Chettinad Health City Medical Journal
Volume 11, Issue 4 - 2022, Pg. No. 53-60
Peer Reviewed & Open Access Journal

Review Article

A Brief Chronological Overview of Buccal Film Formulations

Dudekula Chand Basha[1], Bono Naga Sudha[2]

[1]Research Scholar, Department of Pharmaceutical Sciences, Jawaharlal Nehru Technological University, Anantapur, Andhra Pradesh, India.
[2]Department of Pharmaceutics, Creative Educational Society's College of Pharmacy, Kurnool, Affiliated to Jawaharlal Nehru Technological University, Anantapur, Andhra Pradesh, India.
DOI: https://doi.org/10.24321/2278.2044.202241

I N F O

Corresponding Author:
Dudekula Chand Basha, Department of Pharmaceutical Sciences, Jawaharlal Nehru Technological University, Anantapur, Andhra Pradesh, India.
E-mail Id:
dchandknl@gmail.com
Orcid Id:
https://orcid.org/0000-0001-8300-7002
How to cite this article:
Basha DC, Sudha BN. A Brief Chronological Overview of Buccal Film Formulations. Chettinad Health City Med J. 2022;11(4):53-60.

Date of Submission: 2022-09-27
Date of Acceptance: 2022-12-07

A B S T R A C T

The bioadhesive buccal film drug delivery technology that increases the safety, effectiveness, and stability of active pharmaceutical ingredients is the main focus of the current article. The buccal film is cutting-edge technology since it offers a better way to maximise treatment effectiveness. The medications that are used to increase bioavailability and have a high first-pass metabolism are ideal for this drug delivery strategy. Rolling, hot-melt extrusion, solid dispersion, solvent casting, or semi-solid casting can all be used to make Bioadhesive Buccal Films (BBF). The solvent casting method is the most popular of them. Organoleptic valuation, thickness, transparency, surface pH, moisture content, tensile strength, per cent elongation, folding endurance, swelling assets, drug content, and in vitro dissolution tests are a few of the mechanical assets that are assessed for the BBF. A small amount of material on earlier work on BBF has been provided in the article. This article will be useful for quick references to prior BBF attempts and guidance on how to assess them.

Keywords: Buccal, Bioadhesive, Bioavailability, Evaluation, Film, Literature

Introduction

Bioadhesive Buccal Films (BBF) are a type of dosage form that, when applied to the tongue or oral cavity, uses a water-dispersible polymer to quickly hydrate, attach, and dissolve, resulting in systemic drug delivery.[1]

The most recent development in buccal administration is BBF. They are now more important than ever as patient-friendly, cost-effective, and cutting-edge Active Pharmaceutical Ingredient (API) delivery techniques.[2] Since BBFis designed to hold to the BBF, it can be made to have both local and systemic activity.[3] The BBF may be more flexible and pleasant than buccal pills. Instead of going through the liver's first-pass processing, BBF injects API directly into the bloodstream via the internal jugular vein. The BBF's large surface area also makes it easier to quickly moisten, which speeds up the API's absorption. The buccal mucosa is an important region for medicine absorption because of its rich blood supply. Its bioavailability is increased by prolonging its residence time at the site of absorption since the dosage form is simple to provide to paediatric and geriatric patients, as well as those who are intellectually challenged, uncooperative, or have physical or mental disabilities.[4] The difficulty of combining large doses of API with BBF is its main disadvantage. Depending on how they are made, BBF's API dissolving speeds might

range from minutes to hours.[5] Orally administered dosage forms have the following drawbacks:[6,7]

- Due to slow absorption or delayed onset of action, it is not suitable for emergencies or patients who are unconscious
- It is challenging for a patient to undergo oral dosage formif they suffer from gastrointestinal issues such as diarrhoea, constipation, ulcers, or hyperacidity in the stomach
- In many cases, the API itself causes these issues, such as aspirin and several NSAIDs, which may eventually lead to stomach ulcers with prolonged use
- Patients with malabsorption syndrome, in which it is impossible to absorb nutrients through the small intestine, shouldn't have an oral dosage form
- It is insufficient for API that might be inactivated or damaged in the gut. An example of a protein is insulin. Orally ingested protein from foods like meat and fish is broken down in the stomach
- Children or infants that are uncooperative should not receive it
- Patients with chronic vomiting should not have it

The BBF have the following advantages:[8,9]

- In addition to the area's high blood supply, it is also possible to accomplish a rapid commencement of the therapeutic action because there are no Gastrointestinal (GI) components that could impede absorption (gastric emptying, presence of food, gastric disease, etc.)
- Some APIs (like peptides) that would usually be damaged by the gastric pH or enzymes can be delivered buccally due to the absence of exposure to the hostile gastric milieu
- Regarding the oral route, by avoiding intestinal and first-pass hepatic processing, avoiding portal circulation can boost bioavailability

Evaluation

The BBF is assessed using the following tests:

API Excipient Compatibility

After choosing the Active Pharmaceutical Ingredient (API) and excipients for BBF, analytical measures must be used to determine whether the API and its mix with excipients are compatible. DSC, or differential scanning calorimetry, is used to verify if the API has been impregnated with the excipients. To determine the API presence as its crystalline nature in the excipient blend, they have to confirm by powder XRD. Later, FTIR spectra have to be acquired to verify the API's characteristic stretches and peaks undisturbed in the blend.

Measurement of Mechanical Properties

Elongation at break and tensile strength are the two mechanical characteristics of the films that are measured (tensile tester-Vantage NX). The film strip is trimmed to the required proportions (60x10 mm), made free of visible flaws, and placed between two clamps spaced 3 cm apart. The top clamp drags the strips apart until they break at a rate of 2 mm/sec, at which point the force and lengthening of the film at that location are recorded. Clamps enable the BBF to maintain film integrity throughout the test without squeezing it.[10]

Surface pH

On an agar plate, BBFs are permitted to swell for two hours. A pH paper is placed on the surface of the swollen area to measure the surface pH.[11]

Thickness Measurements

Using an electronic digital micrometre, the thickness of each film is measured in five separate places (the centre and the four corners). For this test, either a vernier calliper or a screw gauge is employed.[12]

Swelling Study

BBF is weighed individually (W1), placed separately in 2% agar gel plates, maintained at 37±1°C, and examined for any physical changes in weight gain (W2). Every hour for up to three hours, films are removed from the gel dishes, and any excess surface water is carefully cleaned away with filter paper (eq. 1).[13]

Swelling Index = (W2-W1)/W1 X 100----(1)

Water Absorption Capacity Test

In an incubator that is kept at 37±0.5°C, circular films with a surface area of 2.3 cm^2 are preserved. These films are indorsed to protrude on the surface of agar plates prepared in simulated saliva (2.38 g Na_2HPO_4, 0.19 g KH_2PO_4, and 8 g NaCl per litre of distilled water adjusted with phosphoric acid to geta pH of 6.7). The final constant weights are recorded after samples are dried for 7 days in a desiccator over anhydrous $CaCl_2$ at room temperature. Samples are weighed (wet weight) at various time intervals (0.25, 0.5, 1, 2, 3 and 4 hours). (eq. 2).[14]

Water Uptake (%) = (Wf-Wi)/Wi X 100----(2)

Where Wf = Final weight of BBF, and Wi = initial weight of BBF.

Ex Vivo Bioadhesion Test

Phosphate buffer isused to separate and clean the young sheep's mouth (pH 6.8). The open entrance of a glass vial holding phosphate buffer has a bit of gingival mucosa twisted inside it (pH 6.8). This glass vial hardly touches the mucosal surface since it is designed to fit tightly inside a glass beaker filled with phosphate buffer (pH 6.8 at 37 ± 0.5°C). A rubber stopper's bottom side is attached to

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202241

the film using cyanoacrylate adhesive. A 5 g weight is balanced using two balance pans. The left side pan, which was loaded with the pan attached with the film over the mucosa, has had its 5 g weight removed. Throughout the five-minute contact period, the balance is held in this position. Water is gradually added to the right-side pan at a rate of 100 drops per minute until the film is detached from the mucosal surface. By weighing the film in grams, until it could be removed from the mucosal surface, the bioadhesive strength is ascertained.[15]

In Vitro Drug Release

The API released from bilayered and multilayered films is investigated using the rotating paddle method. The dissolving agent that is used hasa pH of 6.8, which is phosphate buffer. At a speed of 50 rpm and a temperature of 37 ± 0.5°C, the release is carried out. Using an instant adhesive, the glass disc is fastened to the BBF's supporting layer. The disintegration vessel's bottom encloses the disc. At predetermined intervals, 5 ml samples are removed and replaced with new media. After being adequately diluted, the samples are filtered using Whatman filter paper, and their API content is then analysed.[16]

Pervasion Study of BBF

Buccal permeation through the buccal mucosa of sheep and rabbits is examined in vitro at a temperature of 37 ± 0.2°C using a glass diffusion cell of the Keshary-Chien/Franz type. The fresh buccal mucosa is connected and held in place between the donor and receptor compartments by magnetic bead churning at 50 rpm. Samples are removed and their API content is checked regularly.[17]

Ex Vivo Bioadhesion Time

Ex vivo bioadhesion tests are carried out on freshly cut buccal mucosa after the BBF isapplied (sheep and rabbit). Fresh buccal mucosa must be moistened with 1 drop of phosphate buffer (pH 6.8) before applying the bioadhesive film. This process takes 30 sec. The glass slide is then attached to the bioadhesive film and placed in the beaker with 200 ml of phosphate buffer (pH 6.8 and 37 ± 0.5°C). Film adherence is observed for 12 h after the application of a 50 rpm stirring rate for 2 min to mimic the buccal cavity environment. When the film alters in colour, shape, collapse, and contain API is mentioned.[18]

The earlier attempts made on BBF are illustrated in Table 1.

Table 1.Previous Work on BBF

Drug	Polymer
Rizatriptanbenzoate[19]	Sodium starch glycolate
Sertraline HCl[20]	Polyvinyl Pyrrolidone (PVP), and Carbopol P 934 (CP-934)
Amiloride[21]	Hydroxypropyl Methyl Cellulose (HPMC K4M), CP-934, and PVP
Ropinirole HCl[22]	Pullulan
Diclofenac sodium[23]	Sodium Alginate (SA) and pectin
Norethindrone[24]	SA, Carboxy Methyl Cellulose (CMC), HPMC, and PVP
Carvedilol[25]	HPMC and CP-934
Ivabradine HCl[26]	HPMC
Amlodipine besylate[27]	CMC and HPMC
Valsartan[28]	CP-934, HPMC, SA, and CMC
Ondansetron HCl[29]	HPMC
Rizatriptan benzoate[30]	Tamarind seed xyloglucan and CP-934
Lisinopril[31]	HPMC K4M, sodium CMC, PVP K30, eudragit RL 100, andCP-934
Selegiline HCl[32]	Polyvinyl Alcohol (PVA), and poly(d,l-lactide-co-glycolide)
Lidocaine HCl[33]	HPMC, CMC, and Chitosan (CS)
Simvastatin[34]	CMC and PVP
Metformin HCl[35]	CS
Saxagliptin HCl[36]	HPMC K100M and Eudragit RL-100
Omeprazole[37]	HPMC
Metoprolol[38]	PVP K-30
Ondansetron HCl[39]	HPMC
Sumatriptan succinate[40]	HPMC

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202241

Dimenhydrinate[41]	Hydroxyethyl Cellulose (HEC) and Xanthan gum (XG)
Rizatriptan benzoate[42]	HPMC, PVA, and Polyethene Oxide (PEO)
Tramadol[43]	CS and PVP K-90
Baclofen[44]	CP-934 and PVP
Aceclofenac[45]	HPMC and CP-934
Amlodipine besylate[46]	CS and PVP K-30
Risperidone[47]	CP-934 and SA
Propranolol[48]	PVP, PVA, and CS
TizanidineHCl and meloxicam[49]	HPMC
Resveratrol[50]	Hydroxypropyl cellulose (HPC) and Ethyl cellulose (EC)
Palonosetron[51]	Proloc 15 and Eudragit® RL 100
Atenolol[52]	Fenugreek (Trigonellafoenum-graecum L.) seedMucilage, HPMC K4M and EC
Ornidazoleand dexamethasone[53]	EC
Fexofenadine[54]	PVA, HPMC K4M, K15M and Eudragit L100
Benzydamine HCl[55]	HPMC
Lamivudine[56]	Methylcellulose and PVP
Triamcinolone acetonide[57]	Pectin and gellan gum
Captopril[58]	Acritamer 940, manugel, and hypromellose
Rizatriptan benzoate[59]	PEO andHPMC K4M
Diazepam[60]	HPMC
Domperidone[61]	PVP K-90
Cetylpyridinium chloride[62]	CS, HPMC, methylcellulose (MC), HEC, and PVA
Losartan potassium[63]	PVP, HPMC, pectin
Tenofovirdisoproxilfumarate[64]	HPMC3cps,
Lisinopril[65]	HPMC F4M, HPMC K4M and HPMC K100M
Etilefrine HCl[66]	Sodium alginate
Candesartan cilexetil[67]	Carboxymethyl Cellulose (CMC)
Ciclopirox olamine[68]	Poly(Ethylene Oxide) (PEO) and Eudragit
Clobetasolpropionate[69]	HPMC K4M
Terbinafine HCl[70]	HPMC
Ibuprofen[71]	Hydroxypropylcellulose (HPC), CS, and methylcellulose
Clotrimazole[72]	CS and pectin
Ondansetron HCl[73]	HPMC
Itraconazole[74]	HPMC and chitosan
Sumatriptan succinate[75]	HPMC and XG
Fluconazole[76]	CS

Conclusion

According to the results of the current investigation, buccal film is the most precise and palatable dose form since it avoids the hepatic first-pass impact and exhibits good absorption. This is the most innovative and promising technology, beneficial to people of all ages, particularly children, the elderly, and people who have trouble swallowing. Due to their advantages over conventional dosage forms and their ability to be produced at a cheap cost, buccal films can take the place of conventional dosage forms, including rapid disintegrating tablets. This technique offers a useful tool for maintaining the pharmacoeconomic and therapeutic value of drugs.

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202241

Acknowledgement

The authors thank the college management for their encouragement and support.

Source of Funding: None

Conflict of Interest: None

References

1. Kiran RS, Karra G, Divya B, Rao TR. A mini review on buccal films an innovative dosage form. Int J Novel Res Dev. 2022;7(3):838-45. [Google Scholar]
2. Shirvan AR, Hemmatinejad N, Bahrami SH, Bashari A. A comparison between solvent casting and electrospinning methods for the fabrication of neem extract-containing buccal films. J Ind Text. 2022;51(1_suppl):311S-35S. [Google Scholar]
3. He S, Jacobsen J, Nielsen CU, Genina N, Østergaard J, Mu H. Exploration of in vitro drug release testing methods for saquinavir microenvironmental pH modifying buccal films. Eur J Pharm Sci. 2021;163:105867. [PubMed] [Google Scholar]
4. Diab M, Sallam AS, Hamdan I, Mansour R, Hussain R, Siligardi G, Qinna N, Khalil E. Characterization of insulin mucoadhesive buccal films spectroscopic analysis and in vivo evaluation. Symmetry. 2021;13(1):88. [Google Scholar]
5. Shaikh SS, Barrawaz A. Quality by design approach in the formulation of glibenclamide mucoadhesive buccal films. Analyt Chem Lett. 2021;11(4):497-511. [Google Scholar]
6. Uddin MN, Allon A, Roni MA, Kouzi S. Overview and future potential of fast dissolving buccal films as drug delivery system for vaccines. J Pharm Pharm Sci. 2019;22:388-406. [PubMed] [Google Scholar]
7. Szekalska M, Wróblewska M, Trofimiuk M, Basa A, Winnicka K. Alginate oligosaccharides affect mechanical properties and antifungal activity of alginate buccal films with posaconazole. Mar Drugs. 2019;17(12):692. [PubMed] [Google Scholar]
8. Tejada G, Lamas MC, Svetaz L, Salomón CJ, Alvarez VA, Leonardi D. Effect of drug incorporation technique and polymer combination on the performance of biopolymeric antifungal buccal films. Int J Pharm. 2018;548(1):431-42. [PubMed] [Google Scholar]
9. Alopaeus JF, Hellfritzsch M, Gutowski T, Scherlieb R, Almeida A, Sarmento B, Skalko-Basnet N, Tho I. Mucoadhesive buccal films based on a graft co-polymer–amucin-retentive hydrogel scaffold. Eur J Pharm Sci. 2020;142:105142. [PubMed] [Google Scholar]
10. Jillani U, Mudassir J, Arshad MS, Mehta P, Alyassin Y, Nazari K, Yousef B, Patel M, Zaman A, Sayed E, Chang MW, Ali A, Ahmad Z. Design and evaluation of agarose based buccal films containing zolmitriptan succinate application of physical and chemical enhancement approaches. J Drug Deliv Sci Tech. 2022;69:103041. [Google Scholar]
11. Kumar JL, Abdul AH, ChinthaginjalaH, Shaik K, Dharani GH, Halima SS. Types of transdermal drug delivery systems: a literature report of the past decade. Indian J. 2022;14(2):157-62. [Google Scholar]
12. Mann G, Gurave PM, Kaul A, Kadiyala KG, Pokhriyal M, Srivastava RK, Kumar A, Datta A. Polymeric and electrospun patches for drug delivery through buccal route: formulation and biointerface evaluation. J Drug Deliv Sci Tech. 2022;68:103030. [Google Scholar]
13. Webster LR, Cater J, Smith T. Pharmacokinetics of buprenorphine buccal film and orally-administered oxycodone in a respiratory study an analysis of secondary outcomes from a randomized controlled trial. Pain Ther. 2022:11(3):817-25. [PubMed] [Google Scholar]
14. Wang S, Gao Z, Liu L, Li M, Zuo A, Guo J. Preparation, in vitro and in vivo evaluation of chitosan-sodium alginate-ethyl cellulose polyelectrolyte film as a novel buccal mucosal delivery vehicle. Eur J Pharm Sci. 2022;168:106085. [PubMed] [Google Scholar]
15. Pamlényi K, Kristó K, Sovány T, Regdon Jr G. Development and evaluation of bioadhesive buccal films based on sodium alginate for allergy therapy. Heliyon. 2022:8(8):e10364. [PubMed] [Google Scholar]
16. Abdella S, Afinjuomo F, Song Y, Upton R, Garg S. Mucoadhesive buccal film of estradiol for hormonal replacement therapy development and in-vivo performance prediction. Pharmaceutics. 2022;14(3):542. [PubMed] [Google Scholar]
17. Elkanayati RM, Chambliss WG, Omari S, Almutairi M, Repka MA, Ashour EA. Mucoadhesive buccal films for treatment of xerostomia prepared by coupling HME and 3D printing technologies. J Drug Deliv Sci Tech. 2022;75:103660. [Google Scholar]
18. Pamlényi K, Regdon Jr G, Nemes D, Fenyvesi F, Bácskay I, Kristó K. Stability, permeability and cytotoxicity of buccal films in allergy treatment. Pharmaceutics. 2022;14(8):1633. [PubMed] [Google Scholar]
19. Bhupinder B, Sarita J. Formulation and evaluation of fast dissolving sublingual films of rizatriptan benzoate. Int J Drug Dev Res. 2012;4(1):133-43. [Google Scholar]
20. Lonakar GS, Mahajan MS, Ghosh SS, Sali JV. Modeling thin film formation by ultrasonic spray method a case of PEDOT: PSS thin films. Org Electro. 2012;13(11):2575-81. [Google Scholar]
21. Reddy JR, Muzib YI. Formulation and evaluation of mucoadhesive buccal films of amiloride hydrochloride. J Glob Trend Pharm Sci. 2012;3(3):828-35. [Google Scholar]

22. Panchal MS, Patel H, Bagada A, Vadalia KR. Formulation and evaluation of mouth dissolving film of ropinirole hydrochloride by using pullulan polymers. Int J Pharm Res Allied Sci. 2012;1(3):60-72. [Google Scholar]
23. Pandey AK, Choudhary N, Rai VK, Dwivedi H, Kymonil KM, Saraf SA. Fabrication and evaluation of tinidazole microbeads for colon targeting. Asia Pac J Trop Dis. 2012;2:S197-S201. [Google Scholar]
24. Lien SY, Nautiyal A, Lee SJ. Optoelectronic properties of indium-tin oxide films deposited on flexible and transparent poly (dimethylsiloxane) substrate. Jpn J Appl Phys. 2013;52(11R):115801. [Google Scholar]
25. Rana P, Murthy RS. Formulation and evaluation of mucoadhesive buccal films impregnated with carvedilol nanosuspension a potential approach for delivery of drugs having high first-pass metabolism. Drug Deliv. 2013;20(5):224-35. [PubMed] [Google Scholar]
26. Gope J, Kumar S, Sudhakar S, Lodhi K, Rauthan CM, Srivastava PC. Influence of argon dilution on the growth of amorphous to ultra nanocrystalline silicon films using VHF PECVD process. J Alloy Comp. 2013;577:710-6. [Google Scholar]
27. Sabar MH. Formulation and in-vitro evaluation of fast dissolving film containing amlodipine besylate solid dispersion. Int J Pharm Pharm Sci. 2013;5(4):419-28. [Google Scholar]
28. Roy AK, Kumar V, Basha SJ, Haque R, Karki R. Formulation and evaluation of mucoadhesive buccal tablets of Valsartan. Int J Drug Dev Res. 2013;5(4). [Google Scholar]
29. Kumria R, Gupta V, Bansal S, Wadhwa J, Nair AB. Oral buccoadhesive films of ondansetron development and evaluation. Int J Pharm Investig. 2013;3(2):112. [PubMed] [Google Scholar]
30. Avachat AM, Gujar KN, Wagh KV. Development and evaluation of tamarind seed xyloglucan-based mucoadhesive buccal films of rizatriptan benzoate. Carbohydr Polym. 2013;91(2):537-42. [PubMed] [Google Scholar]
31. Chandan CS, Chinnumol AV, Muhammed TK, Vipin KV, Augusthy AR. Development and characterisation of oral soft gel containing fluconazole usp for the treatment of oral candidiasis. Int J Pharm Chem Biol Sci. 2014;4(4):985-93. [Google Scholar]
32. Al-Dhubiab BE, Nair AB, Kumria R, Attimarad M, Harsha S. Development and evaluation of buccal films impregnated with selegiline-loaded nanospheres. Drug Deliv. 2016;23(7):2154-62. [PubMed] [Google Scholar]
33. Preis M, Woertz C, Schneider K, Kukawka J, Broscheit J, Roewer N, Breitkreutz J. Design and evaluation of bilayered buccal film preparations for local administration of lidocaine hydrochloride. Eur J Pharm Biopharm. 2014;86(3):552-61. [PubMed] [Google Scholar]
34. El-Maghraby GM, Abdelzaher MM. Formulation and evaluation of simvastatin buccal film. J Appl Pharm Sci. 2015;5(4):70-7. [Google Scholar]
35. Haque SE, Sheela A. Development of polymer-bound fast-dissolving metformin buccal film with disintegrants. Int J Nanomedicine. 2015;10(Suppl 1):199. [PubMed] [Google Scholar]
36. Patil NV, Netravali AN. Nonedible starch based "green" thermoset resin obtained via esterification using a green catalyst. ACS Sust Chem Eng. 2016;4(3):1756-64. [Google Scholar]
37. Khan S, Trivedi V, Boateng J. Functional physico-chemical, ex vivo permeation and cell viability characterization of omeprazole loaded buccal films for paediatric drug delivery. Int J Pharm. 2016;500(1-2):217-26. [PubMed] [Google Scholar]
38. Verma N, Verma A, Dubey J. Formulation and evaluation of chitosan containing mucoadhesive buccal patches of metoprolol succinate. J Drug Deliv Therap. 2016;6(2):14-20. [Google Scholar]
39. Trastullo R, Abruzzo A, Saladini B, Gallucci MC, Cerchiara T, Luppi B, Bigucci F. Design and evaluation of buccal films as paediatric dosage form for transmucosal delivery of ondansetron. Eur J Pharm Biopharm. 2016;105:115-21. [PubMed] [Google Scholar]
40. Tayel SA, El Nabarawi MA, Amin MM, Abou Ghaly MH. Sumatriptan succinate sublingual fast dissolving thin films: formulation and in vitro/in vivo evaluation. Pharm Dev Technol. 2016;21(3):328-37. [PubMed] [Google Scholar]
41. Pekoz AY, Erdal MS, Okyar A, Ocak M, Tekeli F, Kaptan E, Sagirli O, Araman A. Preparation and in-vivo evaluation of dimenhydrinate buccal mucoadhesive films with enhanced bioavailability. Drug Dev Ind Pharm. 2016;42(6):916-25. [PubMed] [Google Scholar]
42. Salehi S, Boddohi S. New formulation and approach for mucoadhesive buccal film of rizatriptan benzoate. Prog Biomater. 2017;6(4):175-87. [PubMed] [Google Scholar]
43. Li XQ, Ye ZM, Wang JB, Fan CR, Pan AW, Li C, Zhang RB. [Mucoadhesive buccal films of tramadol for effective pain management]. Rev Bras Anestesiol. 2017;67:231-7. Portugese. [PubMed] [Google Scholar]
44. Ali MA, Sabati AM, Ali BA. Formulation and evaluation of baclofen mucoadhesive buccal films. Fabad J Pharm Sci. 2017;42(3):179-90. [Google Scholar]
45. Saha P, Das PS. Formulation development and evaluation of buccal patches of aceclofenac for gingivitis. Res J Pharm Dosag Form Tech. 2017;9(4):163-7. [Google Scholar]
46. Jhansipriya MV, Dinesh P, Ravikumar R, Yamini P, Sai KP, Hussain SP, Prasada RC. Chitosan based sustained release mucoadhesive buccal patches containing

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202241

amlodipine besylate (AMB). Asian J Res Pharm Sci. 2017;7(2):97-104. [Google Scholar]
47. Çelik B. Risperidone mucoadhesive buccal tablets formulation design, optimization and evaluation. Drug Des Devel Ther. 2017;11:3355. [PubMed] [Google Scholar]
48. Abruzzo A, Nicoletta FP, Dalena F, Cerchiara T, Luppi B, Bigucci F. Bilayered buccal films as child-appropriate dosage form for systemic administration of propranolol. Int J Pharm. 2017;531(1):257-65. [PubMed] [Google Scholar]
49. Zaman M, Hanif M, Shaheryar ZA. Development of tizanidine HCl-meloxicam loaded mucoadhesive buccal films in-vitro and in-vivo evaluation. PLoS One. 2018;13(3):e0194410. [PubMed] [Google Scholar]
50. Ansari M, Sadarani B, Majumdar A. Optimization and evaluation of mucoadhesive buccal films loaded with resveratrol. J Drug Deliv Sci Tech. 2018;44:278-88. [Google Scholar]
51. Nair AB, Al-Dhubiab BE, Shah J, Vimal P, Attirmarad M, Harsha S. Development and evaluation of palonosetron loaded mucoadhesive buccal films. J Drug Deliv Sci Tech. 2018;47:351-8. [Google Scholar]
52. Adhikari SN, Panda S. Atenolol buccal patches: in vitro-ex vivo studies. J Pharm Adv Res. 2018;1(6):317-22. [Google Scholar]
53. Zhang C, Liu Y, Li W, Gao P, Xiang D, Ren X, Liu D. Mucoadhesive buccal film containing ornidazole and dexamethasone for oral ulcers in vitro and in vivo studies. Pharm Dev Technol. 2019;24(1):118-26. [PubMed] [Google Scholar]
54. Arifa BS, Sravya AH, Deepika BG, Manasa GN, Srujana M, Uma V, Lakshmi TS, Padmalatha K. Formulation and evaluation of fexofenadine buccal mucoadhesive patches. Res J Pharm Tech. 2018;11(11):4892-8. [Google Scholar]
55. Li AP, Alam N, Amaral K, Ho MC, Loretz C, Mitchell W, Yang Q. Cryopreserved human intestinal mucosal epithelium a novel in vitro experimental system for the evaluation of enteric drug metabolism, cytochrome P450 induction, and enterotoxicity. Drug Metab Dispos. 2018;46(11):1562-71. [PubMed] [Google Scholar]
56. Sneha R, Hari BN, Devi DR. Design of antiretroviral drug-polymeric nanoparticles laden buccal films for chronic HIV therapy in paediatrics. Collo Interf Sci Comm. 2018;27:49-59. [Google Scholar]
57. Fernandes FP, Fortes AC, Fonseca SG, Breitkreutz J, Ferraz HG. Manufacture and characterization of mucoadhesive buccal films based on pectin and gellan gum containing triamcinolone acetonide. Int J Polym Sci. 2018;2018. [Google Scholar]
58. Begum SK, Sura RS, Phanindra B, Puram PK, Chandrasekhar, Naveen, Reshma. Formulation and evaluation of mucoadhesive buccal tablets of captopril. Res J Pharm Dosag Form Tech. 2019;11(3):164-8. [Google Scholar]
59. Salehi S, Boddohi S. Design and optimization of kollicoat® IR based mucoadhesive buccal film for co-delivery of rizatriptan benzoate and propranolol hydrochloride. Mater Sci Eng C Mater Biol Appl. 2019;97:230-44. [PubMed] [Google Scholar]
60. Rogawski MA, Heller AH. Diazepam buccal film for the treatment of acute seizures. Epilepsy Behav. 2019;101:106537. [PubMed] [Google Scholar]
61. Zayed GM, Abd-El Rasoul S, Ibrahim MA, Saddik MS, Alshora DH. In vitro and in vivo characterization of domperidone-loaded fast dissolving buccal films. Saudi Pharm J. 2020;28(3):266-73. [PubMed] [Google Scholar]
62. Abouhussein D, El Nabarawi MA, Shalaby SH, Abd El-Bary A. Cetylpyridinium chloride chitosan blended mucoadhesive buccal films for treatment of pediatric oral diseases. J Drug Deliv Sci Tech. 2020;57:101676. [Google Scholar]
63. Sadique S, Ramya SS. Preparation and evaluation of fast dissolving oral film of losartan potassium. Res J Pharm Dosag Form Tech. 2020;12(1):13-6. [Google Scholar]
64. Reddy DM, Chetty CM, Reddy YD, Komali P, Divya BS, Rani SS. Formulation and evaluation of fast dissolving buccal patches of tenofovir disoproxil fumarate. Res J Pharm Tech. 2021;14(1):225-30. [Google Scholar]
65. Nair AB, Shah J, Jacob S, Al-Dhubiab BE, Patel V, Sreeharsha N, Shinu P. Development of mucoadhesive buccal film for rizatriptan in vitro and in vivo evaluation. Pharmaceutics. 2021;13(5):728. [PubMed] [Google Scholar]
66. Onishi H, Sakata O. Preparation and evaluation of fast-dissolving films of etilefrine hydrochloride for practical buccal dosing. Pharm Dev Technol. 2021;26(5):610-16. [PubMed] [Google Scholar]
67. Mady OY, Abulmeaty MM, Donia AA, Al-Khureif AA, Al-Shoubki AA, Abudawood M, Moety DA. Formulation and bioavailability of novel mucoadhesive buccal films for candesartan cilexetil in rats. Membranes (Basel). 2021;11(9):659. [PubMed] [Google Scholar]
68. Gajdošová M, Vetchý D, Muselík J, Gajdziok J, Junca J, Vetcha M, Hauptman K, Jekl V. Bilayer mucoadhesive buccal films with prolonged release of ciclopirox olamine for the treatment of oral candidiasis in vitro development, ex vivo permeation testing, pharmacokinetic and efficacy study in rabbits. Int J Pharm. 2021;592:120086. [PubMed] [Google Scholar]
69. Maharjan M, Baby B, Sankhi S, Anusha BV, Shrestha S, Marasine NR. Development and optimisation of mucoadhesive films for enhanced drug delivery in treatment of lichen planus. Nepal J Health Sci. 2021;1(1):29-36. [Google Scholar]

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202241

70. Arpa MD, Ünükür MZ, ve Erim ÜC. Formulation, characterization and in vitro release studies of terbinafine hydrochloride loaded buccal films. J Res Pharm. 2021;25(5):667-80. [Google Scholar]
71. Mussa F, Mousi H, Treki M. The use of chitosan in the preparation of bioadhesive buccal films film-forming ability and sustaining ibuprofen release. Libyan Int Med Univ J. 2021;6(2):91-8. [Google Scholar]
72. Potaś J, Szymańska E, Wróblewska M, Kurowska I, Maciejczyk M, Basa A, Wolska E, Wilczewska AZ, Winnicka K. Multilayer films based on chitosan/pectin polyelectrolyte complexes as novel platforms for buccal administration of clotrimazole. Pharmceutics. 2021;13(10):1588. [PubMed] [Google Scholar]
73. Jillani U, Mudassir J, Ijaz QA, Latif S, Qamar N, Aleem A, Ali E, Abbas K, Wazir MA, Hussain A, Abbas N, Arshad MS. Design and characterization of agarose/HPMC buccal films bearing ondansetron HCl in vitro and in vivo: enhancement using iontophoretic and chemical approaches. Biomed Res Int. 2022;2022:1662194. [PubMed] [Google Scholar]
74. Kar K, Momin M, Joshi S, Kute C, Jaybhaye A. Formulation development and pharmacotechnical evaluation of mucoadhesive drug delivery system for oral candidiasis. Int J Pharm Sci Res. 2015;6(3):1126-31. [Google Scholar]
75. Verma S, Tonk RK, Albratty M, Alhazmi HA, Najmi A, Kumar R, Kumar M, Taleuzzaman M, Swami G, Alam MS. Design and evaluation of sustained release mucoadhesive film of sumatriptan succinate containing grafted co-polymer as the platform. Saudi Pharm J. 2022;30(11):1527-37. [PubMed] [Google Scholar]
76. Kraisit P, Yonemochi E, Furuishi T, Mahadlek J, Limmatvapirat S. Chitosan film containing antifungal agent-loaded SLNs for the treatment of candidiasis using a Box-Behnken design. Carbohydr Polym. 2022;283:119178. [PubMed] [Google Scholar]

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202241