



Formulation and Evaluation of Mucoadhesive Based Buccal Tablet for Improved Bioavailability

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Abstract: Mucoadhesive buccal drug delivery systems have gained considerable attention as an effective alternative to conventional oral dosage forms due to their ability to improve drug bioavailability, prolong drug release, and bypass first-pass hepatic metabolism. Buccal tablets are designed to adhere to the mucosal surface of the oral cavity, allowing controlled and sustained release of therapeutic agents directly into systemic circulation. The present study focuses on the formulation and evaluation of mucoadhesive based buccal tablets for enhanced drug delivery and improved bioavailability. Various mucoadhesive polymers such as hydroxypropyl methylcellulose (HPMC), carbopol, sodium alginate, and chitosan were utilized to prepare buccal tablets using the direct compression method. The formulated tablets were evaluated for physicochemical parameters including hardness, thickness, friability, weight variation, surface pH, swelling index, drug content uniformity, mucoadhesive strength, and in vitro drug release behavior. The results demonstrated that the optimized formulation exhibited satisfactory mucoadhesive properties, prolonged residence time, controlled drug release, and improved drug permeation through the buccal mucosa. The study concluded that mucoadhesive buccal tablets are a promising drug delivery system for enhancing therapeutic efficacy, patient compliance, and bioavailability of drugs with poor oral absorption and extensive first-pass metabolism.

Keywords: Mucoadhesive Buccal Tablet, Buccal Drug Delivery, Bioavailability, Mucoadhesive Polymer

I. INTRODUCTION

Mucoadhesive buccal drug delivery represents a significant advancement in pharmaceutical technology, offering a novel approach to circumvent the limitations associated with conventional oral drug delivery. This system involves the administration of drugs through the buccal mucosa—the lining of the cheek—utilizing adhesive polymers that extend the residence time and promote drug absorption directly into the systemic circulation. The buccal mucosa is an attractive site for drug delivery due to its rich vascular supply, relative permeability, and accessibility. Drugs absorbed through the buccal mucosa enter the systemic circulation via the internal jugular vein, thereby bypassing the harsh acidic environment of the stomach, enzymatic degradation in the gastrointestinal tract, and the extensive first-pass metabolism in the liver. This is particularly beneficial for drugs that exhibit low oral bioavailability due to these presystemic elimination mechanisms. Propranolol hydrochloride (PRH) is a non-selective β_1 and β_2 -adrenergic antagonist widely used in the management of hypertension,



angina pectoris, cardiac arrhythmias, migraine prophylaxis, and essential tremor . Chemically, it is described as 2-Propranolol, 1-[(1-methylethyl)amino]-3-(1-naphthalenyloxy)-, hydrochloride, with a molecular formula $C_{16}H_{21}NO_2 \cdot HCl$ and molecular weight of 295.80 . Despite being highly soluble in water and ethanol, and almost completely absorbed from the gastrointestinal tract ($95 \pm 5\%$), propranolol exhibits a low and highly variable oral bioavailability ranging from 15% to 25% . This is primarily attributed to extensive first-pass hepatic metabolism, which significantly limits its therapeutic efficacy and necessitates frequent dosing (three to four times daily) . The development of a mucoadhesive buccal tablet formulation aims to deliver propranolol hydrochloride directly into the systemic circulation, bypassing hepatic first-pass metabolism, thereby enhancing its bioavailability, reducing dosing frequency, and improving patient compliance.

II. REVIEW OF LITERATURE

Year	Author(s)	Formulation	Key findings
1995	Çelebi et al.	PAA, HPMC, HPC tablets	Non-Fickian release, zero-order kinetics; highest adhesive force with high PAA
2004	Akbari et al.	HPMC K4M + polycarbophil	Fillers (lactose, DCP) increased dissolution rate but reduced bioadhesion
2007	Patel et al.	Bilayer tablets (sodium alginate + Carbopol 934P)	Bioadhesive strength: 28.9 g; 68.65% permeation in 12 hours
2008	Vijayaraghavan et al.	Locust bean gum + chitosan	2-fold higher AUC compared to oral tablets in humans
2015	Abruzzo et al.	Chitosan/gelatin microparticles	Excess chitosan best mucoadhesion and permeation
2021	Kurćubić et al.	PEO 15% matrix tablets	AUC enhanced by 2.2× compared to IR tablets in rats
2024	Bommanchu & Kanukuntla	HPMC, SCMC, Carbopol tablets	F4: max swelling, Higuchi model, pH neutral, stable

III. MATERIALS AND METHODOLOGY

Materials

Ingredient	Role
Propranolol hydrochloride (PRH)	Drug
Carbopol 934P	Mucoadhesive polymer
Hydroxypropyl methylcellulose (HPMC K4M)	Mucoadhesive polymer, release retardant
Sodium alginate	Mucoadhesive polymer
Lactose monohydrate	Diluent
Magnesium stearate	Lubricant
Talc	Glidant
Microcrystalline cellulose (Avicel PH 102)	Binder/ diluent
Potassium dihydrogen phosphate	Buffer component
Disodium hydrogen phosphate	Buffer component
Sodium hydroxide	pH adjustment
Ethanol (95%)	Solvent
Porcine buccal mucosa	Ex vivo membrane

Water used: Deionized distilled water throughout.

Instruments / Apparatus Used

Instrument	Make/ Model	Purpose
Digital pH meter	Lab India PICO+	pH measurement
Electronic balance (0.1 mg)	Sartorius CPA224S	Weighing
Tablet compression Machine	Cadmach, 8-station	Tablet preparation
Hardness tester	Monsanto type	Hardness
Friability tester	Roche	Friability
Vernier caliper	Mitutoyo	Thickness
Dissolution test apparatus (USP II)	Lab India DS 8000	In vitro release
UV-Vis spectrophotometer	Shimadzu UV-1800	Drug quantification
Modified physical balance	Custom	Mucoadhesive strength
Stability chamber	Remi CH-100	Stability testing
Sonicator	Ultrasonic Cleaner	Deaeration

Methodology

3.1 Pre-formulation Studies of Propranolol Hydrochloride

Solubility determination: Excess propranolol HCl was added to 10 mL each of water, phosphate buffer (pH 6.8), and 0.1N HCl in separate vials. Vials were shaken for 24 hours at 25±1°C, filtered, and analyzed spectrophotometrically at 290 nm after appropriate dilution.

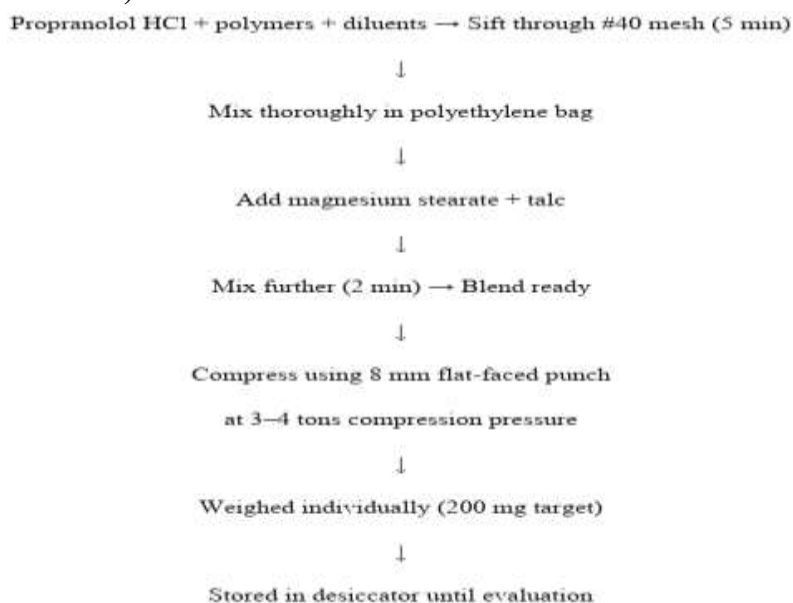
Determination of powder flow properties:

Parameter	Method
Bulk density	10 g powder in 50 mL graduated cylinder, volume measured
Tapped density	1250 taps in a tapped density tester, volume measured
Carr's index	$(\text{Tapped density} - \text{Bulk density}) / \text{Tapped density} \times 100$
Hausner ratio	$\text{Tapped density} / \text{Bulk density}$
Angle of repose	Fixed funnel method; $\tan \theta = \text{height of pile} / \text{radius of base}$

3.2 Compatibility Studies

FTIR spectra of the pure drug, polymers (Carbopol 934P, HPMC K4M, sodium alginate), and physical mixtures (1:1 ratio) were recorded in the range of 4000–400 cm⁻¹ using KBr pellet method. DSC thermograms were recorded from 30°C to 300°C at a heating rate of 10°C/min under nitrogen purge.

Procedure (Flowchart):



Direct compression method steps:

1. All ingredients (propranolol HCl, Carbopol 934P, HPMC K4M, sodium alginate, lactose, MCC) were accurately weighed and sifted through a #40 mesh sieve.
2. The powders were blended in a polybag for 10 minutes to achieve uniform mixing.
3. Magnesium stearate and talc were added and mixed further for 2 minutes.
4. The blend was evaluated for angle of repose, bulk density, tapped density, Carr's index, and Hausner ratio.
5. The blend was compressed into tablets using a Cadmach 8-station rotary tablet press fitted with 8 mm flat-faced punches at a compression pressure of 3–4 tons to achieve a target hardness of 5–7 kg/cm².
6. Tablets were stored in tightly closed amber glass containers for further evaluation.

IV. RESULTS

4.1 Pre-formulation Characterization

Solubility of propranolol HCl:

Solvent	Solubility (mg/mL at 25°C)
Distilled water	35.2 ± 1.8
Phosphate buffer (pH 6.8)	33.5 ± 1.5
0.1 N HCl	38.1 ± 1.6

Calibration curve of propranolol HCl in phosphate buffer (pH 6.8): Linear range: 5–30 µg/mL; regression equation: $y = 0.0213x + 0.0041$; $R^2 = 0.9998$.

Powder flow properties of pure drug and physical mixtures:

Formulation	Angle of repose (°)	Bulk density (g/mL)	Tapped density (g/mL)	Carr's index (%)	Hausner ratio
Pure drug	38.5 ± 1.2	0.41 ± 0.02	0.58 ± 0.03	29.3	1.41
F1 blend	31.2 ± 0.8	0.52 ± 0.02	0.63 ± 0.02	17.5	1.21
F2 blend	30.8 ± 0.9	0.53 ± 0.01	0.64 ± 0.02	17.2	1.21
F3 blend	31.5 ± 1.0	0.51 ± 0.02	0.62 ± 0.02	17.7	1.22
F4 blend	30.5 ± 0.7	0.54 ± 0.01	0.65 ± 0.01	16.9	1.20
F5 blend	31.8 ± 1.1	0.51 ± 0.02	0.62 ± 0.02	17.7	1.22

Interpretation: All blends showed good to excellent flow properties (Carr’s index 12– 18%; Hausner ratio 1.19–1.25).

4.3 Post-compression Evaluation of Buccal Tablets

Physicochemical properties of F1–F5 (mean \pm SD, n=20)

Parameter	F1	F2	F3	F4	F5	I.P. limit
Weight variation (mg)	199.5 \pm 2.1	200.3 \pm 1.9	201.2 \pm 2.3	200.5 \pm 2.0	199.8 \pm 2.2	\pm 7.5%
Thickness (mm)	3.21 \pm 0.05	3.24 \pm 0.04	3.27 \pm 0.06	3.22 \pm 0.05	3.19 \pm 0.05	—
Hardness (kg/cm ²)	6.2 \pm 0.3	6.5 \pm 0.2	6.8 \pm 0.3	6.1 \pm 0.2	5.8 \pm 0.3	>5
Friability (%)	0.48 \pm 0.08	0.42 \pm 0.06	0.38 \pm 0.07	0.52 \pm 0.09	0.62 \pm 0.10	<1
Drug content (%)	98.2 \pm 0.8	99.1 \pm 0.6	99.3 \pm 0.7	98.5 \pm 0.8	97.8 \pm 0.9	90–110
Surface pH	6.4 \pm 0.2	6.6 \pm 0.1	6.3 \pm 0.2	6.5 \pm 0.2	6.7 \pm 0.1	5.5–7.5

V. CONCLUSION

- Five formulations (F1–F5) of mucoadhesive buccal tablets of propranolol hydrochloride (20 mg) were prepared by direct compression using combinations of Carbopol 934P, HPMC K4M, and sodium alginate as mucoadhesive polymers.
- Physicochemical evaluation showed that all formulations met pharmacopoeial limits for weight variation, thickness, hardness (>5 kg/cm²), friability (<1%), drug content (90–110%), and surface pH (6.3–6.7), indicating no mucosal irritation.
- Swelling index was highest for F3 (228.3% at 8 h), which also exhibited the best mucoadhesive strength (28.5 g) and longest in vitro residence time (8.2 h).
- In vitro drug release from F3 was sustained (70.4% at 12 h) and followed Higuchi and Korsmeyer–Peppas models, with non-Fickian (anomalous) diffusion as the release mechanism.



- Ex vivo permeation through porcine buccal mucosa confirmed good drug flux (10.38 $\mu\text{g}/\text{cm}^2/\text{h}$) and lag time (30 min).
- Accelerated stability studies of F3 at $40\pm 2^\circ\text{C}/75\pm 5\%$ RH for 90 days showed no significant changes, confirming formulation stability.

Final conclusion: The optimized formulation F3 (Carbopol 934P 30 mg, HPMC K4M 15 mg, sodium alginate 15 mg) is a stable, effective, and safe mucoadhesive buccal tablet of propranolol hydrochloride, with potential to improve bioavailability by avoiding hepatic first-pass metabolism, thereby reducing dosing frequency and improving patient compliance. All objectives set in Chapter 3 were fully achieved.

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