IJBPAS, November, 2024, 13(11): 5381-5390

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

REVIEW OF ANALYTICAL TECHNIQUES FOR THE ESTIMATION OF REPAGLINIDE AND VOGLIBOSE IN PHARMACEUTICAL DOSAGE FORMS

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Received 24th July 2023; Revised 25th Sept. 2023; Accepted 22nd Dec. 2023; Available online 1st Nov. 2024

https://doi.org/10.31032/IJBPAS/2024/13.11.8359

ABSTRACT

Repaglinide is Chemically benzoic acid derivatives. It belongs to the class of antihyperglycemic medications. Repaglinide is an oral antihyperglycemic agent used for the treatment of non-insulin-dependent diabetic mellitus (NIDDM). It is a member of the meglitinide class of short-acting insulin secretagogues, which work by binding to β cells of the pancreas to stimulate insulin release. Repaglinide induces an early insulin response to meals decreasing postprandial blood glucose levels. Voglibose is an α-glucosidase inhibitor and it is chemically cyclohexane-1,2,3,4-tetrol) derivatives. It is used to lower postprandial blood glucose levels in people with diabetes mellitus. The fixed-dose combination of repaglinide and voglibose is an effective pharmacologic method for controlling both fasting (FHG) and after-meal hyperglycaemia (PPHG) with adequate tolerance and safety. The dosage ratio for the fixed-dose combination of repaglinide and voglibose is 0.5:0.2 mg. The present work highlights the analytical techniques that had been developed for the estimation of repaglinide and voglibose, either alone or in combination with other drugs. We have reviewed various analytical methods, such as HPLC-UV, Stability indicating RP-HPLC, TLC,

Spectrophotometric (UV-Vis), and other methods that have been developed for the combination of Repaglinide and Voglibose.

Keywords: Repaglinide, Voglibose, Analytical techniques, Antidiabetic, Stability indicating RP-HPLC, UV-visible Spectrophotometer, HPLC, TLC Method

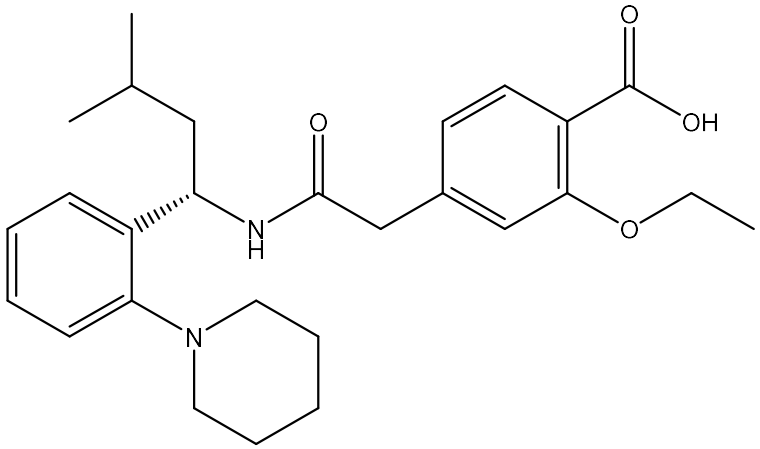
INTRODUCTION:

Repaglinide belongs to meglitinides, which is used in type 2 diabetes to help regulate blood sugar levels in addition to diet and exercise. "The repaglinide is an insulin secretagogue that binds to receptors on pancreatic β cells and stimulates insulin release" **[1]**. It also binds to an ATP-dependent potassium channel on β cells, known as SUR1, bringing about its closure, a main side effect concern is hypoglycemia **[1]**.

In 1994, Voglibose made its debut in Japan. "Anti-hypoglycaemic action of voglibose results from a reversible inhibition of membrane-bound intestinal α-glycosidase enzyme which hydrolyzes oligosaccharides and disaccharides to glucose and other monosaccharides in the brush border of the small intestine" **[1]**. Voglibose is an α-glucosidase inhibitor that helps persons with diabetes mellitus lower their postprandial blood glucose levels. **"**Voglibose delays the absorption of glucose thereby reducing the risk of macrovascular complications" **[1]**.

Physicochemical properties:

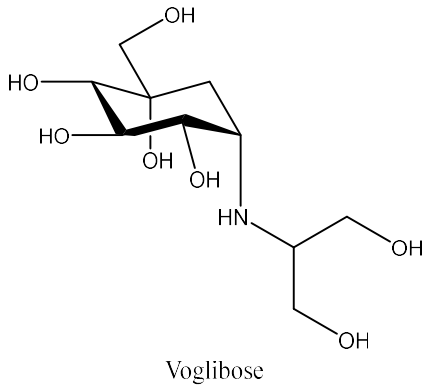
"Repaglinide belongs to a class of antihyperglycemic agents known as meglitinides" **[2]**. The repaglinide has the following molecular formula and weight: $C_{27}H_{36}N_2O_4$ and 452.6 gm/mol, respectively. It has a half-life of 1 hour and it is majorly excreted in the feces (90%) and in urine (8%). Repaglinide has Log P value is 5.9. The melting point of repaglinide is 130-131ºC. **Figure 1** displays the Repaglinide's chemical structure **[2]**.



repaglinide

Figure 1: Chemical structure of Repaglinide

"Voglibose belongs to a class of competitive α-glucosidase inhibitors" **[3]**. The voglibose has the following molecular formula and weight: $C_{10}H_{21}NO_7$ and 267.3 gm/mol, respectively. It has a half-life of 4.08 hours and it is majorly excreted in the feces (98%) and in urine (5%). Voglibose has Log P value is -2.33. The melting point of voglibose is 161-166ºC. **Figure 2** displays the Voglibose's chemical structure **[3]**.



Voglibose

Figure 2: Chemical structure of Voglibose

Table 1: Official techniques for estimation of Repaglinide

Sr. No.	Method	Description	Ref.
1	LC	Stationary phase: Silica gel AGP for chiral chromatography R (5µm) Column size: l= 0.1 m, Ø= 4.0 mm Mobile phase: A- 1.0 g/l Solution of potassium dihydrogen phosphate R (pH 4.7) with dilute sodium hydroxide solution R B- Acetonitrile R Flow Rate: 1.0 ml/min Detection: 240 nm Retention Time: (REPA)- About 3.3 min Injection volume: 10.0µl [4]	BP 2022 Volumn-2 P.P.- 806-808 [4]
2	LC	Stationary phase: Silica gel for chromatography R (5µm) Column size: l= 0.15 m, Ø= 4.6 mm Mobile phase: A- 4.0 g/l Solution of potassium dihydrogen phosphate R (pH 3.2) with dilute phosphoric acid R B- Mobile phase a: Acetonitrile R (300:700 v/v) Flow Rate: 1.5 ml/min Detection: 240 nm Retention Time: (REPA)- About 10 min Injection volume: 10.0µl [4]	BP 2022 Volumn-2 P.P.- 806-808 [4]
3	LC	Column size: 4.6 mm × 12.5 cm; 5µm Mobile phase: Methanol: Buffer (8:2 v/v) Flow Rate: 1 ml/min Detection: 240 nm Injection volume: 10.0µl [5]	USP 2020 Volumn-2 P.P.- 3854-3857 [5]
4	LC	Column: size: 4.0 mm × 6 cm; 5µm Mobile phase: Methanol: Buffer (pH 2.5) (7:3 v/v) Flow Rate: 1 ml/min Detection: 245 nm Injection volume: 20.0µl [5]	USP 2020 Volumn-2 P.P.- 3854-3857 [5]
5	LC	Column size: (12.5 cm × 4 mm; 5µm) Mobile phase: Acetonitrile: Potassium phosphate (pH 2.3): Methanol Flow Rate: 1.0 ml/min Detection: excitation- 244 nm, emission- 348 nm Injection volume: 20.0µl [6]	IP 2018 Volume-3 P.P.- 3103-3104 [6]

Table 2: Reported techniques for estimation of Repaglinide

Sr. No.	Author	Method	Description	Ref. No.
1	Mohite M *et al*. 2013 [7]	UV-Visible	Linearity Range: Method A- 10-80 µg/ml Method B- 10-70 µg/ml R^2: Method A- 0.9995 Method B- 0.9996 Zero order Derivative spectra: 293 nm First-order Derivative spectra: 245 nm [7]	[7]
2	Begum AK *et al*. 2014 [8]	HPLC	Column: ACE- C_{18} (250 x 4.0; 5 microns) Mobile phase: Potassium dihydrogen phosphate: Methanol (80:20 v/v) Flow rate: 1 ml/min Wavelength: 285 nm R^2: 0.99 Retention time: 3.016 min [8]	[8]
3	Mishra J *et al*. 2016 [9]	UV-Visible	Linearity Range: 10µg/ml to 90µg/ml R^2: 0.999 Wavelength: 237nm Solvent: Methanol [9]	[9]
4	Jain PS *et al*. 2013 [10]	HPTLC	Stationary phase: Aluminum plates precoated with silica gel 60 RP-18 F254 Mobile phase: Chloroform: Methanol: Ammonia (4.5:0.8:0.05 v/v) Linearity Range: 600–1600 ng/spot R^2: 0.998 R_f value: 0.55 ± 0.03 [10]	[10]
5	Pingale PL *et al*. 2012 [11]	RP-HPLC	Column: C_{18} column (100×4.6) mm×5µ Kromasil ODS Mobile phase: Methanol: Phosphate buffer (pH 3) (70:30 v/v) Flow rate: 1 ml/min Linearity Range: 1-5 µg/ml Wavelength: 242 nm R^2: 0.999 Retention time: 3.81 min [11]	[11]
6	Pattanaik P *et al*. 2013 [12]	RP-HPLC	Column: HSF5 C_{18} (4.6mm x 250 mm; 5 µm) Mobile phase: Methanol: Ammonium acetate buffer (pH 4) (80:20 v/v) Flow rate: 1 ml/min Linearity Range: 0.5-200 µg/ml Wavelength: 240 nm R^2: 0.9996 Retention time: 6.2 min Injection volume: 20µl Column temperature: 23 ± 0.2 ^{0}C [12]	[12]

Official technique for estimation of Voglibose
Voglibose does not have an official method in any pharmacopeia.

Table 3: Reported techniques for estimation of Voglibose

Sr. No.	Author	Method	Description	Ref. No.
1	Nagasarapu MR *et al*. 2020 [13]	HPTLC	Stationary phase: Silica gel 60 F254 TLC plates (20×10 cm & 10×10 cm, layer thickness 0.2 mm, Merck, Germany) Mobile phase: Acetonitrile: Methanol: Ammonia (15:4:0.1 v/v/v) Linearity Range: 100 to 450 ng/spot R^2: 0.9995 R_f value: 0.66 ± 0.03 [13]	[13]
2	Rao NM *et al*. 2010 [14]	UV-Visible	Linearity Range: 10-80 µg/ml R^2: 0.997 Wavelength: 282 nm Solvent: Methanol [14]	[14]
3	Daswadkar SC *et al*. 2013 [15]	RP-HPLC	Column: TC C_{18} (250 × 4.6 mm; 5µm) Mobile phase: Acetonitrile: Water (20:80 v/v) Flow rate: 1 ml/min Linearity Range: 10–70 µg/ml Wavelength: 272 nm R^2: 0.9992 Retention time: 3.17 ± 0.01 min Injection volume: 20µl Temp.: Ambient 25 ^{o}C [15]	[15]

Table 4: Reported techniques for estimation of Repaglinide & Voglibose

Sr. No.	Author	Method	Description	Ref. No.
1	Hadad GM *et al*. 2009 [16]	HPLC	Column: C_{18} (25 cm × 0.46 cm) Hypersil BDS Mobile Phase: Buffer (pH 3.5): Methanol (30:70 v/v) Flow Rate: 1.0 ml/min Linearity Range: (REPA) 7.5-22.5 µg/ml (VOG) 4.5-13.5 µg/ml Wavelength: 240 nm R^2: (VOG)- 0.9992 (REPA)- 0.9994 Retention time: Repaglinide: 3.670 min Voglibose: 5.333 min Injection volume: 20.0µl Run time: 20 min [16]	[16]
2	Konatham TK *et al*. 2020 [17]	RP-HPLC	Column: Symmetry C_{18} (150 cm × 4.6 mm; 5 µm) Mobile phase: Methanol: Dihydrogen phosphate buffer (pH 5.0) (60:40 v/v) Flow rate: 1.5 ml/min Linearity Range: (REPA) 2-18 µg/ml (VOG) 2-18 µg/ml Wavelength: 255 nm R^2: (VOG)- 0.9989 (REPA)- 0.9868 Retention time: Repaglinide: 5.8 min Voglibose: 3.1 min Injection volume: 20.0µl [17]	[17]

Table 5: Reported techniques for estimation of Repaglinide & and other drugs

Sr. No.	Author	Method	Description	Ref. No.
1	Kamal AH *et al*. 2022 [18]	HPLC/UV	Column: Termo Hypersil® ODS C_{18} column (150 mm × 4.6 mm; 5 µm) Mobile phase: Phosphate buffer (10 mm, pH 2.5): Acetonitrile (45:55 v/v) Flow rate: 1 ml/min Linearity Range: 1–100 ng/ml [18]	[18]
2	Kumar HK *et al*. 2021 [19]	UPLC	Column: DIKMA Endoversil (2.1 x 50 mm; 1.7µm) Mobile phase: Phosphate buffer (pH 4.2): Methanol (38:62 v/v) Flow rate: 0.3 ml/min Linearity Range: 1-50 µg/ml Wavelength: 241 nm R^2: (MET)- 0.997 (REPA)- 0.999 Retention time: (REPA) 1.152 min (MET) 0.516 min Injection volume: 10.0µl [19]	[19]
3	Han DG *et al*. 2019 [20]	HPLC	Column: C_{18} column (250 × 4.6 mm; 5 µm, 100 Å) Mobile phase: ACN: (pH 6.0) Phosphate buffer (53.6:46.4 v/v) Flow rate: 1 ml/min Linearity Range: 10–2000 ng/ml Wavelength: (REP) 240 nm (CEL) 380 nm Injection volume: 20 µl Run time: 23 min [20]	[20]
4	M Fouad M *et al*. 2014 [21]	HPLC	Column: C_{18} column (250 x 4.6; 5µ particle size) Mobile phase: Methanol: 0.2% Heptane sulphonate sodium (70:30 v/v) Flow rate: 1 ml/min Linearity Range: (REPA) 5- 40 µg/ml (MET) 2-12 µg/ml	[21]

			Wavelength: 240 nm R^2: (MET)- 0.9982 (REPA)- 0.9903 Retention time (min): (REPA) 14.21 (MET) 3.42 [21]	
5	**Tatiparthi R *et al*. 2010 [22]**	**RP-HPLC**	**Column: BDS Hypersil® column C_{18} (150mm × 4.6mm; 5µm) Mobile phase: Acetonitrile: Phosphate buffer (pH 4.0) (60:40 v/v) with 1% triethylamine Flow rate: 0.8 ml/min Linearity Range: (REPA) 55-550 ng/ml (MET) 420-4200 ng/ml Wavelength: 254 nm R^2: (MET)- 0.997 (REPA)- 0.9995 Retention time (min): (REPA) 7.4 (MET) 5.1 [22]**	**[22]**
6	**Joshi SS *et al*. 2012 [23]**	**RP-HPLC**	**Column: YMC-pack AM-ODS column (5 µm; 250 mm × 4.6 mm) Mobile phase: (70:30 v/v) Methanol: 10 mm Potassium dihydrogen phosphate buffer (pH adjusted to 2.5 with 10% ortho-phosphoric acid) Flow rate: 1 ml/min Linearity Range: (REPA) 1-200 µg/ml (MET) 5-200 µg/ml Wavelength: 210 nm R^2: (MET)- 0.9997 (REPA)- 0.9998 Retention times: (MET) 2.6 min (REPA) 11.3 min [23]**	**[23]**
7	**Aslan SS *et al*. 2017 [24]**	**HPLC - UV**	**Mobile phase: Acetonitrile: Phosphoric acid pH adjusted to 3 with 1 N NaOH (40:60 v/v) Flow rate: 1 ml/min Linearity Range: 5.0 - 50.0 µg/ml UV R^2: (MET)- 0.9999 (REPA)- 0.9950 HPLC R^2: (MET)- 0.9999 (REPA)- 1.0000 Retention times: (MET) 4.25 min (REPA) 6.28 min [24]**	**[24]**

Table 6: Reported techniques for estimation of Voglibose & other drugs

Sr. No.	Author	Method	Description	Ref. No.
1	**Mamatha B *et al*. 2019 [25]**	**HPLC**	**Column: Waters ODS C_{18} RP Column Mobile phase: Phosphate Buffer (pH - 6.5): Acetonitrile (65:35 v/v) Flow rate: 1.0 ml/ min Linearity Range: (VOG) 10–60 µg/ml (MET) 05–40 µg/ml Wavelength: 251 nm R^2: (MET)- 0.9998 (VOG)- 0.9991 Injection Volume: 10µl Run time: 6 min [25]**	**[25]**
2	**Neelima K *et al*. 2014 [26]**	**RP-HPLC**	**Column: Inertsil ODS 3V (150 × 4.6 mm; 5 µm) Mobile phase: 0.02 M Phosphate buffer adjusted to pH 2.5 using dilute orthophosphoric acid: Acetonitrile (50:50 v/v) Flow rate: 1 ml/min Linearity Range: (VOG) 0.08-0.24 µg/ml (MET) 200-600 µg/ml (GLI) 0.8-2.4 µg/ml Wavelength: 230 nm R^2: 0.999 Retention times: (MET) 2.423 min (VOG) 8.191 min (GLI) 11.708 min Injection volume: 20 µl [26]**	**[26]**
3	**Devi MG *et al*. 2018 [27]**	**RP-HPLC**	**Column: Hypersil BDS C_{18} column (250 × 4.6; 5 µm) Mobile phase: 0.02M KH2PO4: Acetonitrile (50:50 v/v)**	**[27]**

			Flow rate: 1 ml/min Linearity Range: (VOG) 0.3-0.18 µg/ml (MET) 50-300 µg/ml Wavelength: 236 nm R^2: (MET)- 0.997 (VOG)- 0.998 [27]	
4	**Dholakia SP *et al*. 2022 [28]**	**RP-HPLC**	**Column: Cosmosil BDS C_{18} (15 cm × 0.46 cm; 5µm) Mobile phase: Phosphate buffer (pH 4.0): Methanol (30:70 v/v) Flow rate: 1 ml/min Linearity Range: (VOG) 0.5-1.50 µg/ml (MITI) 25-75 µg/ml Wavelength: 233 nm R^2: (MITI)- 0.999 (VOG)- 0.998 Injection volume: 20µl Run time: 8 min [28]**	**[28]**
5	**Shende MA *et al*. 2019 [29]**	**RP-HPLC**	**Column: Cosmosil C_{18} (250 x 4.6 mm; 5µm) Mobile phase: 0.1% v/v Acetonitrile: Triethylamine (30:70 v/v) pH 2.5 Flow rate: 0.8 ml/min Linearity Range: (VOG) 0.08-0.24 µg/ml (MET) 200-600 µg/ml (PIO) 30-90 µg/ml Wavelength: 232 nm R^2: (MET)- 0.998, (PIO)- 0.999, (VOG)- 0.999 Injection volume: 20µl [29]**	**[29]**

CONCLUSION:

The present work highlights the analytical techniques that have been developed for the estimation of repaglinide and voglibose, either alone or in combination with other drugs. We have reviewed various analytical methods, such as HPLC-UV, Stability indicating RP-HPLC, TLC, Spectrophotometric (UV-Vis), and other methods that have been developed for the combination of Repaglinide and Voglibose. An overview of the latest progressive analytical techniques for determining repaglinide and voglibose is provided in this paper, which will be helpful for future studies on this combination. This review will help the reader to get acquainted with the various solvents & laboratory equipment, which are useful for the analysis of repaglinide and voglibose.

REFERENCES:

[1] Hadad GM, Emara S, Mahmoud WM. Development and validation of a stability-indicating RP-HPLC method for the determination of paracetamol with dantrolene or/and cetirizine and pseudoephedrine in two pharmaceutical dosage forms. Talanta. 2009 Oct 15;79(5):1360-7.

[2] https://go.drugbank.com/drugs/DB00912 Assessed on Date: - 9 Aug 2023.

[3] https://go.drugbank.com/drugs/DB04878 Assessed on Date: - 9 Aug 2023.

[4] The department of health, social services and public safety, British pharmacopoeia, 2022, volume-II, published by stationary office on behalf of medicine and healthcare

products regulatory agency. Page no.: 806-808.

[5] The U. S. Pharmacopoeia national formulary, 2020, volume-II, published by U. S. Pharmacopoeia national formulary. Page no.: 3854-3857.

[6] Government of India, Ministry of health and family welfare, Indian pharmacopoeia 2018, volume-III, published by Indian Pharmacopoeia commission, Ghaziabad. Page no.: 3103-3104.

[7] Mohite M, Maste M, Baravalisaya S, Tandel J. Analytical method development of Repaglinide in bulk and single component formulation. Int J Res. 2013;4(1):136-7.

[8] Begum AK, Pamu S, Kodali G, Kasu P. Development and validation of repaglinide by reversed phase high performance liquid chromatography (RP-HPLC) in tablet dosage forms. Indo american journal of pharmaceutical sciences. 2014 Sep 1;1(3):142-50.

[9] Mishra J, Nayak SK, Sahoo SK. Development, validation and stability study of UV spectrophotometric method for determination of Repaglinide in bulk and pharmaceutical dosage forms. Journal of Innovations in Applied Pharmaceutical Science (JIAPS). 2016 Sep 30:10-6.

[10] Jain PS, Patel MK, Surana SJ. Development and validation of stability-indicating high-performance thin-layer chromatography method for estimating repaglinide in bulk and pharmaceutical formulation. Acta Chromatographica. 2013 Sep 1;25(3):531-44.

[11] Pingale PL, Nandasana PV. Development and validation of RP-HPLC method for the estimation of Repaglinide in bulk drug and pharmaceutical formulation. Int. J. Drug Dev. Rese. 2012 Jul; 4:247-52.

[12] Pattanaik P, Panda OP, Mohanty C, Naresh P. New RP-HPLC method for the estimation of repaglinide in bulk and in pharmaceutical dosage forms. Int J Pharmaceut Sci. 2013;3(2):189-93.

[13] Nagasarapu MR, Konda R. Development and validation of high-performance thin layer chromatographic method for the determination of voglibose in bulk and their formulations. Lett Appl NanoBioSci. 2020; 9:1074-8.

[14] Rao NM, Bagyalakshmi J, Ravi TK. Development and validation of UV-Spectroscopic method for estimation of Voglibose in bulk and tablets. J

Chem Pharm Res. 2010 May;2(2):350-56.

[15] Daswadkar SC, Walode SG, Mahendra Kumar CB. Stability indicating RP-HPLC method for estimation of Voglibose in bulk and tablet dosage form. Pharmacophore. 2013 Sep 1;4(5):158-65.

[16] Hadad GM, Emara S, Mahmoud WM. Development and validation of a stability-indicating RP-HPLC method for the determination of paracetamol with dantrolene or/and cetirizine and pseudoephedrine in two pharmaceutical dosage forms. Talanta. 2009 Oct 15;79(5):1360-7.

[17] Konatham TK, Vallakeerthi N, Masipogu A. Method development and validation of repaglinide and voglibose in pure and pharmaceutical dosage form by using reverse phase high performance liquid chromatography. World Journal of Pharmaceutical Research. 2020 May 6;9(6):1553-1558.

[18] Kamal AH, Hammad MA, Kannouma RE, Mansour FR. Response surface optimization of a vortex-assisted dispersive liquid–liquid microextraction method for highly sensitive determination of repaglinide in environmental water by HPLC/UV. BMC chemistry. 2022 May 14;16(1):33.

[19] Kumar HK, Acharyya S, Patra PK. Development and Validation of Novel Ultra Performance Liquid Chromatography Technique for the Simultaneous Determination of Metformin and Repaglinide in Bulk and Formulation. Journal of Pharmaceutical Research International. 2021 Jun 24;33(33A):115-24.

[20] Han DG, Kwak J, Seo SW, Kim JM, Yoo JW, Jung Y, Lee YH, Kim MS, Jung YS, Yun H, Yoon IS. Pharmacokinetic evaluation of metabolic drug interactions between repaglinide and celecoxib by a bioanalytical HPLC method for their simultaneous determination with fluorescence detection. Pharmaceutics. 2019 Aug 2;11(8):382.

[21] M Fouad M, S Rashed N. Development and validation of chromatographic and spectroscopic methods for estimation of repaglinide and metformin HCL in combined dosage form. Journal of Global Trends in Pharmaceutical Sciences. 2014; 5(3): 1844- 1848.

[22] Tatiparthi R, Duraiswamy D, Bannoth CK. Method development and validation of metformin and

repaglinide in rabbit plasma by RP-HPLC. Fabad J Pharm Sci. 2010; 35:69-75.

[23] Joshi SS, Nahire RR, Shastri NR, Surendranath KV, Satish J. Validated stability-indicating RP-HPLC UV method for simultaneous determination of metformin and repaglinide. Acta Chromatographica. 2012 Sep 1;24(3):419-32.

[24] Aslan SS, Yılmaz B. Derivative spectrophotometric and isocratic high performance liquid chromatographic methods for simultaneous determination of repaglinide and metformin hydrochloride in pharmaceutical preparations. American Journal of Analytical Chemistry. 2017 Sep 5;8(9):541-52.

[25] Mamatha B, Narmada V, Shyamsunder R. Method Development, Validation and Forced Degradation Studies of Voglibose and Metformin in Pure and Pharmaceutical Dosage Form by RP-HPLC. International Journal of Pharmacy and Biological Sciences. 2019;9(4): 29-40.

[26] Neelima K, Prasad YR. Analytical method development and validation of metformin, voglibose, glimepiride in bulk and combined tablet dosage form by gradient RP-HPLC. Pharmaceut Meth. 2014 Jan 1; 5:27-33.

[27] Devi MG, Maanasa K, Manoja MG. Analytical method development and validation for the estimation of metformin and voglibose in bulk and fixed dose combination (tablets) by RP-HPLC. Indo american journal of pharmaceutical sciences. 2018 Feb 1;5(2):825-31.

[28] Dholakia SP, Patel RM, Patel J, Patel MM. Analytical method development and validation for simultaneous estimation of Voglibose and Mitiglinide calcium hydrate in pharmaceutical dosage form. Journal of Medical Pharmaceutical and Allied Sciences. 2022 July 24;11(4):5056-5071.

[29] Shende MA, Budde BR. Novel RP-HPLC method development and validation for simultaneous estimation of metformin, voglibose and pioglitazone in bulk and triple fixed drug combinations pharmaceutical dosage form. Journal of Drug Delivery and Therapeutics. 2019 Jan 15;9(1):30-7.