Ars Pharmaceutica
https://revistaseug.ugr.es/index.php/ars
E-ISSN: 2340-9894 ISSN: 0004-2927

doi: 10.30827/ars.v67i1.34718
Artículos originales

Formulation and Evaluation of Oral Disintegrating Tablets of Enalapril Maleate Using Synthetic and Natural Superdisintegrants

Formulación y evaluación de comprimidos desintegrables orales de maleato de enalapril utilizando superdesintegrantes sintéticos y naturales

Swapna Megavath[1] 0009-0005-7880-5137
Prasanna Kumar Desu[2] 0000-0001-6709-6551
Rahul Molla[1] 0009-0008-7523-6073
Vanitha Kondi[1] 0000-0003-4674-3670

[1]Department of Pharmaceutics, Vishnu Institute of Pharmaceutical Education and Research, Narsapur, Telangana – 502313

[2]Department of Pharmaceutics, Dr Samuel George Institute of Pharmaceutical Sciences, Markapur, India – 523316

Correspondence

Vanitha Kondi
Vanitha.k@viper.ac.in

Received: 20.08.2025
Accepted: 24.11.2025
Published: 20.12.2025

Funding

No specific funding was received for this research

Conflict of interests

The authors declare no conflict of interest.

Acknowledgment

We would like to thank management and principal of Vishnu institute of Pharmaceutical Education and Research for providing the chemicals and facilities for the carrying out of this research work.

Resumen

Introducción: Las tabletas orodispersables (ODTs) mejoran la adherencia del paciente, especialmente en poblaciones pediátricas, geriátricas y con disfagia. El Maleato de Enalapril, un inhibidor de la enzima convertidora de angiotensina (ECA) con baja solubilidad en agua, fue seleccionado como fármaco modelo para evaluar la eficiencia de superdesintegrantes sintéticos y naturales en formulaciones ODT.

Método: Las ODTs de Maleato de Enalapril se prepararon por compresión directa utilizando superdesintegrantes sintéticos (Croscarmelosa Sódica, Almidón Glicolato Sódico) y un desintegrante natural (mucílago de *Plantago ovata*). Se desarrollaron ocho formulaciones y se evaluaron en parámetros de precompresión y poscompresión, estudios de desintegración in vitro, disolución y uniformidad de contenido.

Resultados: Todas las formulaciones cumplieron con las especificaciones farmacopeicas. Entre los lotes sintéticos, CCS3 mostró el menor tiempo de humectación (8,55 s), tiempo de desintegración (17,64 s) y una disolución rápida (99,24% a los 20 min). La formulación natural PO2 (20 mg de mucílago de *Plantago ovata*) presentó un rendimiento comparable con un tiempo de desintegración de ~12–14 s y una liberación casi completa del fármaco (99,98% a los 20 min).

Conclusiones: Tanto los superdesintegrantes naturales como los sintéticos produjeron eficazmente ODTs de Maleato de Enalapril con rápida desintegración y disolución. El mucílago de *Plantago ovata* demostró una eficiencia comparable a los superdesintegrantes sintéticos, respaldando su potencial como alternativa rentable, sostenible y ecológica para formulaciones ODT.

Palabras clave: Tabletas orodispersables; Maleato de Enalapril; Superdesintegrantes; Mucílago de *Plantago ovata; Compresión directa; Disolución*.

Abstract

Introduction: Oral disintegrating tablets (ODTs) improve patient compliance, especially in pediatric, geriatric, and dysphagic populations. Enalapril Maleate, an angiotensin-converting enzyme (ACE) inhibitor with poor water solubility, was selected as a model drug to evaluate the efficiency of synthetic and natural superdisintegrants in ODT formulations.

Method: ODTs of Enalapril Maleate were prepared by direct compression using synthetic superdisintegrants (Croscarmellose Sodium, Sodium Starch Glycolate) and a natural disintegrant (*Plantago ovata* mucilage). Eight formulations were developed and evaluated for pre-compression and post-compression parameters, in vitro disintegration, dissolution, drug content uniformity studies.

Results: All formulations complied with pharmacopoeial specifications. Among synthetic batches, CCS3 exhibited the shortest wetting time (8.55 s), disintegration time (17.64 s), and rapid dissolution (99.24% at 20 min). The natural formulation PO2 (20 mg *Plantago ovata* mucilage) showed comparable performance with disintegration time of ~12–14 s and nearly complete drug release (99.98% at 20 min).

Conclusions: Both natural and synthetic superdisintegrants effectively produced ODTs of Enalapril Maleate with rapid disintegration and dissolution. *Plantago ovata* mucilage demonstrated comparable efficiency to synthetic disintegrants, supporting its potential as a cost-effective, sustainable, and eco-friendly alternative for ODT formulations.

Keywords: Oral disintegrating tablets; Enalapril Maleate; Superdisintegrants; *Plantago ovata* mucilage; Direct compression; Dissolution.

Highlights

Current knowledge indicates that oral disintegrating tablets (ODTs) enhance patient compliance, especially in those with swallowing difficulties, and both synthetic and natural superdisintegrants are effective in improving rapid disintegration and dissolution.

This study demonstrates that *Plantago ovata* mucilage is a sustainable, cost-effective natural superdisintegrant with performance comparable to synthetic agents in Enalapril Maleate ODTs.

The results support the use of *Plantago ovata* mucilage as a green, low-cost excipient for ODTs, improving patient compliance in hypertensive therapy and promoting sustainable excipient choices in pharmaceutical practice.

Introduction

Oral drug delivery continues to be the most preferred and convenient route of administration for therapeutic agents, accounting for nearly 80–90 % of all marketed formulations [1]. This preference stems from its non-invasiveness, cost-effectiveness, ease of administration, and high patient compliance compared to parenteral or alternative routes. Among the oral dosage forms, tablets dominate the pharmaceutical market due to their accurate dosing, chemical and physical stability, ease of large-scale production, and patient acceptability[2]. Despite these advantages, conventional tablets present challenges for certain populations, particularly pediatric and geriatric patients, individuals with neurological disorders, or patients experiencing dysphagia (difficulty in swallowing). Studies indicate that approximately 35% of the global population encounters swallowing difficulties with conventional tablets and capsules, which often leads to poor adherence, suboptimal therapeutic outcomes, and in some cases, discontinuation of therapy[3].

To overcome these limitations, novel dosage forms have been developed to enhance patient compliance and therapeutic effectiveness. Among these, oral disintegrating tablets (ODTs), also known as orally dispersible tablets, fast dissolving tablets, or rapid disintegrating tablets, have gained substantial attention over the past two decades. ODTs are designed to disintegrate rapidly, usually within seconds, when placed on the tongue, releasing the drug into saliva for immediate absorption or swallowing without the need for water. This dosage form is particularly advantageous in pediatric, geriatric, bedridden, or psychiatric patients, as well as in emergency conditions such as allergic reactions, motion sickness, or hypertensive crises where immediate drug action is desirable[4].

The U.S. Food and Drug Administration (FDA) define an ODT as “a solid dosage form containing medicinal substances which disintegrates rapidly, usually within a matter of seconds, when placed upon the tongue [5]. Unlike conventional tablets or capsules that typically require 10–15 minutes for disintegration and subsequent dissolution, ODTs disintegrate within 30 seconds to 3 minutes, ensuring a faster onset of action and improved patient convenience. Additionally, in some cases, ODTs enable pregastric absorption of the drug through the oral mucosa, bypassing first-pass hepatic metabolism, thereby enhancing bioavailability and reducing variability in therapeutic response[6].

The mechanism underlying ODT performance primarily involves rapid water uptake by the tablet matrix, followed by swelling or wicking action of incorporated disintegrants, leading to structural breakdown of the dosage form. Conventional disintegrants such as starch and cellulose derivatives have long been used in tablet formulations[7]. However, with the demand for ultra-rapid disintegration, a new class of excipients termed “superdisintegrants” was introduced. Superdisintegrants, such as Croscarmellose Sodium (CCS), Sodium Starch Glycolate (SSG), and Crospovidone, are effective at low concentrations (typically 1–10%) and promote rapid water penetration and swelling, resulting in faster tablet disintegration. The choice and concentration of disintegrants play a critical role in ODT formulation, influencing not only disintegration time but also dissolution rate and overall bioavailability of the drug[8].

While synthetic superdisintegrants have been widely employed and are highly effective, the pharmaceutical industry has witnessed growing interest in exploring natural excipients as alternatives. Natural polymers and mucilages, derived from plants, offer several advantages, including biocompatibility, biodegradability, low cost, and widespread availability. Moreover, they align with the increasing emphasis on sustainable and “green” pharmaceutical development. Among the natural disintegrants investigated, *Plantago ovata* (commonly known as Isapghula or psyllium husk) mucilage has emerged as a promising candidate. *Plantago ovata* is widely cultivated and its husk is traditionally used as a dietary fiber and laxative. The mucilage derived from its seeds is hydrophilic in nature, exhibits excellent swelling capacity, and can absorb many times its weight in water. These properties make it suitable for use as a natural disintegrant in ODTs, where rapid water uptake and swelling are crucial for disintegration[9].

Enalapril Maleate, an angiotensin-converting enzyme (ACE) inhibitor, was selected as the model drug for the present investigation. It is widely prescribed in the management of hypertension and congestive heart failure. Enalapril itself is a prodrug that undergoes hydrolysis to its active form, Enalaprilat, which inhibits ACE and subsequently prevents the conversion of angiotensin I to angiotensin II, a potent vasoconstrictor. Despite its clinical efficacy, Enalapril Maleate exhibits poor water solubility and variable bioavailability, leading to inter- and intra-patient variability in therapeutic response. Furthermore, patients requiring long-term antihypertensive therapy often belong to the geriatric population, which is particularly prone to dysphagia and poor adherence to conventional tablets. Thus, developing an ODT formulation of Enalapril Maleate offers dual benefits: enhanced patient compliance through ease of administration and improved therapeutic performance via faster disintegration and dissolution[10].

Several studies have investigated ODT formulations of antihypertensive drugs using both synthetic and natural disintegrants. Synthetic excipients like CCS and SSG are well-documented for their efficiency in reducing disintegration time and promoting dissolution. However, limited research has directly compared their performance with natural alternatives such as *Plantago ovata* mucilage. Considering the global trend toward eco-friendly and cost-effective excipients, there is a compelling need to evaluate whether natural disintegrants can match or surpass the performance of synthetic agents in ODT formulations.

The present study was therefore designed to formulate and evaluate ODTs of Enalapril Maleate using both synthetic superdisintegrants (Croscarmellose Sodium, Sodium Starch Glycolate) and a natural disintegrant (*Plantago ovata* mucilage).

Methods

Materials

Enalapril Maleate was procured as the active pharmaceutical ingredient (API). Excipients used included Croscarmellose Sodium (CCS), Sodium Starch Glycolate (SSG), Crospovidone, Microcrystalline Cellulose (MCC, PH-102), Lactose Anhydrous, Magnesium Stearate, Talc, Sodium Saccharin, and Orange Flavor (all obtained from SD Fine Chemicals, Mumbai, India). The natural superdisintegrant, *Plantago ovata* mucilage, was isolated in-house from *Plantago ovata* seeds. All reagents and solvents were of analytical grade.

Isolation of natural superdisintegrant

The mucilage of *Plantago ovata* was extracted by soaking the seeds in distilled water for 48 hours, followed by gentle boiling to ensure complete release of mucilage. The swollen mass was filtered through muslin cloth to separate the marc [11]. The filtrate was precipitated using an equal volume of acetone. The precipitate obtained was dried in a hot air oven at a temperature below 60 °C, pulverized, passed through #80 mesh sieve, and stored in a desiccator until further use.

Preparation of mixed blends of drug and excipients

All the ingredients were weighed accordingly specified in the formulation (table-8) and mixed well except magnesium stearate/ glyceryl behenate [12]. Then the blend was passed through sieve no 60 which was used for the evaluation of flow properties. The results are given in table 1.

Table 1: Formulation of oral disintegrating tablets of Enalapril maleate

Ingredients*	CCS1	CCS2	CCS3	SSG1	SSG2	SSG3	PO1	PO2
Enalapril maleate	10	10	10	10	10	10	10	10
Lactose Anhydrous	176	171	166	176	171	166	171	161
Cros Carmellose Sodium	5	10	15	-	-	-	-	-
Sodium Starch Glycollate	-	-	-	5	10	15	-	-
Plantago ovata Powder	-	-	-	-	-	-	10	20
Sodium Sacharin	3	3	3	3	3	3	3	3
Talc	3	3	3	3	3	3	3	3
Magnesium Stearate	3	3	3	3	3	3	3	3
Total Weight	200	200	200	200	200	200	200	200

* All ingredients were weighed in mg. CCS – Croscarmallose Sodium; SSG – Sodium Starch Glycolate; PO – *Plantago Ovata*

Evaluation of pre compressional parameters of tablets blend[13-17]

Bulk density; Apparent bulk density was determined by pouring the blend into a graduated cylinder. The bulk volume (V_b) and weight of the powder was determined.

$$\text{Bulk density} = M / V_b$$

Tapped density: The measuring cylinder containing a known mass of powder blend was tapped for a fixed number of times as per USP apparatus-11. The minimum volume occupied by the powder after tapping was measured.

$$\text{Tapped density} = \text{weight/tapped volume}$$

Compressibility index: Compressibility index is calculated as follows

$$CI = \text{Tapped density- Bulk density/ Tapped density*100}$$

The value below 15% indicates a powder with good flow characteristics whereas above 25% indicates poor flowability.

Hausner's ratio: It is an indirect index of ease of powder flow; it is calculated as follows.

$$\text{Tapped density / Bulk density}$$

Hausner's ratio <1.25 indicates good flow properties, where as >1.5 indicates poor flowability.

Angle of Repose; Angle of repose was determined using funnel method. The blend was poured through funnel that can rise vertically until a maximum cone height (h) was obtained. Radius of the heap(r) was measured, and angle of repose was calculated as follows.

$$Ø = h/r$$

Compression of tablets

To the mixed blend of powder and excipients finally add magnesium stearate and glyceryl behenate and then mixed for 5 min. The mixed blend was compressed with sixteen (16) station tablet punching machine using 7 mm flat punches with break line. Four punches in the sixteen-station compressor are fixed with die cavity and remaining is fixed with dummy punches. A minimum of 500 tablets for each batch were prepared[18,19].

Evaluation of tablets[20-25]

All the prepared tablets were evaluated for the following parameters as per the Indian Pharmacopoeia (I.P.) guidelines and the results are given in the table 7.

Weight variation: Twenty tablets from each formulation were selected randomly and average weight was determined. Individual tablets were then weighed and compared with average weight.

Hardness test: The force required to break a tablet in a diametric compression was determined by using Pfizer tablet hardness tester.

Friability: The weight of twenty tablets was noted and placed in the friabilator and then subjected to 100 revolutions at 25 rpm. Tablets were dedusted using a soft muslin cloth and reweighed.

$$\text{Percent friability} = [\text{initial weight} - \text{final weight} / \text{initial weight}] \times 100$$

Wetting time and water absorption ratio

A piece of paper folded twice was kept in a petri dish (internal diameter 6 cm) containing 6 ml of purified water. A tablet was put on the paper and time required for complete wetting was measured. The wetted tablet was weighed. Water absorption ratio, R was determined using the following equation.

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

where Wa, Wb are the weights of tablets before and after wetting.

In vitro dispersion time

Tablet was added to 10 ml of distilled water at 37± 0.5˚C, time required for complete dispersion of tablet was measured.

Drug content uniformity

The drug content uniformity was determined by taking the powder equivalent to 10 mg, then it was (n=3) dissolved in pH 6.8 phosphate. Required dilution

(10 µg/ml) was prepared and absorbance was taken against the blank at 206 nm.

In vitro disintegration time

The disintegration was performed using an I.P 85 disintegration apparatus with distilled water at 37±0.5 ˚C.

In vitro dissolution studies

Dissolution rate of Enalapril maleate from all formulations was performed using LABINDIA DISSO 2000 an eight-stage dissolution rate testing apparatus with paddle. The dissolution fluid was 900 ml of pH 6.8 phosphate buffer with a speed of 50 rpm and temperature of 37±0.5˚C were used in each test. 5 ml of sample was withdrawn at different time intervals (2.5, 5, 10, 15 & 20 mins) and fresh medium was replaced to maintain sink conditions. The samples are analyzed by using UV- Visible spectrophotometer at λ_{max} 205 nm. Dissolution studies were performed in triplicate.

Results & Discussion

The mucilage from *Plantago ovata* seeds was successfully extracted by aqueous soaking, boiling, and subsequent precipitation with acetone. The dried mucilage appeared as a light-brown amorphous powder with excellent swelling capacity and high-water retention. On contact with water, the mucilage rapidly hydrated, forming a viscous colloidal dispersion. These physicochemical properties indicate its suitability as a natural superdisintegrant, as rapid water uptake and swelling are critical for tablet disintegration. The mucilage powder passed through a #80 mesh sieve without difficulty, confirming good particle size uniformity for direct compression.

Pre-compression parameters

Pre-compression parameters such as angle of repose, bulk density, tapped density, Carr's index, and Hausner's ratio were evaluated to determine the flow properties of the powder blends (Table 2). The angle of repose values ranged between 28° and 36°, indicating that most formulations exhibited good to excellent flow characteristics. PO2 demonstrated an angle of repose of 35°, falling within the good flow range, and a Carr's index of 11.2 %, confirming good compressibility. Its Hausner's ratio (1.14) also supported this finding, indicating low interparticle friction and consistent packing ability. Bulk and tapped density values of 0.66 g/cm^3 and 0.76 g/cm^3, respectively, reflected uniform particle distribution and optimal packing characteristics. Although some formulations exhibited slightly lower Carr's index or angle of repose, PO2 was selected as the best formulation based on its balanced combination of flow properties, compressibility, and packing density, making it most suitable for further formulation development.

Table 2: Evaluation of flow properties of the blend:

Formulation code	Angle of repose (°)	Bulk density (g/cm^3)	Tapped density (g/cm^3)	Carr's index	Hausner's ratio	Flowability
CCS1	32	0.58	0.66	13.82	1.17	Fair
CCS2	33	0.56	0.65	13.87	1.16	good
CCS3	34	0.69	0.77	10.98	1.19	Excellent
SSG1	29	067	0.79	13.18	1.13	good
SSG2	31	0.53	0.61	12.19	1.11	good
SSG3	28	0.66	0.73	8.16	1.18	good
PO1	36	0.58	0.64	7.9	1.08	good
PO2	35	0.66	0.76	11.2	1.14	good

CCS – Croscarmallose Sodium; SSG – Sodium Starch Glycolate; PO – *Plantago Ovata*

Evaluation of post compressional parameters

Post-compression parameters such as average weight, hardness, friability, wetting time, and water absorption ratio were evaluated to assess the mechanical strength and disintegration characteristics of the prepared tablets (Table 3). The average tablet weight for all formulations ranged between 147 ± 0.16 mg and 151.3 ± 1.8 mg, indicating good weight uniformity. Hardness values were in the range of 3.5 ± 0.49 to 4.0 ± 0.32 kg/cm^2, which is within the acceptable limits for uncoated tablets, ensuring adequate mechanical strength. Friability values were below 1% for all formulations, confirming their resistance to mechanical abrasion during handling and transport. Wetting time varied significantly among formulations, with CCS3 showing the shortest wetting time (8.55 ± 0.15 s), followed by IH2 (11.56 ± 0.12 s) and CCS2 (10.13 ± 0.34 s), suggesting faster onset of disintegration in these batches. Water absorption ratio was highest for IH2 (54 ± 0.17), indicating superior wicking action, followed by PO1 (51 ± 0.13). While PO2 exhibited the best disintegration-related parameters, PO2 was considered the best overall formulation when combining both pre-compression and post-compression results, due to its optimal balance of flowability, compressibility, mechanical strength, and acceptable wetting and water absorption characteristics, making it highly suitable for further development.

Table 3: Quality control tests for the oral disintegrating tablets of enalapril maleate.

Formulations*	Average Weight* (mg)	Hardness *kg/cm^2	Friability *(%)	Wetting time* (sec)	Water absorption ratio*
CCS1	149±0.12	3.6±0.11	0.481±0.16	11.12±0.21	39±0.14
CCS2	150±0.21	3.6±0.24	0.56±0.17	10.13±0.34	28±0.15
CCS3	151.3±1.8	3.5±0.49	0.57±0.17	8.55±0.15	34±0.24
SSG1	149.5±0.25	3.9±0.11	0.31±0.16	16.87±0.16	38±0.16
SSG2	148.9±0.54	3.8±0.14	0.46±0.19	14.76±0.19	40±0.14
SSG3	150±0.01	3.9±0.17	0.41±0.24	15.41±0.13	38±0.18
PO1	147±0.16	3.8±0.2	0.31±0.16	13.12±0.13	51±0.13
PO2	149.4±0.87	4.0±0.32	0.295±0.22	11.56±0.12	54±0.17

* Data represent mean ±SD (n=3). CCS – Croscarmallose Sodium; SSG – Sodium Starch Glycolate; PO – *Plantago Ovata*

The disintegration time, drug content, and percentage drug dissolved after 10 minutes were determined for all formulations (Table 4). Disintegration times ranged from 12.24 ± 0.49 s (IH2) to 45.21 ± 0.79 s (SSG3), with IH2 showing the fastest disintegration, followed closely by IH1 (14.24 ± 0.58 s) and CCS3 (17.64 ± 0.79 s). Drug content across all batches was within the acceptable pharmacopoeial limits (96.56 ± 0.56 % to 107.21 ± 0.78 %), ensuring dose uniformity. The percentage drug dissolved after 10 minutes was above 95 % for all formulations, indicating rapid release. The highest release was observed in CCS1 (99.24 ± 0.68 %) and CCS3 (99.24 ± 0.78 %), followed closely by IH2 (99.21 ± 0.79 %). While IH2 exhibited the most favourable disintegration profile, PO2 was selected as the best overall formulation considering its balanced pre-compression flow properties, satisfactory post-compression mechanical strength, acceptable wetting and water absorption capacity, and compliance with disintegration, content uniformity, and dissolution requirements, making it a robust candidate for further scale-up and development.

Table 4: Quality control tests for the oral disintegrating tablets of enalapril maleate.

Formulations*	Disintegration time * (sec)	Drug content* (%)	Percentage Drug Dissolved After 10 min*.
CCS1	19.25±0.54	107.21±0.78	99.24±0.68
CCS2	18.51±0.82	99.97±0.58	98.21±0.39
CCS3	17.64±0.79	97.58±0.72	99.24±0.78
SSG1	28.21±0.28	99.25±0.98	97.24±0.82
SSG2	25.85±0.46	99.21±0.87	95.25±0.39
SSG3	45.21±0.79	96.56±0.56	95.35±0.55
PO1	14.24±0.58	99.25±0.59	98.21±0.74
PO2	**12.24±0.49**	**99.6±0.25**	**99.21±0.79**

* Data represent mean ±SD (n=3). CCS – Croscarmallose Sodium; SSG – Sodium Starch Glycolate; PO – *Plantago Ovata*

In vitro dissolution profiles for all formulations were evaluated over 20 min (Table 5). The percentage of drug released increased progressively with time for all batches, with most formulations achieving more than 95 % release within 20 min. PO2 showed a cumulative drug release of 71.25 ± 0.28% at 5 min and 86.18 ± 0.58 % at 10 min, indicating a rapid dissolution rate. By 15 minutes, PO2 achieved 95.48 ± 0.75 % release, reaching almost complete dissolution (99.98 ± 0.99 %) at 20 min. While CCS3 also demonstrated a fast release profile (86.28 ± 0.21% at 10 minutes and 98.96 ± 0.28 % at 20 min), PO2 provided a

more balanced release pattern with consistent performance across all time points. The results confirm that PO2 not only meets but exceeds the pharmacopeial dissolution requirements for immediate-release tablets, further supporting its selection as the optimal formulation based on combined pre-compression, post-compression, disintegration, content uniformity, and dissolution performance.

Table 5: Dissolution profile of all formulations of oral disintegrating tablets of enalapril maleate

Formulations	Cumulative % drug disolved (mins)					
	0	2.5	5	10	15	20
CCS1	0	38.6±0.62	592.87±0.53	78.75±0.29	90.28±0.42	96.58±0.13
CCS2	0	42.25±0.21	62.58±0.59	80.58±0.17	94.28±0.98	98.12±0.17
CCS3	0	51.24±0.22	72.89±0.13	86.28±0.21	92.78±0.12	98.96±0.28
SSG1	0	45.2±3.18	58.49±0.42	79.28±0.32	87.17±0.18	97.28±0.65
SSG2	0	44.21±0.24	61.28±0.81	76.27±0.33	88.7±0.13	97.69±0.41
SSG3	0	44.8±2.38	70.28±0.53	79.28±0.62	92.38±0.23	96.12±0.78
PO1	0	48.26±0.24	65.28±0.12	82.28±0.12	92.89±0.68	98.28±0.31
PO2	0	20.12±0.47	71.25±0.28	86.18±0.58	95.48±0.75	99.98±0.99

* Data represent mean ±SD (n=3). CCS – Croscarmallose Sodium; SSG – Sodium Starch Glycolate; PO – *Plantago Ovata*

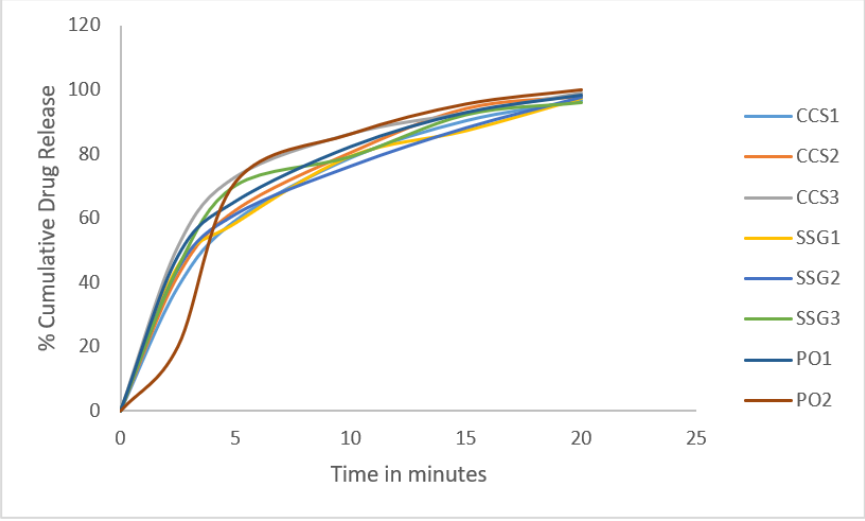

Figure 1. Comparative dissolution profile of Enalapril maleate of all formulations

Conclusion

The study clearly demonstrated that both natural and synthetic superdisintegrants are effective in formulating oral disintegrating tablets (ODTs) of Enalapril Maleate with rapid disintegration and high dissolution rates. Among the synthetic disintegrants evaluated, Croscarmellose Sodium (CCS3) exhibited the best overall performance, while among the natural options, Plantago ovata mucilage (PO2) showed results comparable to, and in certain parameters superior to, its synthetic counterparts—particularly in terms of water absorption capacity and sustainability. The optimized natural disintegrant batch, PO2, exhibited good flow properties suitable for direct compression, mechanical strength within pharmacopeial limits, and disintegration and dissolution profiles matching those of the best synthetic formulations, achieving 99.98% drug release within 20 minutes. These findings are significant as they demonstrate that natural disintegrants can serve as viable alternatives to synthetic agents in ODT formulation, offering a cost-effective and eco-friendly approach without compromising product quality. Furthermore, the results support the growing pharmaceutical industry trend toward the adoption of "green" excipients and sustainable manufacturing practices.

References

1. Dhiman J. Dev D, Prasad D.Superdisintegrants: brief review. J Drug Deliv Ther. 2022; 12(1):170-175. doi.10.22270/jddt.v12i1.5155

2. Pradhan D, Chakraborty P, Halder S, Bagchi A. An overview on FDA-approved natural super disintegrants efficacy in a fast-dissolving drug delivery system. J Appl Pharm Res. 2021;9(3):01-7. doi.10.18231/j.joapr.2021.v9.i3.1-7

3. Fahmansyah LP, Agus S. Of superdisintegrant ingredients in fast disintegrant tablet tablet preparations. Medical Sains: Jurnal Ilmiah Kefarmasian. 2024;9(3):857-76.

4. Sharma D, Gupta A, Yadav JS. Natural superdisintegrant: a key ingredient for orodispersible dosage form. J Pharm Negat Results. 2022;8:5150-60. Doi:10.52711/2321-5844.2021.00003

5. Nautyal U, Katna R, Kumar D. FDA-Approved Natural Disintrgrant for Fast Dissolving Tablets. Asian Pac J. Nurs and Health. 2021;4(2):8-13. doi.10.46811/apjnh/4.2.3

6. Bhatti S, Kaushik M. Utilization of natural superdisintegrant in mouth dissolving tablet: A simplified review. Tablet. 2020;8:32-8.

7. Alburyhi MM, Saif AA, Noman MA, Salim YA, Hamidaddin MA. Formulation and Evaluation of Lisinopril Orally Disintegrating Tablets. World Journal of Pharmacy and Pharmaceutical Sciences. 2023;12(9):357-69.

8. Patel SK, et al. Optimizing Irbesartan fast dissolving tablets using natural polysaccharides for enhanced drug delivery and patient compliance. Int Res J Multidiscip Scope. 2025;6(1):1181-90.

9. KRISHNA NS, Jayanthi B, Madhukar A. Formulation development and evaluation of chronomodulated drug delivery system by zafirlukast. Int J App Pharm. 2021;13(4):211-20. doi.10.22159/ijap.2021v13i4.41734

10. Samanthula KS, et al. Physiological, In-vitro, and Analytical Studies of Cellular Oxidative Stress for Evaluation of Antioxidant Pharmacological Effects of Natural Polysaccharide in Fast Dissolving Tablet Formulations. Front Health Inform. 2024;13(5).

11. Tarannum S, Jain K. Formulation Evaluation and Development of Specialized Tablets. In Advances in Pharmaceutical Product Development 2025; (pp. 175-197). Singapore: Springer Nature. doi.10.1007/978-981-97-9230-6_7

12. Kandekar U, Ramdasi S, Thakurdesai P. Fenugreek: Novel delivery technologies and versatile formulation excipients. Fenugreek. 2022:361-400.

13. Yamini Srinivas G, Sri Naga Varun M, Sunil Kumar KT, Mohan Varma M. Formulation and evaluation of sublingual tablets of losartan potassium by using natural and synthetic super disintegrants. Journal of Pharma Insights and Research. 2023. 4;1(2):145-53.

14. Pingale PL, Boraste SS, Amrutkar SV. Formulation and evaluation of pravastatin fast disintegrating tablets using natural superdisintegrant. J med Pharm Allied Sci. 2021;10(3):2977-81.

15. Joseph F, Premaletha K. Natural superdisintegrants for the formulation of orally disintegrating tablets. Int J Res Rev. 2021;8:123-8.

16. Singh K, Sharma S. Development of nifedipine orodispersible tablets by different techniques using natural and synthetic superdisintegrants. Res J Pharm Technol. 2021;14(2):715-24.

17. Ahmed Abid MA, Chukka S. Formulation and in vitro evaluation of fosinopril mouth dissolving tablets using natural and synthetic superdisintegrants. Biochemical & Cellular Archives. 2025;25(1).

18. Thapa C, Rauniyar Nk, Yadav A, Chaudhari P. Formulation, in-vitro evaluation, and comparative study of diclofenac potassium loaded fast dissolving tablet using natural and synthetic superdisintegrants. J Pharm Res. 2021;13(3).

19. Mahesh M, et al. Formulation and Evaluation of Fast Disintegrating Tablets of Antihistamine Drug Using Natural Super Disintegrants. J Young Pharm . 2024;16(4): 762-771.

20. Sharma D, Gupta A, Yadav JS. Natural superdisintegrant: a key ingredient for orodispersible dosage form. J Pharm Negat Results. 2022;8:5150-60.

21. Draksiene G, Venclovaite B, Pudziuvelyte L, Ivanauskas L, Marksa M, Bernatoniene J. Natural polymer chitosan as super disintegrant in fast orally disintegrating meloxicam tablets: Formulation and evaluation. Pharmaceutics. 2021;13(6):879. doi.10.3390/pharmaceutics13060879

22. Safhi AY, Ali MS, Alshamrani M, Alam MI, Sabei FY, Salawi A. Formulation design and evaluation of epalrestat mouth dissolving tablets comprising superdisintegrant from natural sources manufactured by direct compression method and stability studies of optimized formulation. Pak J Pharm Sci. 2023;36(5):1677-1685

23. Rathore D, Jain DV, Gehalot N. Formulation and Evaluation of Fast Dissolving Tablets of Aceclofenac Using Natural Superdisintegrant. International Journal of Pharmaceutical Sciences & Medicine. 2022;7(10):39-64. Doi: 10.47760/ijpsm.2022.v07i10.004

24. Rani NI, Dev DH. Formulation and evaluation of fast disintegrating tablet of propranolol hydrochloride using modified tamarind seed gum as a natural superdisintegrant. Asian J Pharm Clin Res. 2022;15(9):185-92.

25. Khadka M, Khanal DP, Baniya DP, Karki P, Shrestha S. Formulation and evaluation of oral disintegrating tablets of furosemide: Formulation of ODTs of Furosemide. World J Curr Med Pharm Res. 2021; 3(6): 149-56.