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# Fast Dissolving Tablets: Advances in Formulation Strategies, Technologies, and Patient-Centric Drug Delivery

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**ABSTRACT:** Fast dissolving tablets (FDTs) are innovative oral dosage forms that dissolve in the mouth in a matter of seconds without the need for water, making them a good substitute for traditional tablets. These formulations are particularly helpful for bedridden, dysphagic, geriatric, psychiatric, and paediatric patients who frequently have trouble swallowing solid oral medications. The growing popularity of FDTs can be explained by the fact that traditional tablets take longer to dissolve and typically exhibit lower patient acceptability.

The basic concepts of FDT preparation are highlighted in this review article, with special attention to the roles of cutting-edge super disintegrants such as croscopovidone, croscarmellose sodium, sodium starch glycolate and new generation starch malonates. The effects of key formulation methods on tablet texture, hardness, porosity, and dissolution behaviour are examined, including direct compression, lyophilization, sublimation, moulding, and spray drying. Additionally investigated are innovations like 3D-printed FDTs, co-processed excipients, and solubility enhancement based on nanotechnology. Key evaluation parameters, including disintegration time, wetting time, water absorption ratio, mechanical strength, and dissolution profile, are discussed in relation to important formulation considerations, such as taste masking through ion-exchange resins, microencapsulation, and cyclodextrin complexation.

In Conclusion, Fast dissolving tablets are a patient-focused medication delivery method with a lot of promise, and new developments keep improving their functionality and potential.

**KEYWORDS:** Fast Dissolving Tablet, Super Disintegrant, Taste Masking, Oral Drug Delivery System.

## I. INTRODUCTION

Oral drug delivery systems are the popular route of administration of drugs because of their convenience and patient acceptability [1, 2]. But some groups of patients, such as paediatric patients, geriatric patients, patients with dysphagia, psychiatric patients, and bedridden patients, cannot swallow any conventional dosage form like tablets and capsules [2, 3]. Patient acceptance is lost because of such problems. Also, it has a bad impact on the treatment outcome [3]. There is a growing need for patient-friendly oral formulations [4]. Fast-dissolving tablets appear as a good alternative to conventional tablets [4, 5]. They are made in such a manner that they disperse quickly in the mouth without the application of water; therefore, they are easy to administer and give comfort to the patient [5]. Rapid disintegrating tablets help to get a quick onset of action and good bioavailability [5]. Fast-dissolving tablets are particularly useful for the elderly population, as well as for those with swallowing difficulties, bedridden patients, and individuals who prefer not to use watery preparations [2, 4]. As a result of these advantages, formulation of FDTs has gained a lot of attention from Pharmaceutical researchers and product developers [4, 5].

The selection of excipients and manufacturing processes required is important for the formulation of FDTs [4, 5]. The rapid disintegration of tablets can be attained with the help of superdisintegrants [5]. Manufacturing methods includes direct compression, lyophilisation, sublimation, moulding, and spray drying, and it affects porosity, mechanical strength, and dissolution behaviour of the tablet [4, 5].

So, in order to guarantee product quality and patient acceptance, there are issues related to taste masking, stability and moisture sensitivity that must be solved together [4, 5].

## II. NEED OF FAST-DISSOLVING TABLETS

As conventional oral solid dosage forms are commonly used, their administration is mostly problematic in a selected group of patients [6]. The presence of swallowing impairment is mostly seen in paediatric and geriatric patients [6, 7]. Except for this, it can also be seen in other patients associated with multi-factorial conditions such as dysphagia, neurological disorders, etc. According to references [6, 7], the problem is commonly associated with improper intake and skipping of doses, which leads to reduced therapeutic effectiveness.

Fast-dissolving tablets were created to make an attempt to resolve some issues related to traditional tablets by offering a tablet that will quickly dissolve in the oral cavity without requiring water [8]. By doing this, it will be easier to administer the dosage form, hence there will be fewer chances of a person choking on a tablet, especially when administering medications in emergency conditions, like while travelling, or in individuals who require assistance in taking their prescribed medications [8, 9].

FDTs must also be considered and offered because of the demand for a rapid onset of action [9]. Since these tablets quickly dissolve in saliva, and then the drug can be absorbed at an earlier stage than with standard tablets [9]. Also, in some cases, fractional absorption may also occur through the oral mucosa, which aids to improve bioavailability [9, 10].

In addition to better administration of the dosage form, fast-dissolving tablets are more acceptable to patients because of the improved mouthfeel and reduced fear linked with swallowing traditional tablets [8, 10]. Therefore, fast-dissolving tablets represent an important patient-centric drug delivery method for chronic conditions where long-term compliance will be required [10].

## III. MECHANISM OF DISINTEGRATION OF FAST-DISSOLVING TABLETS

Fast-dissolving tablets (FDTs) undergo rapid disintegration in the presence of saliva or aqueous medium because of the combined effects of capillary-driven liquid penetration, i.e., wicking, swelling of superdisintegrant particles with the development of swelling pressure, and elastic recovery of particles compressed during tablet manufacturing. The predominance of each and every mechanism depends on the chemical nature of the disintegrant used, tablet porosity, compression force, and the mode of disintegrant incorporation into the formulation [11–14].

### **Fundamental Disintegration Mechanisms:**

Tablet disintegration is a multifactorial phenomenon in which several mechanisms act simultaneously rather than independently [12, 14, 15].

#### **Swelling-induced disruption:**

When a tablet containing superdisintegrants comes in contact with water, the hydrophilic material rapidly absorbs the liquid and expands in volume. This expansion creates an internal stress within the tablet matrix. These stresses weaken and rupture the interparticle bonds, which leads them to separate, ultimately leading to the disintegration of the tablet [13–15].

#### **Elastic (strain) recovery:**

During compaction, some particles deform elastically and store mechanical energy. Upon wetting, partial recovery of the original particle shape releases this stored energy, leading to crack formation and fragmentation of the tablet matrix [12, 14, 16].

#### **Dissolution-assisted weakening:**

In tablets with very water-soluble ingredients, binders or fillers might dissolve quickly when wet, leading to reduced mechanical strength in the tablet's structure. This process aids disintegration but is dependent on the specific formulation used [12,15,17].

These mechanisms operate synergistically: capillary penetration promotes disintegrant hydration, swelling reduces bonding strength, and elastic recovery facilitates complete fragmentation of the tablet structure [11–15,17].

**Formulation Design Considerations:**

For achieving a very quick disintegration (typically <30 s), formulations should contain superdisintegrants with complementary mechanisms, such as crospovidone (primarily acts by wicking and elastic deformation) combined with croscarmellose sodium (predominantly acts by swelling). Optimized compression forces or engineered porosity enhance liquid penetration while maintaining acceptable mechanical strength. Extragranular disintegrant placement and minimization of hydrophobic excipients at the tablet surface further improve disintegration performance [11–14,16–18].

**IV. ROLE OF SUPERDISINTEGRANTS IN FAST DISSOLVING TABLETS**

Superdisintegrants are vital formulation ingredients in fast dissolving tablets since they enable that tablet to disintegrate rapidly when in contact with saliva. These agents in comparison to traditional disintegrants are effective at much lower concentrations, and they lead to quicker disintegration via increased swelling tendencies, capillary (wicking) activity, and quick hydration features [19,20]. Crospovidone, croscarmellose sodium and sodium starch glycolate are commonly used synthetic superdisintegrants in fast dissolving tablet preparations. Crospovidone is used to cause the disintegration of tablets mainly by capillary effect and it does not produce a gel when it is in contact with water which helps in quick dispersion of the tablets [21]. Croscarmellose sodium is utilized in a dual action such as swelling and wicking, whereas sodium starch glycolate is subjected to extensive swelling in aqueous conditions, which causes the enough internal pressure to break the structure of the pill [22]. Development and use of novel and natural superdisintegrants, e.g., chemically modified starches (e.g., starch malonate), plant-based polymers and co-processed excipient systems have become the focus of more attention in recent years. These substances are engineered to increase the performance of disintegration with a preservation of hardness of the pills and a reduction in the friability [23,24]. The type and concentration of superdisintegrants should be optimized carefully because excess is likely to cause adverse effects on mechanical strength or unwanted gelling. To conclude, superdisintegrants play a very vital role in determining the performance of fast dissolving tablets and its proper selection is significant in realizing the rapid disintegration of tablets without affecting their structure [25]

**V. MANUFACTURING TECHNIQUES FOR FAST-DISSOLVING TABLETS**

The technology applied in the manufacturing of fast-dissolving tablets has a significant influence on product quality, performance, and patient acceptance [4, 5, 27]. Manufacturing methods directly affect key tablet characteristics such as porosity, hardness, disintegration behaviour, dissolution profile, and mouthfeel [4, 5, 28]. Since these tablets are intended to dissolve rapidly in the oral cavity while maintaining sufficient mechanical strength, the choice of manufacturing method depends on the physicochemical properties of the drug, the nature of the excipients used, and the intended mode of therapy [5, 27, 28]. To meet these requirements, both conventional and advanced manufacturing techniques have been developed to achieve rapid disintegration without compromising tablet stability or handling characteristics [4, 5, 28].

**Direct Compression:** Direct compression is one of the most commonly adopted methods for the manufacture of fast-dissolving tablets owing to its operational simplicity and economic feasibility. In this method, the active pharmaceutical ingredient is blended uniformly with superdisintegrants, diluents, and other necessary excipients, followed by compression into tablets without any preliminary granulation steps.

The major benefits of direct compression include fewer processing stages, ease of scale-up, and suitability for drugs that are sensitive to heat or moisture. However, careful selection of excipients with appropriate flowability and compressibility is essential. Excessive compression force may reduce tablet porosity, thereby negatively affecting disintegration and dissolution behaviour [27].

**Lyophilization (Freeze Drying):** Lyophilization is a specialized manufacturing technique used to produce highly porous and low-density fast-dissolving tablets. The process involves freezing a drug solution or suspension followed by sublimation of the solvent under reduced pressure. This structure enables extremely rapid penetration of saliva, resulting in very fast tablet disintegration.

Freeze-dried tablets generally exhibit excellent mouthfeel and disintegrate within seconds; however, they are mechanically fragile and highly sensitive to moisture. As a result, specialized packaging is required, and the high cost of equipment and processing limits the large-scale commercial applicability of this technique [29].

**Sublimation Technique:** The sublimation technique involves the incorporation of volatile substances such as camphor, menthol, or ammonium bicarbonate into the tablet formulation. After tablet formation, these volatile components are removed by sublimation, leaving behind a porous matrix that facilitates rapid water uptake and tablet disintegration. Although this method effectively enhances porosity and dissolution rate, it requires an additional processing step and precise optimization to ensure complete removal of volatile materials, which may complicate manufacturing [31].

**Moulding Method:** In the moulding method, tablets are prepared by shaping a moist blend of drug and excipients into moulds, followed by drying. Tablets produced by this technique are generally softer, less dense, and provide a smooth mouthfeel, making them suitable for paediatric and geriatric patients.

Despite their rapid disintegration properties, moulded tablets often possess lower mechanical strength and higher friability compared to conventionally compressed tablets. These limitations may pose challenges during handling, storage, and transportation [29, 31].

**Spray Drying:** Spray drying is a rapid solvent evaporation technique used to produce fine, porous powders with enhanced dissolution characteristics. In this process, a solution or suspension containing the drug and excipients is atomized into a heated chamber, where the solvent evaporates quickly, yielding dry particles.

The resulting spray-dried powders can be compressed into fast-dissolving tablets exhibiting improved content uniformity and rapid drug release. However, the requirement for specialized equipment and controlled processing conditions contributes to increased production costs [27, 31].

**Emerging Methods:** Recent advancements in fast-dissolving tablet technology have focused on the use of co-processed excipients, three-dimensional (3D) printing, and nanotechnology-based solubility enhancement approaches. Co-processed excipients combine multiple functional properties, such as improved compressibility and rapid disintegration, within a single excipient system.

Three-dimensional printing enables precise control over tablet geometry, internal structure, and porosity, allowing customization of dose and disintegration behaviour. In addition, nanotechnology-based approaches, including nanosuspensions and nanocrystals, enhance drug solubility and dissolution rate, leading to improved bioavailability. These emerging techniques represent promising strategies for the development of next-generation, patient-centred fast-dissolving tablets [37–39].

Disintegrant Class	Dominant Mechanisms	Typical Formulation Notes
Sodium Starch Glycolate	Rapid intraparticle swelling producing high swelling pressure	Effective at low concentration; sensitive to compression and granulation method [2,4]
Croscarmellose Sodium	Wicking plus multidirectional swelling; fibrous particles enhance capillary flow	Works both intra- and extragranularly; particle morphology matters [2,4]
Crospovidone	Strong capillary/wicking and elastic recovery; low bulk swelling	Especially effective when placed extragranularly; less sensitive to moisture [2,4]
Natural Disintegrants (e.g., plantago, starches)	Combination of swelling and wicking depending on source and processing	Variable performance, may require higher levels and careful specification [5, 6]

## VI. TASTE MASKING TECHNIQUES IN FAST DISSOLVING TABLETS

The issue of taste masking is a significant concept in the development of fast-dissolving tablets, as the drug is released in the mouth immediately. Most of the common active pharmaceutical compounds have a negative or bitter taste, and this may adversely influence patient acceptance, especially in geriatric and paediatric patients [33]. As such, proper taste masking interventions are required in order to achieve patient compliance.

The use of ion-exchange resins is a commonly used method in which the drug is attached to a resin complex, preventing interaction with taste buds until release in the gastrointestinal tract [34]. In contrast, microencapsulation involves covering drug particles with polymers to form a barrier, which decreases bitterness without altering dissolution [35]. The primary distinction is that ion-exchange resins delay taste impact by restricting release until reaching the GI tract, whereas microencapsulation creates a direct physical barrier to mask taste while maintaining the drug's dissolution profile.

Other complexation methods that have been used to mask taste in FDTs include cyclodextrin complexation. Cyclodextrins make complexes with drug molecules and conceal the bad taste, besides enhancing drug stability and solubility [36]. Also, sweeteners, flavours, and flavour-polymer combinations can be used to increase palatability and overall mouthfeel of the formulation [37].

The choice of taste masking method depends on the drug's physicochemical characteristics, required release profile, and manufacturability. A successful technique ensures greater patient acceptability while maintaining fast tablet dissolution and therapeutic benefit [38].

## VII. EVALUATION PARAMETERS OF FAST DISSOLVING TABLETS

Evaluation of fast-dissolving tablets is essential to ensure product quality, performance, and patient acceptability. Along with conventional tablet evaluation tests, FDTs require specific parameters to assess their rapid disintegration behaviour in the oral cavity [39].

**Disintegration Time:** Disintegration time is one of the most critical quality attributes of FDTs. It is defined as the time required for a tablet to break down into particles small enough to pass through a screen under specified conditions. For FDTs, the disintegration time is generally expected to be within a few seconds to one minute [40].

**Wetting Time:** Wetting time indicates the ability of saliva to penetrate the tablet structure. A shorter wetting time corresponds to faster disintegration and better patient experience. This parameter is influenced by tablet porosity and the type of superdisintegrant used [41].

**Water Absorption Ratio:** The water absorption ratio measures the extent of water uptake by the tablet during wetting. Higher water absorption promotes swelling of disintegrants and accelerates tablet breakup [42].

**Mechanical Strength:** Mechanical strength, including hardness and friability, ensures that the tablets can withstand handling, packaging, and transportation. A balance between sufficient mechanical strength and rapid disintegration is essential in FDT formulation [43].

**In Vitro Dissolution Studies:** In vitro dissolution testing is performed to evaluate the drug release profile from FDTs. Rapid drug dissolution is desirable to ensure the quick onset of action and consistent therapeutic performance [44].

Overall, systematic evaluation of fast-dissolving tablets ensures that the formulation meets pharmacopeial standards while delivering rapid disintegration and optimal drug release [45].

## VIII. RECENT ADVANCES IN FAST DISSOLVING TABLETS

Recent studies on fast-dissolving tablets have focused on improving formulation performance, patient acceptability, and expanding the application of FDTs to a wider range of drug categories. One significant advancement is the introduction of co-processed excipients, in which two or more excipients are combined at the sub-particle level to improve flowability, compressibility, and disintegration efficiency. These excipients assist in achieving rapid disintegration while maintaining adequate tablet strength [46, 47]. Nanotechnology-based approaches have also gained considerable attention in FDT formulation, particularly for poorly water-soluble drugs. Techniques such as nanosuspensions, solid lipid nanoparticles, and drug nanocrystals enhance solubility and dissolution rate, resulting in improved bioavailability when incorporated into fast-dissolving tablets [48,49]. Another emerging technology is the application of three-dimensional (3D) printing in the design of fast-dissolving tablets. This technique allows precise control over tablet structure, porosity, and dose,

enabling the production of highly porous tablets with extremely rapid disintegration. In addition, 3D printing supports personalized medicine and on-demand drug manufacturing [50, 51]. Furthermore, increasing research interest is being directed toward natural polymers and novel superdisintegrants to improve safety, cost-effectiveness, and sustainability. These developments reflect the evolving concept of fast-dissolving tablets and their growing potential to meet future pharmaceutical and patient-centered needs [52].

### **IX. LIMITATION AND CHALLENGES OF FAST TABLETS**

However, in spite of the many benefits of fast-dissolving tablets, there are some limitations and challenges that limit their application. Among the greatest issues are dose limitation, since FDTs are typically applicable to low dose drugs. This is because high-dose drugs result in larger tablet size, low mouthfeel, and slower disintegration [53]. Another challenge that is of high significance is mechanical strength because very porous tablets with a fast disintegration rate tend to have low hardness and high friability. This renders them more susceptible to destruction throughout handling, transportation, and packaging [54]. Also, most of the FDT recipes are hygroscopic, hence sensitive to moisture, and they need special packaging to be stable [55]. The masking of bad taste is also difficult, especially when dealing with very bitter drugs, where complicated methods to mask the bad taste are necessary, which might raise the complexity of formulations and cost [56]. Also, a compromise between fast disintegration and tolerable behaviour of dissolution is another formulation difficulty. In the manufacturing side, there are more sophisticated technologies, including lyophilization and 3D printing, that require a higher cost of production, and it might not be appropriate in large-scale commercial manufacturing [57]. The regulatory issues and quality control requirements are also other factors that contribute to the difficulties related to FDT development. Comprehensively, it is imperative to deal with these shortages using optimization of formulations and technological development as a means of achieving the maximum potential of fast-dissolving tablets [58].

### **X. CONCLUSION AND FUTURE PERSPECTIVES**

Fast-dissolving tablets constitute a significant development in oral drug delivery systems, enhancing patient convenience, improving compliance, and providing a rapid onset of action. Their rapid breakdown in the oral cavity and the absence of a need for water make them particularly suitable for paediatric, geriatric, dysphagic, psychiatric, and bedridden patients.

Considerable advancements have been achieved in the design and development of FDTs through the use of novel and efficient superdisintegrants, optimized manufacturing processes, and effective taste masking technologies. Innovations such as co-processed excipients, nanotechnology-based solubility enhancement, and 3D printing have further expanded the scope of FDTs, enabling their application to a wider range of drugs.

Despite these developments, challenges related to dose limitation, mechanical strength, moisture sensitivity, and production cost still persist. These limitations are expected to be addressed through continued research on novel excipients, improved processing technologies, and patient-centric design approaches.

Overall, fast-dissolving tablets remain a promising and versatile drug delivery system. Future developments are likely to enhance their therapeutic efficiency, commercial feasibility, and application in the field of personalized medicine.

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