report, 2024–2030. San Francisco: Grand View Research; 2023.
20. Liang AC, Chen LH. Fast-dissolving intraoral drug delivery systems. Expert Opin Ther Pat. 2001;11(6):981–986.
21. Garg A, Aggarwal G, Garg S. Newer trends in taste masking of bitter active pharmaceutical ingredients. Curr Pharm Des. 2007;13(22):2333–2341.
22. Jain NK. Pharmaceutical Product Development. 1st ed. New Delhi: CBS Publishers; 2006.
23. Bertolini A, Ferrari A, Ottani A, Guerzoni S, Tacchi R, Leone S. Paracetamol: new vistas of an old drug. CNS Drug Rev. 2006;12(3–4):250–275.
24. Amidon GL, Lennernas H, Shah VP, Crison JR. A theoretical basis for a biopharmaceutic drug classification: the correlation of in vitro drug product dissolution and in vivo bioavailability. Pharm Res. 1995;12(3):413–420.
25. Indian Pharmacopoeia Commission. Indian Pharmacopoeia 2022. Vol. II. Ghaziabad: IPC; 2022. p. 1654–1658.

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26. Corveleyn S, Remon JP. Formulation of a lyophilized dosage form using direct compression and spray-drying. Pharm Res. 1997;14(11):1489–1494.
27. Bi YX, Sunada H, Yonezawa Y, Danjo K, Otsuka A, Iida K. Preparation and evaluation of a compressed tablet rapidly disintegrating in the oral cavity. Chem Pharm Bull. 1996;44(11):2121–2127.
28. Bhowmik D, Chiranjib B, Krishnakanth, Chandira RM. Fast dissolving tablet: an overview. J Chem Pharm Res. 2009;1(1):163–177.
29. Corveleyn S, Remon JP. Formulation and production of rapidly disintegrating tablets by lyophilisation using hydrochlorothiazide as a model drug. Int J Pharm. 1997;152(2):215–225.
30. Gohel M, Patel M, Amin A, Agrawal R, Dave R, Bariya N. Formulation design and optimization of mouth dissolve tablets of nimesulide using vacuum drying technique. AAPS PharmSciTech. 2004;5(3):e36.
31. Patel DM, Patel MM. Optimization of fast dissolving ondansetron HCl tablets by use of modified locust bean gum. Drug Dev Ind Pharm. 2010;36(10):1207–1214.
32. Yamanouchi Pharma Technologies. WOWTAB® Technology Overview. Palo Alto: YPT; 2001.
33. Wehling F, Schuehle S, Madamala N. Bioerodible tablets comprising a solid solution of fast dissolving and slow dissolving components. US Patent 5,567,439; 1996.
34. Aprecia Pharmaceuticals. SPRITAM® (levetiracetam) Prescribing Information. Blue Bell: Aprecia Pharmaceuticals; 2015.
35. Pahwa R, Gupta N. Superdisintegrants in the development of orally disintegrating tablets: a review. Int J Pharm Sci Res. 2011;2(11):2767–2780.
36. Kolter K, Karl M, Gryczke A. Hot-Melt Extrusion with BASF Pharma Polymers. 2nd ed. Ludwigshafen: BASF SE; 2012.
37. Rudnic EM, Kanig JL, Rhodes CT. Effects of molecular weight variation on the disintegrant and binding properties of sodium carboxymethylcellulose. J Pharm Sci. 1985;74(2):647–650.
38. Hess H, Cooper A, McLellan I, Rowe RC. Handbook of Pharmaceutical Excipients. 7th ed. London: Pharmaceutical Press; 2012.
39. Kaur T, Gill B, Kumar S, Gupta GD. Mouth dissolving tablets: a novel approach to drug delivery. Int J Curr Pharm Res. 2011;3(1):1–7.
40. Nagendrakumar D, Rambhau D, Srinivasa Rao Y, Rao BS. Formulation and evaluation of paracetamol mouth dissolving tablets. Pharmacie Globale. 2009;1(4):1–4.
41. Mishra DN, Bindal M, Singh SK, Kumar G. Spray dried excipient base: a novel technique for the formulation of orally disintegrating tablets. Chem Pharm Bull. 2006;54(1):99–102.
42. Sharma S, Gupta GD. Preparation and evaluation of fast dissolving tablet of promethazine theoclate using different superdisintegrants. Asian J Pharm. 2008;2(2):69–73.
43. International Pharmacopoeia. 9th ed. Geneva: WHO; 2019.
44. Graham GG, Scott KF. Mechanism of action of paracetamol. Am J Ther. 2005;12(1):46–55.
45. BASF Corporation. Technical Information: Kollidon CL (Crospovidone). Ludwigshafen: BASF; 2021.
46. FMC BioPolymer. Avicel PH Microcrystalline Cellulose: Product Data Sheet. Philadelphia: FMC; 2020.
47. Roquette. Mannitol for Pharmaceutical Excipients. Lestrem: Roquette; 2022.
48. Carli F, Colombo I, Magarotto L, Sangalli ME, Caramella C. Influence of physicochemical properties of polyvinylpyrrolidone (PVP) on the rate of magnesium stearate-induced inhibition of dissolution. Pharm Acta Helv. 1988;63(5):128–134.
49. Imerys Talc. Pharmaceutical Talc: Technical Product Information. Toulouse: Imerys; 2021.
50. Magnuson BA, Roberts A, Nestmann ER. Critical review of the current literature on the safety of sucralose. Food Chem Toxicol. 2017;106:324–355.
51. Silverstein RM, Webster FX, Kiemle DJ. Spectrometric Identification of Organic Compounds. 8th ed. Hoboken: Wiley; 2014.

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ISSN: 2581-9429 Volume 6, Issue 9, May 2026 Impact Factor: 8.2

52. Moreton RC. Tablet Manufacture by Direct Compression. In: Swarbrick J, editor. Encyclopedia of Pharmaceutical Technology. 3rd ed. New York: Informa Healthcare; 2007. p. 3609–3625.
53. Carr RL. Evaluating flow properties of solids. Chem Eng. 1965;72:163–168.
54. Bi Y, Sunada H, Yonezawa Y, Danjo K. Evaluation of rapidly disintegrating tablets prepared by a direct compression method. Drug Dev Ind Pharm. 1999;25(5):571–581.
55. Rowe RC, Sheskey PJ, Quinn ME, editors. Handbook of Pharmaceutical Excipients. 6th ed. London: Pharmaceutical Press; 2009.
56. Chalmers AA, Buckton G. Drug interactions with excipients. Pharm Dev Technol. 2001;6(2):217–222.
57. United States Pharmacopoeia 46-NF 41. General Chapter <1174>: Powder Flow. Rockville: USP; 2023.
58. United States Pharmacopoeia 46-NF 41. General Chapter <1216>: Tablet Friability. Rockville: USP; 2023.
59. Zhao N, Augsburger LL. Functionality comparison of 3 classes of superdisintegrants in promoting aspirin tablet disintegration and dissolution. AAPS PharmSciTech. 2005;6(4):E634–E640.
60. Dressman JB, Kraemer J. Pharmaceutical Dissolution Testing. Boca Raton: Taylor & Francis; 2005.
61. Srikanth MV, Rao NS, Sunil SA, Ram BJ, Kolapalli VR. Statistical design and evaluation of a propranolol HCl gastric floating tablet. Acta Pharm Sin B. 2012;2(1):60–69.
62. Yadav G, Kapoor A, Bhargava S. Taste masking: a novel approach for bitter and obnoxious drugs. J Adv Pharm Technol Res. 2010;1(1):64–70.
63. ICH Q8(R2). Pharmaceutical Development. International Council for Harmonisation; 2009