WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review on Analytical Methods for the Determination of Benazepril in Bulk and Pharmaceutical Dosage Forms.

R. Jawaharsamuvel[1]*, Dr. P.G. Sunitha[2], M. Madhumithra[3], R. Priyadharshini[4], S. Neelambari[5], G. Gishmi[6], H. Mohammed Idrees[7]

[1]*Post Graduate Student, Department of Pharmaceutical Chemistry, College of Pharmacy, Madras Medical College, Chennai.
[2]Assistant Professor, Department of Pharmaceutical Chemistry, College of Pharmacy, Madras Medical College, Chennai.
[3]Post Graduate Student, Department of Pharmaceutical Chemistry, College of Pharmacy, Madras Medical College, Chennai.
[4]Post Graduate Student, Department of Pharmaceutical Chemistry, College of Pharmacy, Madras Medical College, Chennai.
[5]Post Graduate Student, Department of Pharmaceutical Chemistry, College of Pharmacy, Madras Medical College, Chennai.
[6]Post Graduate Student, Department of Pharmaceutical Chemistry, College of Pharmacy, Madras Medical College, Chennai.
[7]Post Graduate Student, Department of Pharmaceutical Chemistry, College of Pharmacy, Madras Medical College, Chennai.
Email id: jawaharsam2606@gmail.com

ABSTRACT

Benazepril is the efficacious ACE inhibitor for treating high blood pressure. This drugs clinical and pharmaceutical analysis necessitates efficient analytical techniques for quality assurance, pharmacodynamics, pharmacokinetic, and stability investigations. We have reviewed in detail the literature from many journals related to analytical and pharmaceutical chemistry, and we have looked at instrumental analytical methods that were created and used to find a drug in bulk drugs, formulations, and biological fluids, either by itself or in combination with other drugs. This review covers the most recent analytical methods including, HPTLC, UV, RP HPLC, UPLC and liquid chromatography were reported.

Keywords: Benazepril, Blood pressure, Method development, validation.

Introduction

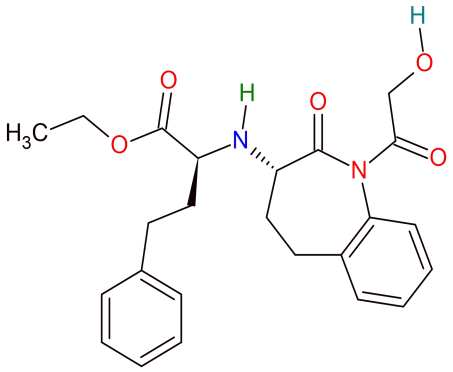
Benazepril is an Angiotensin-Converting Enzyme Inhibiting medication used to treat high blood pressure, heart failure, and diabetic kidney disease. It is a reasonable initial treatment for high blood pressure. In terms of chemistry, it is 2-[(3*S*)-3-[[(2*S*)-1-ethoxy-1-oxo-4-phenylbutan-2-yl]amino]-2-oxo-4,5-dihydro-3*H*-1-benzazepin-1-yl]acetic acid, which belongs to the group of medicines called ACE inhibitors[1]. A Literature survey revealed that there are various methods that have been reported for estimation of benazepril, such as TLC, UV and HPLC, individually and in combined dosage form with other drugs.

Drug Profile[2]

IUPAC name: 2-[(3*S*)-3-[[(2*S*)-1-ethoxy-1-oxo-4-phenylbutan-2-yl]amino]-2-oxo- 4,5-dihydro-3*H*-1-benzazepin-1-yl]acetic acid

Molecular formula : $C_{24}H_{28}N_2O_5$

Chemical structure :



Molecular weight	**:** 424.49 g/mol.
Solubility	**:** freely soluble in solvents like methanol, water, acetonitrile.
CAS number	**:** 86541-75-5
Category	**:** Anti-hypertensive
Sub Category	**:** Angiotensin-converting enzyme Inhibitors (ACE inhibitors)
Appearance	**:** White or almost white crystalline powder
Melting point	**:** 148°C - 149°C
Storage conditions	**:** Desiccated, Protected from Light

Mechanism of Action

Benazeprilat, the active metabolite of Benazepril, competes with angiotensin I for binding at the angiotensin-converting enzyme, blocking the conversion of angiotensin I to angiotensin II. Inhibition of ACE results in decreased plasma angiotensin II. As angiotensin II is a vasoconstrictor and a negative-feedback mediator for renin activity, lower concentrations result in a decrease in blood pressure and stimulation of baroreceptor reflex mechanisms, which leads to decreased vasopressor activity and to decreased aldosterone secretion[3,4].

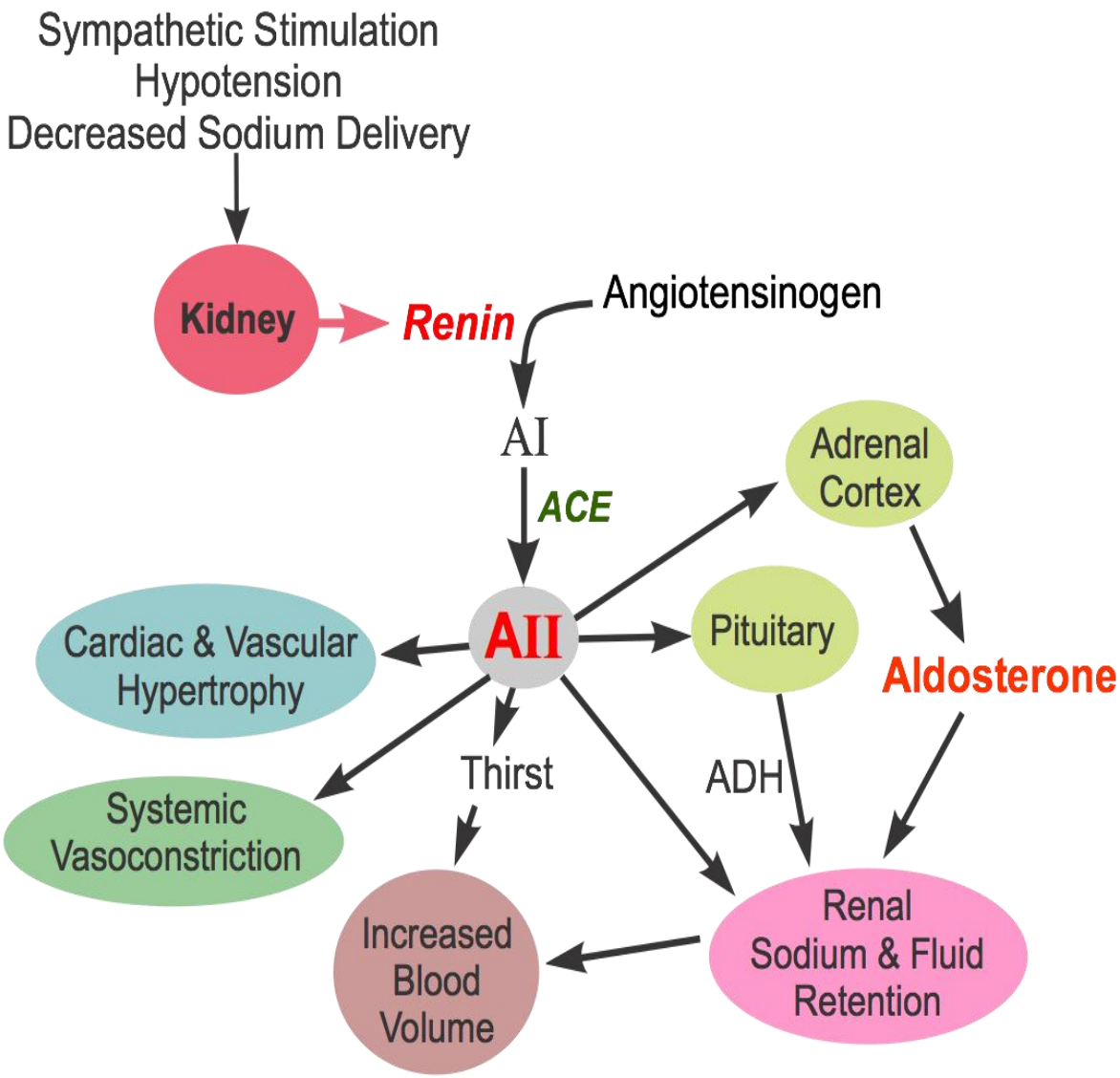


Figure 1: Mechanism of Action of Benazepril

Table 1: Thin Layer Chromatographic Methods

STATIONARY PHASE	MOBILE PHASE	DETECTION	SPECIFICATION	REFERENCE
Silica gel GF_{254}	Carbon tetrachloride: Methanol: Triethylamine (7.6: 2.4: 0.1 v/v)	240 nm	Stability-Indicating HPTLC Method for Estimation of Benazepril in Bulk and Tablet Dosage Form	[5]
HPTLC silica gel 60 F_{254}	Ethyl acetate: methanol: glacial acetic acid (85:2:0.3 v/v/v)	240 nm	Simultaneous Determination of Hydrochlorothiazide and Benazepril Hydrochloride or Amiloride Hydrochloride in Presence of Hydrochlorothiazide Impurities: Chlorothiazide and Salamide by HPTLC Method	[6]

silica gel 60 F254	Ethyl acetate: acetone: acetic acid: water, 8:2:0.5:0.5 (v/v)	215 nm	Development and Validation of an HPTLC–Densitometric Method for Determination of ACE Inhibitors	[7]
Aluminium sheets of silica gel 60 F_{254}	Ethyl acetate: methanol: chloroform (10:3:2 v/v)	238 nm	Application of LC and HPTLC-densitometry for the simultaneous determination of benazepril hydrochloride and hydrochlorothiazide	[8]
Silica gel 60 F_{254}	Ethyl acetate: methanol: ammonia (85: 20: 10 v/v)	240 nm	Reversed-phase high performance liquid chromatographic and thin layer chromatographic methods for the simultaneous determination of benazepril hydrochloride and hydrochlorothiazide in cibadrex tablets	[9]

Table 2: UV Spectrophotometric Methods

SOLVENT	DETECTION	SPECIFICATION	REFERENCE
Methanol	240 nm	Revolutionizing tablet analysis: concurrent spectrophotometric quantification of benazepril hydrochloride and hydrochlorothiazide	[10]
Methanol-water	237 nm	UV Spectrophotometric Method Development and Validation of Benazepril Hydrochloride	[11]
0.1M HCl	240 nm	New spectroscopy methods development for simultaneous estimation of Benazepril and Hydrochlorothiazide in pharmaceutical dosage form	[12]
Methanol	240 nm	Quantification of Benazepril Hydrochloride and Hydrochlorothiazide in Tablet Dosage Form by Simultaneous Equation Spectroscopy	[13]
0.1M NaOH	242 nm	Determination of Benazepril HCl and Hydrochlorothiazide in Pharmaceutical Preparations Using UV-Visible Spectrophotometry and Genetic Multivariate Calibration Methods	[14]

Table 3: High Performance Liquid Chromatographic Methods

STATIONARY PHASE	MOBILE PHASE	DETECTION	SPECIFICATION	REFERENCE
YMC Triart C_{18} (3 µm, 150 x 4.6 mm I.D.) column	Acetonitrile: water binary mixture containing 45% (v/v) acetonitrile adjusted to pH 3.	210 nm	Development and validation of RPLC method for the simultaneous analysis of ACE inhibitors in tablet formulations	[15]

Atlantis T3 column (250 ×4.6 mm × 5 m)	59 mM potassium phosphate buffer (pH 5.4):methanol (69:31) and acetonitrile: water (60:40)	225 nm and 237 nm	Development and Validation of a Reverse Phase-High Performance Liquid Chromatography Method for the Assay of Benazepril Hydrochloride using a Quality-By-Design Approach	[16]
Inertsil ODS (4.6 × 100 mm, 5 µm)	Mixture of 0.1% Triethylamine: methanol: acetonitrile (40:30:30)	235 nm	Method development and validation for the simultaneous determination of amlodipine and benazepril by reverse phase high-performance liquid chromatography in its bulk and pharmaceutical tablet dosage form using biorelevant dissolution media.	[17]
Shodex C_{18} 5e column.	Potassium dihydrogen phosphate buffer pH 5.3: Acetonitrile (55:45 v/v).	237 nm	Development and validation of RP-HPLC and UV-spectrophotometric methods for rapid simultaneous estimation of amlodipine and benazepril in pure and fixed dose combination	[18]
C_{18} (250 x 4.6 mm 5.0 µm)	0.02M tetrabutylammonium hydroxide + 0.05% v/v acetic acid: methanol in the ratio of 50: 50 (v/v)	240 nm	A New Simultaneous HPLC Analytical method for Quantification of Benazepril Hydrochloride and its related Impurities in Bulk Drug Product	[19]
Hichrom 5 C8 column (250 × 4.6 mm i.d., 5 µm particle size)	Mixture of methanol: formic acid 0.1 M (63:37, v/v)	242 nm	A Validated Stability-Indicating Liquid Chromatographic Method for the Simultaneous Determination of Amlodipine and Benazepril in Capsules Dosage Form	[20]
Symmetry C18, (4.6 × 150 mm, 5 micron)	700 mL of DI Water, 200 mL of Acetonitrile and 100 mL of Methanol, Added 2.0 mL of Octylamine and mixed well. Adjusted the pH to 2.50	240 nm	New Stability Indicating Method for Quantification of Impurities in Amlodipine and Benazepril Capsules by Validated HPLC	[21]
Diamond C18 (150 mm × 4.6 mm, 5 µm) column	0.1% acetic acid: acetonitrile (50:50, v/v),	Mass spectrometer	Simultaneous determination of lercanidipine, benazepril and benazeprilat in plasma by LC–MS/MS and its application to a toxicokinetics study	[22]

Zorbax-SB C_{18} column (50 x 4.6 mm, 5 mm)	0.1% formic acid–acetonitrile (15:85, v/v)	Mass spectrometer	Simultaneous determination of atorvastatin, amlodipine, ramipril and benazepril in human plasma by LC-MS/MS and its application to a human pharmacokinetic study	[23]
Hypersil BDS C18 analytical column (5 m, 300 mm × 4.6 mm)	A mixture of acetonitrile (A) and phosphate buffer (pH 2.6, 10 mM) (B)	237 nm	Simultaneous and rapid quantitation of benazepril and benazeprilat in human plasma by high performance liquid chromatography with ultraviolet detection	[24]
PGC analytical column (2.1 × 125.0 mm i.d., particle size 5 µm)	Mobile phase consists of 55% acetonitrile in water containing 0.3% v/v formic acid	Mass spectrometer	Development and validation of a liquid chromatographic/electrospray ionization mass spectrometric method for the determination of benazepril, benazeprilat and hydrochlorothiazide in human plasma	[25]
Zorbax SB C_{18}, (5 µm, 250 mm × 4.6 mm i.d. column)	Phosphate buffer and acetonitrile in the proportion of 65:35 (v/v) with apparent pH adjusted to 7.0	240 nm	Stability indicating RP-HPLC method for simultaneous determination of amlodipine and benazepril hydrochloride from their combination drug product	[26]
Johnson Spherigel analytical column (250 mm × 4.6 mm) packed with 5 µm C18 silica	Acetonitrile (A) and 0.1% formic acid aqueous solution (B)	Mass spectrometer	Simultaneous determination of benazepril hydrochloride and benazeprilat in plasma by high-performance liquid chromatography/electrospray-mass spectrometry	[27]
Hypersil MOS (5 µm particle size, 250 mm × 4 mm)	Mixture of acetonitrile–phosphate buffer (50:50 v/v)	215 nm	Liquid Chromatographic Studies of the Stability of Benazepril in Pure Form and in Tablets	[28]
ODS Phenomenex (150×4.6 mm, 5µm) column	Acetonitrile and water (35:65 v/v) and adjusting to pH 3.3 with acetic acid	240 nm	Application of LC and HPTLC-densitometry for the simultaneous determination of benazepril hydrochloride and hydrochlorothiazide	[29]
Hichrom RPB C_{18}, 5 mm particle size, 250×4.6 mm	Solvent A (500 ml of aqueous 0.025 M sodium dihydrogen phosphate buffer, adjusted pH to 2.8 with concentrated orthophosphoric acid was mixed with 300 ml of acetonitrile and 200 ml of methanol) Solvent B (acetonitrile)	240 nm	A validated method for the determination and purity evaluation of benazepril hydrochloride in bulk and in pharmaceutical dosage forms by liquid chromatography	[30]

Bondapak C_{18} (10 micron, 250 x 4.6 mm).	A mixture of methanol: acetonitrile: water: acetic acid (40: 30: 30: 0.5 v/v)	240 nm	Reversed-phase high performance liquid chromatographic and thin layer chromatographic methods for the simultaneous determination of benazepril hydrochloride and hydrochlorothiazide in cibadrex tablets	[31]
BDS C-18 micro-bore analytical column	Mixture of 0.025 M sodium dihydrogen phosphate (pH 4.8) and acetonitrile (55:45, v/v)	250 nm	Simultaneous determination of benazepril hydrochloride and hydrochlorothiazide by micro-bore liquid chromatography	[32]

Table 4: Ultra Performance Liquid Chromatographic Methods

STATIONARY PHASE	MOBILE PHASE	DETECTION	SPECIFICATION	REFERENCE
A Cosmosil C18 (250 mm x 4.6ID, 5 micron)	0.1% Triethylamine phosphate: Methanol (25:75v/v	236 nm	Stability indicating UPLC method for estimation of benazepril and hydrochlorothiazide in bulk and combined dosage form	[33]
Agilent SB-C_{18} column (50 mm x 2.1 mm, 1.8 µm)	Methanol and 0.1% formic acid in water (95:5, v/v)	Tandem mass spectrometer	Simultaneous ultraperformance liquid chromatography/tandem mass spectrometry determination of four antihypertensive drugs in human plasma using hydrophilic–lipophilic balanced reversed-phase sorbents sample preparation protocol	[34]
Acquity UPLC, BEH C_{18} (100 x 2.1 mm, 1.7 µm)	Solvent-A (1.36 g of potassium dihydrogen phosphate dissolved in one Liter of water, adjusted to pH 3.0 with orthophosphoric acid) and Solvent-B (acetonitrile) (8:2)	240 nm	Stability-Indicating RP-UPLC Method for the Simultaneous Determination of Potential Degradation and Process Impurities of Amlodipine Basylate and Benazepril HCl in Pharmaceutical Dosage Form	[35]
Acquity UPLC BEH C_{18} (50 x 2.1 mm, 1.7 µm) column	Acetonitrile and 0.1% formic acid	Mass spectrometer	Development, optimization and validation of a highly sensitive UPLC–ESI-MS/MS method for simultaneous quantification of amlodipine, benazeprile and benazeprilat in human plasma: Application to a bioequivalence study	[36]

CONCLUSION

This literature review represents an up to date survey about all reported methods that have been developed for determination of benazepril in their pure form, combined form with other drugs, combined form with degradation products, and in biological samples such as liquid chromatography and spectrophotometry.

REFERENCE:

1. Balfour JA, Goa KL. Benazepril: a review of its pharmacodynamic and pharmacokinetic properties, and therapeutic efficacy in hypertension and congestive heart failure. Drugs. 1991 Sep;42:511-39.
2. https://pubchem.ncbi.nlm.nih.gov/compound/5362124

3. Gengo FM, Brady E. The pharmacokinetics of benazepril relative to other ACE inhibitors. Clinical cardiology. 1991 Aug;14(S4):44-50.
4. Hou FF, Zhang X, Zhang GH, Xie D, Chen PY, Zhang WR, Jiang JP, Liang M, Wang GB, Liu ZR, Geng RW. Efficacy and safety of benazepril for advanced chronic renal insufficiency. New England Journal of Medicine. 2006 Jan 12;354(2):131-40.
5. Firke SD, Patil AS, Patil RR, Patil AS. Stability-indicating HPTLC method for estimation of benazepril in bulk and tablet dosage form. Analytical Chemistry Letters. 2018 Jul 4;8(4):552-64.
6. Naguib IA, Abdelaleem EA, Zaazaa HE, Draz ME. Simultaneous determination of hydrochlorothiazide and benazepril hydrochloride or amiloride hydrochloride in presence of hydrochlorothiazide impurities: Chlorothiazide and salamide by HPTLC method. Journal of chromatographic science. 2015 Jan 1;53(1):183-8.
7. Kowalczuk D, Pietraś R, Hopkała H. Development and Validation of an HPTLC–Densitometric Method for Determination of ACE Inhibitors. Chromatographia. 2004 Aug;60:245-9.
8. El-Gindy A, Ashour A, Abdel-Fattah L, Shabana MM. Application of LC and HPTLC-densitometry for the simultaneous determination of benazepril hydrochloride and hydrochlorothiazide. Journal of pharmaceutical and biomedical analysis. 2001 May 1;25(2):171-9.
9. Hassib ST, El-Sherif ZA, El-Bagary RI, Youssef NF. Reversed-phase high performance liquid chromatographic and thin layer chromatographic methods for the simultaneous determination of benazepril hydrochloride and hydrochlorothiazide in Cibadrex tablets. Analytical letters. 2000 Jan 1;33(15):3225-37.
10. Patil SB, More JD. Revolutionizing tablet analysis: concurrent spectrophotometric quantification of benazepril hydrochloride and hydrochlorothiazide.
11. Kokane PA, Bhairav BA, Saudagar RB. UV Spectrophotometric Method Development and Validation of Benazepril Hydrochloride. Asian Journal of Research in Chemistry. 2016;9(8):369-72.
12. Daharwal SJ, Singh VD. New spectroscopy methods development for simultaneous estimation of Benazepril and Hydrochlorothiazide in pharmaceutical dosage form. Columbia Journal of Pharmaceutical Sciences. 2015 Apr;2(2):01-5.
13. Parmar V, Chhalotiya U, Shah D, Bhatt K, Baldania S. Quantification of Benazepril Hydrochloride and Hydrochlorothiazide in Tablet Dosage Form by Simultaneous Equation Spectrophotometric Method. Journal of Applied Chemistry. 2013;2013(1):316137.
14. OzDEMIR DU, Dinc E. Determination of benazepril HCl and hydrochlorothiazide in pharmaceutical preparations using UV-visible spectrophotometry and genetic multivariate calibration method. Journal of Food and Drug Analysis. 2005;13(4):6.
15. Kuzucanli E, Demiralay EC Daldal YD, Ustün Z, Konçe i, Alsancak AG. Development and validation of RPLC method for the simultaneous analysis of ACE inhibitors in tablet formulations. Turkish Journal of Analytical Chemistry. 2022;4(2):103-10.
16. Kiran S, Pasha TY, Asif M, Kamal M, Jawaid T, Alossaimi MA, Ramesh B, Majumder M. Development And Validation Of A Reverse Phase-High Performance Liquid Chromatography Method For The Assay Of Benazepril Hydrochloride Using A Quality-By-Design Approach. Latin American Journal of Pharmacy. 2022 Jan 1;41(5).
17. Shanmugasundaram P, Kamarapu SK. Method development and validation for the simultaneous determination of amlodipine and benazepril by reversephase high-performance liquid chromatography in its bulk and pharmaceutical tablet dosage form using biorelevant dissolution media. Drug Invention Today. 2019 Nov 15;12(11).
18. Kavathia A, Misra M. Development and validation of RP-HPLC and UV-spectrophotometric methods for rapid simultaneous estimation of amlodipine and benazepril in pure and fixed dose combination. Arabian journal of chemistry. 2017 May 1;10:S3021-8.
19. Rao TN, Apparao K, Krishnarao N, Vijayalakshmi A. A new simultaneous HPLC analytical method for quantification of benazepril hydrochloride and its related impurities in bulk drug product. Asian Journal of Research in Pharmaceutical Science. 2017;7(3):135-40.
20. Ashour S, Sakur AA, Kudemati M. A validated stability-indicating liquid chromatographic method for the simultaneous determination of Amlodipine and benazepril in capsules dosage form. Can chem trans. 2014;2(4):418-33.
21. Eranki RJ. New stability indicating method for quantification of impurities in amlodipine and benazepril capsules by validated HPLC. American Journal of Analytical Chemistry. 2013 Dec 2;4(12):715.
22. Chen K, Zhang J, Liu S, Zhang D, Teng Y, Wei C, Wang B, Liu X, Yuan G, Zhang R, Zhao W. Simultaneous determination of lercanidipine, benazepril and benazeprilat in plasma by LC–MS/MS and its application to a toxicokinetics study. Journal of Chromatography B. 2012 Jun 15;899:1-7.
23. Pilli NR, Inamadugu JK, Mullangi R, Karra VK, Vaidya JR, Seshagiri Rao JV. Simultaneous determination of atorvastatin, amlodipine, ramipril and benazepril in human plasma by LC-MS/MS and its application to a human pharmacokinetic study. Biomedical chromatography. 2011 Apr;25(4):439-49.

24. Wang XD, Chan E, Chen X, Liao XX, Tang C, Zhou ZW, Huang M, Zhou SF. Simultaneous and rapid quantitation of benazepril and benazeprilat in human plasma by high performance liquid chromatography with ultraviolet detection. Journal of pharmaceutical and biomedical analysis. 2007 May 9;44(1):224-30.

25. Vonaparti A, Kazanis M, Panderi I. Development and validation of a liquid chromatographic/electrospray ionization mass spectrometric method for the determination of benazepril, benazeprilat and hydrochlorothiazide in human plasma. Journal of mass spectrometry. 2006 May;41(5):593-605.

26. Naidu KR, Kale UN, Shingare MS. Stability indicating RP-HPLC method for simultaneous determination of amlodipine and benazepril hydrochloride from their combination drug product. Journal of pharmaceutical and biomedical analysis. 2005 Sep 1;39(1-2):147-55.

27. Xiao W, Chen B, Yao S, Cheng Z. Simultaneous determination of benazepril hydrochloride and benazeprilat in plasma by high-performance liquid chromatography/electrospray-mass spectrometry. Journal of Chromatography B. 2005 Jan 25;814(2):303-8.

28. Stanisz B. Liquid chromatographic studies of the stability of benazepril in pure form and in tablets. Journal of liquid chromatography & related technologies. 2004 Jan 1;27(19):3103-19.

29. El-Gindy A, Ashour A, Abdel-Fattah L, Shabana MM. Application of LC and HPTLC-densitometry for the simultaneous determination of benazepril hydrochloride and hydrochlorothiazide. Journal of pharmaceutical and biomedical analysis. 2001 May 1;25(2):171-9.

30. Radhakrishna T, Rao DS, Vyas K, Reddy GO. A validated method for the determination and purity evaluation of benazepril hydrochloride in bulk and in pharmaceutical dosage forms by liquid chromatography. Journal of pharmaceutical and biomedical analysis. 2000 May 1;22(4):641-50.

31. Hassib ST, El-Sherif ZA, El-Bagary RI, Youssef NF. Reversed-phase high performance liquid chromatographic and thin layer chromatographic methods for the simultaneous determination of benazepril hydrochloride and hydrochlorothiazide in Cibadrex tablets. Analytical letters. 2000 Jan 1;33(15):3225-37.

32. Panderi IE, Parissi-Poulou M. Simultaneous determination of benazepril hydrochloride and hydrochlorothiazide by micro-bore liquid chromatography. Journal of pharmaceutical and biomedical analysis. 1999 Dec 1;21(5):1017-24.

33. BODKE SS, BHANGALE CJ, BHANDARE SN. STABILITY INDICATING UPLC METHOD FOR ESTIMATION OF BENAZEPRIL AND HYDROCHLOROTHIAZIDE IN BULK AND COMBINED DOSAGE FORM.

34. Mahrouse MA. Simultaneous ultraperformance liquid chromatography/tandem mass spectrometry determination of four antihypertensive drugs in human plasma using hydrophilic–lipophilic balanced reversed-phase sorbents sample preparation protocol. Biomedical Chromatography. 2018 Dec;32(12):e4362.

35. Kasawar GB, Farooqui MN. Stability-Indicating RP-UPLC Method for the Simultaneous Determination of Potential Degradation and Process Impurities of Amlodipine Basylate and Benazepril HCl in Pharmaceutical Dosage Form. Orbital: The Electronic Journal of Chemistry. 2014 Jul 1;6(3).

36. Rezk MR, Badr KA. Development, optimization and validation of a highly sensitive UPLC–ESI-MS/MS method for simultaneous quantification of amlodipine, benazeprile and benazeprilat in human plasma: Application to a bioequivalence study. Journal of Pharmaceutical and Biomedical Analysis. 2014 Sep 1;98:1-8.