SAXAGLIPTIN: A SYSTEMATIC REVIEW ON ITS PHARMACOLOGICAL POTENTIAL AND ANALYTICAL ASPECTS

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ABSTRACT
This review highlights the potential indications of Saxagliptin and its combinations including several analytical aspects. The selective, reversible dipeptidyl peptidase-4 inhibitor Saxagliptin and its active metabolite M2 are used to improve the glycaemic control in type 2 diabetic patients. Saxagliptin prevents the inactivation of the incretin hormones namely glucagon-like peptide-1 and glucose-dependent insulinotropic polypeptide. This increases glucagon-like peptide-1 levels, stimulates insulin secretion and reduces the postprandial glucagon and glucose levels in the body. Saxagliptin therapy in patients with type 2 diabetes are prescribed as monotherapy or as add-on therapy to Metformin, Sulphonyl urea and Thiazolidine-diones, without significant change in body weight while exhibiting a low risk of hypoglycaemia. There is a significant enhancement in the HbA1C levels relative to continued use of existing monotherapy. Some potential indications of Saxagliptin include metabolic disorders, inflammatory disorders, hepatic disorders, neurological disorders and as well as cardiac disease.

Key word: saxagliptin, analytical aspects, dipeptidyl peptidase-4 inhibitor, hypoglycaemia, GLP-1

INTRODUCTION
Saxagliptin is a dipeptidyl peptidase-4 (DPP-4) inhibitor which is used as an anti-diabetic agent. DPP-4 rapidly cleaves and inactivates the incretin hormones glucagon like peptide-1 (GLP-1). Saxagliptin is a glucose dependent insulinotropic polypeptide inhibition of DPP-4 increases intact plasma GLP-1 and GIP concentrations, augmenting glucose-dependent insulin secretion (Boulton et al., 2016).

DPP-4 is an important enzyme responsible for degradation of incretins, such as glucagon-like peptide-1 (GLP-1), which is a hormone responsible for the glucose-dependent stimulation of insulin in the human body (Drucker et al., 2006). DPP-4 inhibitors serve as an effective glucose regulators primarily by enhancing the endogenous concentration of GLP-1. Sitagliptin was the first DPP-4 inhibitors approved by the FDA in 2006 (Ahren et al., 2007). DPP-4 inhibitors have been clinically proven to decreasing blood glucose levels, increase glucose tolerance, and improve insulin response in patients with type 2 diabetes mellitus (Savage et al., 2009, Langley et al., 2007).

GLP-1 and GIP regulate blood glucose homeostasis by stimulation of glucose-dependent insulin secretion. This compound specifically designed for extended inhibition of the DPP-4 enzyme and which is treatment of type-2 diabetes (Augeri et al., 2005). Saxagliptin is a biopharmaceutics Classification System (BCS) class III compound (high solubility/low permeability) but exhibits class-I-like characteristics. Some Clinical study have shown that saxagliptin is rapidly and almost completely absorbed on oral administration (Neumiller et al., 2010). Saxagliptin is metabolized by cytochrome P450 enzymes 3A4 and 3A5 (CYP3A4 and CYP3A5) to the pharmacologically active major metabolite BMS-510849 (Tella et al., 2015). Mostly this compound is used in combination with diet and exercise in the treatment of type 2 diabetes, either alone or with combination of oral hypoglycemic agents. Some study has been shown Saxagliptin is a new medications for liver injury (Savage et al., 2009).

CHEMISTRY
Molecular formula of Saxagliptin is C₁₈H₂₅N₃O₂. The IUPAC name is 1S,3S,5S)-2-[(2S)-2-amino-2-(3-hydroxy-1-adamantyl) acetyl]-2-azabicyclo [3.1.0]hexane-3- carbonitrile and Average Molar mass is 315.41 g/mol (Cole et al., 2008). Saxagliptin is mostly used for anti-diabetic, it is selective and competitive, cyanopyrrolidine-based, orally administration and is metabolized into a less potent, active mono-hydroxy metabolite (5-hydroxy saxagliptin) Saxagliptin is available as a 2.5mg and 5mg tablet and orally administered once a day (Anderson et al., 2016).

PHARMACOKINETICS PROPERTIES OF SAXAGLIPTIN
Saxagliptin has been safe and well tolerated in clinical pharmacology studies at doses up to 80 times the highest usual dose, but it does effects on cardiac repolarization. Multiple doses of saxagliptin is safe at dose 400mg/14 days and well tolerated by healthy subjects (Boulton et al., 2007). There was no found any effect at dose of 40-400 mg on the corrected QT (QTc) interval in healthy subjects, neither any relationship found between plasma concentrations or QTc interval (Boulton et al., 2007). Furthermore, in a dedicated steady state thorough QTc study with healthy subjects, saxagliptin is not associated with clinically significant prolongation of the QTc interval or changes in the heart rate at daily doses up to 40 mg, neither found plasma concentrations of saxagliptin or 5-hydroxy saxagliptin correlated with the QTc interval (Boulton et al., 2017, Patel et al.,2009). Saxagliptin is rapidly and well absorbed after oral administration with bioavailability found 67% It is extensively distributed in extravascular tissue with higher concentrations found in the intestinal tissues and kidney. It is principally hydrolyzed by CYP3A4/5 to major metabolite M2 and other minor metabolites and hence some dosage should be reduced in patients taking concurrent strong CYP3A4 inhibitors (Drucker et al., 2007). (Table 1)

Saxagliptin is excreted by renal and hepatic pathways. 75% of saxagliptin is excreted via urine and 22% in the feces (Holland et al., 2010). Renal clearance of saxagliptin (mean =230 ml/min) higher than the estimated glomerular filtration rate (mean =120 ml/min), which show some active renal excretion of the drug (Ranjan et al., 2018). Protein binding of Saxagliptin (in vitro) and its active metabolite is negligible (<10%) in human serum. The metabolism of Saxagliptin is primarily mediated by cytochrome P450 3A4 (CYP3A4/5).Half of the dose i.e. 50% absorbed dose in hepatic metabolism. The major metabolite of Saxagliptin, 5-hydroxy Saxagliptin, is also a DPP4 inhibitor, which is one-half as potent as Saxagliptin. Saxagliptin mean plasma terminal half-life is 2.5 hours and
its metabolite 5-hydroxy Saxagliptin is 3.1 hours (Defronzo et al., 2009). Saxagliptin excreted through renal and hepatic pathways. Following a single 50 mg dose of 14C- Saxagliptin, 24%, 36%, and 75% of the dose excreted through urine (Hollander et al., 2010, Ranjan et al., 2018). And see the table 1 for pharmacokinetics parameters of saxagliptin and 5-hydroxy saxagliptin (Batta et al., 2015).

<table>
<thead>
<tr>
<th>Drug</th>
<th>$C_{max}$ (ng/mL)</th>
<th>$t_{max}$ (h)</th>
<th>$AUC_{0-2h}$ (ng h/mL)</th>
<th>$t_{1/2}$ (h)</th>
<th>$Kel$ (h–1)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saxagliptin</td>
<td>29.7±6.42</td>
<td>1.56±0.78</td>
<td>129±21.4</td>
<td>3.86±1.06</td>
<td>0.19±0.04</td>
<td>Kagal et al., 2017</td>
</tr>
<tr>
<td>5-hydroxy Saxagliptin</td>
<td>41.2±16.2</td>
<td>2.21±0.57</td>
<td>246±57.5</td>
<td>2.88±0.15</td>
<td>0.24±0.01</td>
<td>Kagal et al., 2017</td>
</tr>
<tr>
<td>Saxagliptin</td>
<td></td>
<td></td>
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</table>

**PHARMACODYNAMIC PROPERTIES OF SAXAGLIPTIN**

Saxagliptin is a class of dipeptidyl peptidase-4 inhibitor for the treatment of type 2 diabetes. DPP-4 inhibitors are a class of compounds that work by altering the action of hormones in the body called incretins. Incretins decreases the blood sugar by increasing consumption of sugar by the body, mainly through enhancing insulin production in the pancreas, and by lowering the production of sugar by the liver. Dipeptidyl peptidase-4 is a membrane-associated peptidase which in many tissues, lymphocytes and plasma (Ranjan et al., 2018). DPP-4 has two primary modes of action, an enzymatic function and secondary mode where DPP-4 binds adenosine deaminase, which carries intracellular signals via dimerization are activated. Saxagliptin forms a covalent bond within its nitrile group and the S630 hydroxyl oxygen on DPP-4 which is reversible, this bond is known as histidine-assisted covalent bond (Patel et al., 2009). The Inhibition of DPP-4 increases levels of glucagon-like peptide 1 (figure 1), which hinders glucagon production from pancreatic alpha cells and increases the production of insulin from pancreatic beta cells (Ranjan et al., 2018).

**DPP-4 Inhibitors Mechanism of Action**

**PHARMACOLOGICAL ACTIVITY**

**Effect of saxagliptin on asthma (inflammatory disorder)**

Saxagliptin have immunomodulatory and anti-inflammatory actions. SAXA shows anti asthmatic effect in OVA-induced allergic asthma through modulation of TLR4 and NF-kB signaling. Also, SAXA may represent a promising therapeutic agent for acute allergic asthma. Anti-inflammatory properties of cytokines and ameliorative impact on oxidative load, positive impact on host antioxidant defenses show nephro-protective impact (Helal et al., 2019). Kagal et al., studied experimental animal model (Male Wistar rats ) SAXA orally administered with combination of vildagliptin on inflammation were tested in acute ( carrageenan-induced paw edema method) and subacute (grass pith and cotton pellet implantation method) models of inflammation which showed a significant anti-inflammatory activity in acute and subacute models of inflammation. And the modulatory effect of SAXA on inflammatory (Kegal et al., 2017).

**Effect of Saxagliptin on neurological disorders**

Saxagliptin is important for modifying neurodegenerative diseases in preclinical studies has proved that saxagliptin has protective role on anti-Parkinson (Teleau et al.,2019). SAXA enhanced motor functions as well as muscle coordination and corrected akinesia . , SAXA control substantia nigra pars compacta tyrosine hydroxylase (TH) immunoreactivity while halting the striatal TH, dopamine (DA) and complex I. SAXA lowering the ROT-induced increment of striatal DPP-4 and the decline in cAMP, ATP/ADP and brain-derived neurotropic factor levels. SAXA increases the striatal energy level was connected with partial hindrance of ROT-induced body weight reduction. SAXA decreased the ROT-induced nuclear factor-xB, inducible nitric oxide synthase, tumor necrosis factor-α, intracellular adhesion molecule-1 and myeloperoxidase. The antiapoptotic marker B-cell lymphoma-2 increases by SAXA, versus reduces in caspase-3 and its intrinsic apoptotic activator cytochrome C. SAXA ameliorated alterations induced by ROT in the transcriptional factor Nrf-2 level and the thio barbituric acid reactive substances. This compound maintained in motor functions so it may show antiparkinsonian efficacy via antioxidant, anti-inflammatory, antiapoptotic, neuroprotective and neurorestorative mechanisms. These effects were linked to DPP-4 inhibition, prevents the neurodegeneration and enhanced DA synthesis (Nassar et al., 2015).

**Effect of saxagliptin on cardiac disorders**

Saxagliptin has been shown preventable effects on cardiac function and support the outcome of SAVOR-TIMI53 trial that connected saxagliptin with the risk of heart failure (Leibowitz et al., 2015). Saxagliptin inhibits the of the Ca2+calmodulin-dependent protein kinase II-phospholamban-sarcoplastic reticulum Ca2+-ATPase 2a axis and Na+-Ca2+ exchanger function in Ca2+ extrusion. Which is lowering the protein reticulum Ca2+ content, diastolic Ca2+ overload, systolic dysfunction and abnormal contractile force. And saxagliptin decreases the protein kinase C-mediated delayed rectifier K+ current that prolonged effects of potential duration and consequently QTc interval. SAXA treated the ischemia/reperfusion injury (Koyani et al., 2017).

**Fig.1: Some important Inhibiting pathway of Saxagliptin.**
GRPT7, PERK, IRE1α, ATF-4 and -6, CHOP, Caspase-3, -8, -9 and -12 in IR reduced with ST (saxagliptin treatment).

SAXA reduces the baseline in liver fat (P = 0.007) and >10% reduction in adipose tissue volumes (P < 0.01), decreases the body weight and serum alanine aminotransferase and aspartate aminotransferase levels (Coskun et al., 2020). And see the figure 2 for some important inhibiting pathways of this compound (Saxagliptin), which helps to give the protective role of these disorders.

**ANALYTICAL ASPECTS OF SAXAGLIPTIN**

**HPLC**

HPLC method with UV detection has been developed for the determination of saxagliptin and metformin in bulk. In this Agilent, Zorbax CN (250 × 4.6 mm I.D., 5 μm) column was used with a mobile phase which is a mixture of methanol-50 mM phosphate buffer (pH 2.7) in a gradient elution mode at rate of flow is 1.0 ml min⁻¹. The analytes were recognized at 225 nm and total run time for the method was 7 min. The graphs were linear in the range of 5.00 to 25.00 μg ml⁻¹ for saxagliptin and 2.50 to 62.50 μg ml⁻¹ for metformin. For stability study, Saxagliptin was subjected to hydrolysis (in acid, neutral and alkali), oxidation and heat stress. For quality control assay for SAXA in tablets the developed method could be used and for stability studies as the method separates SAXA from its degradation products and tablet excipients and see in detail table 2 (Caglar et al., 2014).

**UPLC MS/MS**

The rapid ultraperformance liquid chromatography/tandem mass spectrometry (UPLC-MS/MS) method was developed for quantification of saxagliptin in rat plasma. The Plasma samples were processed by liquid–liquid extraction with ethyl acetate and chromatographed on a C₁₈ column (2.1 × 50 mm id., 1.7 μm). In this mobile phase contain methanol and 0.1% formic acid (40:60, v/v). For detection multiple reaction monitoring transitions were performed in positive- ion mode with an electrospray ionization source. In this calibration curve was linear for concentration range 0.5–100 ng/mL (R² > 0.99). All accuracy standards were between 90.62 and 105.60% relative error and the intra and inter-day precisions were less than 9.66% relative standard deviation. Extraction recover was more than 81.01% and the matrix effect ranged from 90.27 to 109.15%. After validation of method, 0.5 mg/kg saxagliptin were orally given healthy rats for pharmacokinetic study and see table 2 for more informations (Gao et al., 2012).

**RP-HPLC**

The reverse phase high performance liquid chromatographic method (RP-HPLC) was established for the simultaneous analysis of Metformin and Saxagliptin in active pharmaceutical ingredients (APIs) as well as in marketed tablet (combination) dosage forms. The method was achieved on Enable C₁₈ G (250 × 4.6 mm; 5 μm particle size) column using 0.05 M KH₂PO₄ buffer (pH 4.5): Methanol: Acetonitrile (60:20:20 %v/v) use as mobile phase which has flow rate of 0.6 mL/min and by employing UV detection at 220 nm wavelength. The retention time of Saxagliptin and Metformin were found to be 6.92 min and 4.38 min, respectively. The method was validated according to ICH guidelines. LOQ and LOD of Metformin were found to be 0.373 μg/mL and 0.112 μg/mL, respectively, while those of Saxagliptin were found to be 0.029 μg/mL and 0.096 μg/mL, respectively. This method was realized to be rapid, sensitive, linear, specific, accurate, precise and economic for the quality control and stability analyses of Metformin and Saxagliptin in marketed tablet dosage forms and see table 2 for significance of RP-HPLC (Prasad et al., 2015).

**HP-TLC**

For the quantitative analysis of Saxagliptin in active pharmaceutical ingredients (APIs) and pharmaceutical dosage forms the high-performance thin layer chromatographic method (HPTLC) was established. The method was achieved by using stationary phase that is silica gel aluminum plate 60 F₂₅₄ (10 × 10 cm) and Methanol: Chloroform (6:4 v/v) as mobile phase (table 2). The developed plate was scanned densitometrically using UV 222 nm wavelength. The Rₚ value of Saxagliptin was found 0.50 ± 0.02. The developed method was validated according to ICH standard. LOQ and LOD of Saxagliptin by this method were found as 26.54 ng/spot and 7.96 ng/spot, respectively. The method was proved to be sensitive, specific, linear, accurate, precise and robust for the quantitative analysis of Saxagliptin in active pharmaceutical ingredients (APIs) and pharmaceutical dosage forms (Srividya et al., 2015).

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**Table 2 Analytical methods and its significance to detect Saxagliptin.**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Analytical Methods</th>
<th>Mobile Phase</th>
<th>Stationary Phase</th>
<th>Wavelength</th>
<th>Significance</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HPLC</td>
<td>methanol-50 mM phosphate buffer (pH 2.7)</td>
<td>Zorbax CN (250×4.6mm I.D., 5 μm) column</td>
<td>detected at 225 nm and total run time for the method was 7 min</td>
<td>HPLC method with UV detection has been developed for the determination of saxagliptin and metformin in bulk.</td>
<td>(Caglar et al., 2014)</td>
</tr>
<tr>
<td>2</td>
<td>HPLC</td>
<td>Acetonitrile-10M orthophosphoric acid</td>
<td>RP C₁₈ column</td>
<td>Detection at 378nm/excitation at 463nm</td>
<td>This method was developed for the determination of saxagliptin in human plasma as well as for the pharmacokinetic study.</td>
<td>(Tekkeli et al., 2013)</td>
</tr>
<tr>
<td>3</td>
<td>UPLC-MS/MS</td>
<td>Methanol and electrospray ionization source.</td>
<td>a₁₁₁ column (2.150mmid., 1.7nm).</td>
<td>0.5–100ng/mL</td>
<td>This method was established for quantification of saxagliptin in rat plasma.</td>
<td>(Gao et al., 2012)</td>
</tr>
<tr>
<td>4</td>
<td>RP-HPLC</td>
<td>Methanol: Acetonitrile (60:20:20 %v/v)</td>
<td>Enable C₁₈ G (250 × 4.6 mm; 5 μm particle size) column using 0.05 M KH₂PO₄ buffer (pH 4.5)</td>
<td>UV detection at 220 nm wavelength</td>
<td>This method was developed for the simultaneous analysis of Metformin and Saxagliptin in active pharmaceutical ingredients (APIs) as well as in marketed tablet (combination) dosage forms.</td>
<td>(Prasad et al., 2016)</td>
</tr>
<tr>
<td>5</td>
<td>HP-TLC</td>
<td>Methanol: Chloroform (6:4 v/v)</td>
<td>Silica gel aluminum plate 60 F₂₅₄ (10 × 10 cm)</td>
<td>UV detection at 222 nm wavelength</td>
<td>This was developed for the quantitative analysis of Saxagliptin in active pharmaceutical ingredients (APIs) and pharmaceutical dosage forms.</td>
<td>(Srividya et al., 2015)</td>
</tr>
</tbody>
</table>
ADVERSE EFFECTS OF SAXAGLIPTIN
This drug adverse reactions reported in ≥5% of patients those who treated with saxagliptin and less than in patients treated with placebo are: urinary tract infection upper respiratory tract infection, and headache (Rosenstock et al., 2008). And some other side effects are:

Incidence of hypoglycemia
Monotherapy with saxagliptin for 24 weeks has not shown to be connected with hypoglycaemia or weight gain (Rosenstock et al., 2009). Some data from four-year extensions of two randomized, placebo-controlled, double-blind trials on the efficacy of saxagliptin alone or combination with metformin reported infrequent hypoglycaemic episodes in all groups (0.14%) (Rosenstock et al., 2011). In a randomized controlled trial (RCT), incidence of hypoglycaemia with saxagliptin + metformin combination was connected with low frequency of hypoglycaemic events (3.0%).

Incidence of hypoglycaemia was significantly increasing with patients treated with saxagliptin with glipizide (36.3%) over 52 weeks of treatment (Goke et al., 2010). Some similar results were observed in the extension study when saxagliptin versus glipizide used as add-on therapy to regimen of patients with T2DM who were already on metformin (3.5 vs 38.4%). Confirmed hypoglycaemia was reported to be 0 versus 9.1% in saxagliptin versus glipizide group, severally (Goke et al., 2011). In a merge data from post hoc analysis of three Phase III trials, frequency of hypoglycaemia with saxagliptin 2.5, 5 mg/d or placebo with metformin, glyburide, or a thiazolidinedione, in patients with poorly controlled T2DM, was 5.3 and 11.4 versus 6.8%, severally (Goke et al., 2010). The occurrence of hypoglycaemia at 24 weeks of treatment was 18.4% when saxagliptin 5 mg was added to the regimen of patients who are on insulin or insulin with metformin versus 19.9% with placebo (5.3 vs 3.3%, respectively) (Barnett et al., 2012). Saxagliptin, compared to placebo, has not shown increase the risk of hypoglycaemia when added to the regimen of patients with inadequate glycaemic control on stable regimen (> 8 weeks) with insulin plus metformin or insulin alone. Incidence of hypoglycaemia was 22.7 versus 26.5% with saxagliptin versus placebo, respectively, frequency of confirmed hypoglycaemia with finger stick glucose < 50 and associated symptoms was 7.6 versus 6.6% with saxagliptin versus placebo, respectively, at 52 weeks of treatment (Barnett et al., 2011).

Pancreatitism
In GLP-1 based treatment for T2DM there has been reported cases of pancreatitis and even concern of pancreatic cancerous cells with the long-term use. Pancreatitism is an adverse effect reported with the use of DPP-4 inhibitors, especially sitagliptin (Deacon et al., 2013).

Saxagliptin is the same class of drug might carry similar risk. Meta-analysis of RCT on safety of DPP-4 inhibitors reported risk of pancreatitis with DPP-4 inhibitors therapy to be the same as with placebo (Monami et al., 2011).

Furthermore, some study observed based on active drug safety surveillance system reported rate of pancreatitis to be 0.02% out of 16 276 sitagliptin patients at a one-year follow-up (Dore et al., 2009). There is no causal relationship between sitagliptin and pancreatitis was reported in a merge analysis of data from clinical trials of sitagliptin (Engel et al., 2010, Ali et al., 2013).

Saxagliptin and immune inhibition
DPP-4 enzyme has been implicated to have direct effect in T lymphocyte regulation. However, it remains a question if an off-target effect of the DPP 4 inhibitors is responsible for suppression of T-lymphocyte and for adverse effects such as infection, skin reaction and slightly prevents in lymphocyte count related to saxagliptin use. On the flip side, the capability of DPP 4 inhibitors to inhibit enzymes in the DPP family might be of value to treat different immune diseases such as arthritis, inflammatory bowel disease, etc (Yazbeck et al., 2009). The immune system has shown special interest due to the presence of the DPP-4 catalytic site being on the CD26 molecule that can connected with surface antigen CD45 present on lymphocytes; however, there is no any proof that this to date has been shown to affect the immune system for saxagliptin or for any other DPP 4 inhibitor for that matter (Ali et al., 2013).

Other Adverse Effects
Adverse effects has been shown with saxagliptin monotherapy compared to placebo comprised upper respiratory infection (8.8 vs 11.6%), headache (8.2 vs 7.4%), urinary tract infection (6.9 vs 4.2%), and sinusitis (5.6 vs 3.2%) in a RCT (Boulton et al., 2017). Assessment of adverse effects related to combination therapy with saxagliptin added metformin in a randomized controlled trial reported headache, diarrhoea, naso-pharyngitis and hypertension up to 9.9, 9.6, 6.9 and 5.3% (Jadzinsky et al., 2009).

CONCLUSION
Saxagliptin is an antidiabetic drug which helps to improve glycaemic control by blocking the inactivation of the incretin hormones glucagon-like peptide-1 (GLP-1) and glucose-dependent insulinotropic polypeptide. This enhances the GLP-1 levels, stimulates insulin secretion and decreases postprandial glucagon and glucose levels. Saxagliptin used in type 2 diabetes but recently some researcher reported its potential indication in inflammatory disorders, hepatic disorders, neurological disorders and as well as cardiac disease. In this review we summarized saxagliptin analytical properties with main significance. SAXA has similar efficacy compared with most oral anti diabatic drugs, while may be more effective than Acarbose. SAXA is safe in type 2 diabetes patients, and it have a better safety profile than Acarbose, sulphonyl urea and metformin.

Conflict of interest
The author(s) declare(s) that they have no conflict of interest to disclose.

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Abbreviations
GLP-1: Glucagon-like peptide-1
GIP: Gastric inhibitory polypeptide
SAXA: Saxagliptin
RPCT: Randomized placebo control trial
DPP 4: Dipeptidyl peptidease-4
T2DM: Type 2 diabetes mellitus
LOQ: Limit of quantification
LOD: Limit of detection
QTc: Cardio contraction time
cAMP: Cyclic adino monophosphate
ATP: Adinosine triphosphate
ADP: adinosine tri phosphate
NF-kB: Nuclear factor kappa B cell

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