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REDUCTIVE AMINATION OF GLYCOYL ALDOSES: SYNTHESIS OF *N*-GLYCOSYLATED β-GLYCOSYL AMINO ALCOHOLS AND THEIR ANTIDIABETIC POTENTIAL[#]

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ABSTRACT

Reductive amination of glycosyl aldehydes (**1a-1c**, **2**) with glycosyl amino esters (**3a-3c**, **4**) in presence of sodium borohydride gave diglycosylated amino esters (**5-15**) in good yields. *N*-Glycosyl-glycosylated amino esters were reduced to the respective diglycosyl amino alcohols (**16-26**) with $LiAlH_4$ in good yierlds. All the synthesized compounds were studied for their inhibitory effect, if any, against hepatic glucose-6-phosphatase, glycogen phosphorylase and intestinal brush border membrane α-glucosidase, among these compounds **7, 21** and **25** have shown marked inhibition on these enzymes, respectively.

INTRODUCTION

Classical carbohydrate chemistry centered around *O*-glycosides for many years.[1] While this field is still being looked into as fertile area for the development of many therapeutics an increase in the development of a biological or non-natural glycosides that contain C-C bond or C-N bond is gaining momentum at the molecular level for the roles of carbohydrates in glycolipids and glycoproteins.[2] Identification of lead compounds from sugars for drug discovery against various diseases for the well being of the society is being pursued by different groups including ours.[3]

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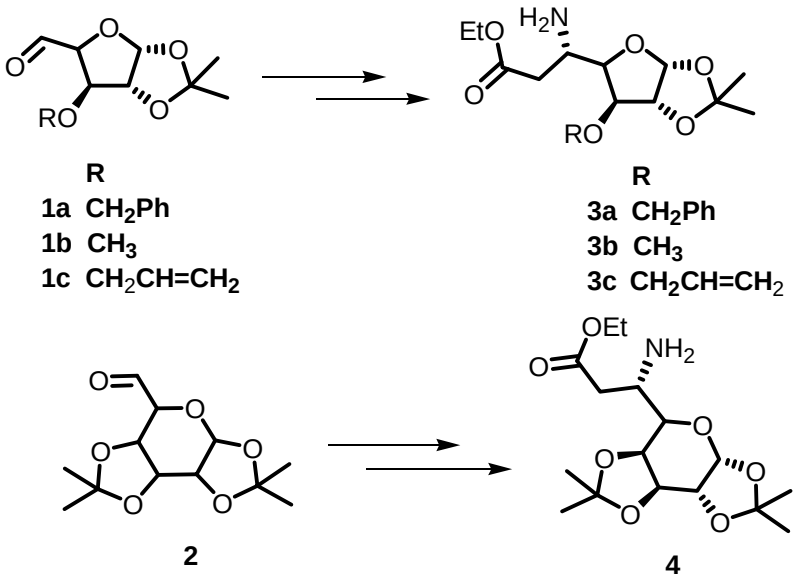
Aza disaccharides with nitrogen in the sugar ring are known to inhibit various glycosyl hydrolases and glycosidases involved in many disease processes and are therefore, important for drug development. [4] Polyhydroxylated pyrrolidines and piperidines are a class of potent inhibitors of glycosidase, though simple azasugars that mimic a monosaccharide act as broad-spectrum inhibitors. Many natural products and synthetic analogs containing aglycon moiety attached to a glycosyl cation mimetics act as selectivese inhibitors [5] of enzyme. Disaccharide analogs linked through spacer having nitrogen have recently been found to bind with 16S RNA indicating their usefulness as amino glycoside antibiotics[6]. Dideoxyimino alditols linked to other sugars by non-hydrolysable links have potential of much specificity towards glycosidases and these have been synthesised using different techniques[7]. In another approach synthesis of nitrogen and sulphur linked pseudodisaccharides as more stable glycosidase inhibitors have been reported recently [8]. In an our ongoing programme to develop glycoconjugates for different biological activities we have carried out reductive amination of aldehydes with aminosugar to synthesise glycosyl urea and certain C-nucleoside analogs and evaluated their α-glucosidase inhibitory activity [9].

Keeping in mind the above we were prompted to synthesise certain aza linked pseudo disachharide analogs having both pyranose and furanose sugar rings and evaluate their efficacy against few enzymes responsible for diabetes.

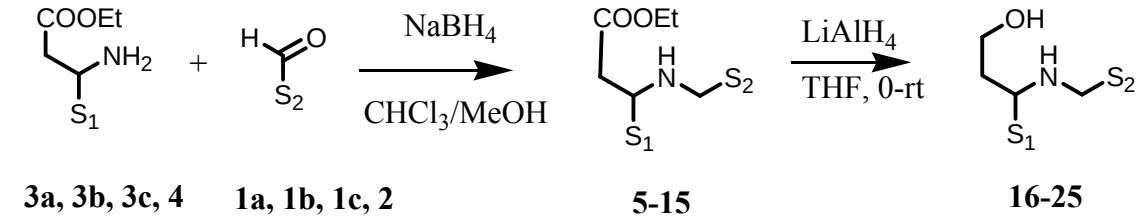
Results and Discussion

To start with reaction of glycosyl aldehyde **(1a)** with glycosyl amino ester **(3a)** [10] resulted in the formation of an intermediate (imine) which on subsequent in situ reduction

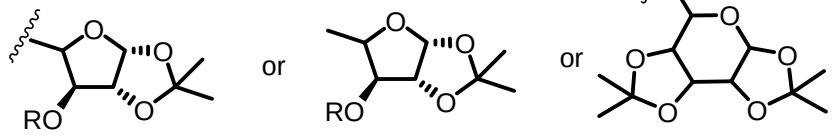
with sodium borohydride formed the disachharide analog **5**. The structure of compound **5** was determined on the basis of spectroscopic data and analysis. IR spectrum of the compound showed absorption band at 3341 cm^{-1} corresponding to NH-



Scheme 1.



S_1 and S_2=



Scheme 2

Table 1. Compounds synthesized

S No.	Compound	R^1	R^2	R^3	S No.	Compound	R^1	R^2	R^3
1	**5**	CH_2Ph	CH_2Ph	COOEt	12	**16**	CH_2Ph	CH_2Ph	CH_2OH
2	**6**	CH_2Ph	CH_3	COOEt	13	**17**	CH_2Ph	CH_3	CH_2OH
3	**7**	CH_2Ph	CH_2CHCH_2	COOEt	14	**18**	CH_2Ph	CH_2CHCH_2	CH_2OH
4	**8**	CH_2Ph	--	COOEt	15	**19**	CH_2Ph	--	CH_2OH
5	**9**	CH_3	--	COOEt	16	**20**	CH_3	--	CH_2OH
6	**10**	CH_2CHCH_2	CH_2Ph	COOEt	17	**21**	CH_2CHCH_2	CH_2Ph	CH_2OH
7	**11**	CH_2CHCH_2	CH_3	COOEt	18	**22**	CH_2CHCH_2	CH_3	CH_2OH
8	**12**	--	CH_2Ph	COOEt	19	**23**	--	CH_2Ph	CH_2OH
9	**13**	--	CH_3	COOEt	20	**24**	--	CH_3	CH_2OH
10	**14**	--	CH_2CHCH_2	COOEt	21	**25**	--	CH_2CHCH_2	CH_2OH
11	**15**	--	--	CH_2OH	22	**26**	--	--	CH_2OH

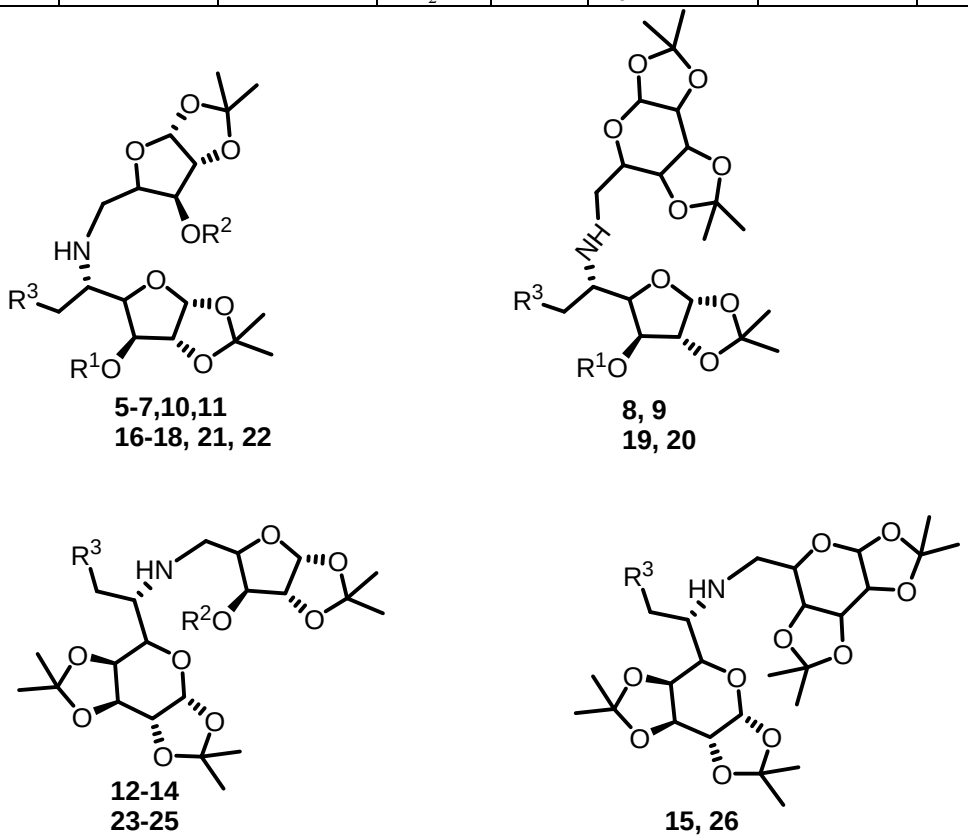


Figure 2. *N*-Glycosyl-glycosylamino ester **5-15** and alcohol **16-26** synthesized.

stretching. In MS (FAB) spectrum, peak at m/z 628, corresponded to $[M+H]^+$, while in ^{1}H NMR spectrum of the above compound **5** the anomeric protons of the two furanoses were observed as *d* at δ 5.92 and 5.90 with J = 3.9 and 3.6 Hz respectively. The protons for CH_2 and CH_3 in carbethoxy group appeared at δ 4.0 and 1.1 as a quartet and triplet with J values of 4.2 and 6.2 Hz respectively. In ^{13} C NMR spectrum the compound **5** showed charecteristic signals for $NHCH_2$, OCH_2, and CH_3 at δ 45.2, 60.7 and 14.5 respectively. Since the stereochemistry has already been assigned to be *S* in the glycosyl amino ester used in this reaction, this is maintained in the final compound as well since C-5 is directly not involved in the reaction.

We have extended this work using pyranosyl aldehydes and glycopyranosyl amino esters in order to synthesis compounds having pyranose ring also. Thus the reaction of glycosyl amino esters **3a** with glycosyl aldehydes **2** gives N-glycopyranosylated glycosyl amino ester (**8**) in good yield. IR spectrum of the compound **8** showed absorption band at 1457 cm^{-1} corresponding to NH-bending frequency. In MS (FAB) spectrum, peak at m/z 608, corresponded to $[M+H]^+$. In ^{1}H NMR spectrum the two doublets for anomeric protons of the furanose and pyranose sugars were observed at δ 5.90 and 5.60 with J = 3.6 and 5.1 Hz respectively. The signals for protons of CH_2 and CH_3 in carbethoxy group appeared at δ 3.95 and 1.24 as a quartet (J = 4.2 Hz) and triplet (J = 6.2 Hz) respectively. In ^{13} C NMR spectrum, compound **8** showed charecteristic $NHCH_2$, OCH_2, and CH_3 carbon peaks at δ 47.1, 60.7 and 14.5 respectively. Similarily reaction of glycopyranosyl amino esters **4** [11] with glycosyl aldehydes **2** resulted in N-glycopyranosyl glycopyranosylated amino ester (**15**) in good yield. The structure of this compound was established on the basis of its spectroscopic data and analysis. IR spectrum of the compound showed absorption band at 3445 cm^{-1} corresponding to NH (stretching). MS (FAB) spectrum of the compound showed a peak at *m/z* 588, corresponding to $[M+H]^+$. In ^{1}H NMR spectrum the anomeric protons of the two sugar rings were observed as *d* at δ 5.60 with J = 5.0 Hz besides other usual signals. In ^{13}C NMR spectrum of the compound quartnery carbon of ester group appeared at δ 172.7 while those of isopropylidene were observed at δ 109.5, 109.3 108.8 and 108.7. The anomeric carbon peaks appeared at δ 96.9 and 96.7 respectively besides other usual signals.

The structures of all the products were similarly established on the basis of spectral data and analysis. In all the compounds anomeric protons corresponding to furanose and pyranose sugars appeared as *d* at around δ 5.9 and 5.6 as *d*, with $J \approx 3.0$ and 5.0 Hz respectively. H-2 for the furanose sugar appeared as *d* at around δ 4.6 in furanose sugar while in pyranose it appeared as *m* merged with H-5 at around δ 4.3 in the disachharide analogs. The characteristic –NH- linkage between two sugars have been characterised both by IR (3341, N-H stretching) and PMR (bs at δ 1.59).

Lithium aluminiumhydride ($LiAlH_4$) reduction of glycosyl amino esters **5-15** was carried out at 0 ^{0}C to ambient temperature resulting in the formation of respective *N*-glycosyl glycosylated amino alcohols **16-26** in very good yields. The formation of alcohols from the respective aminoesters was evidenced by their spectroscopic data and analysis. FAB MS of all the amino alcohols showed peaks corresponding to $[M+H]^+$ and in IR spectrum appaearance of a broad signal around 3400 cm^{-1} and disappearance of signal around 1725 cm^{-1} indicated the reduction of ester functionality into alcohol. In ^{1}H NMR spectrum of the diglycosyl amino alcohols disappearance of the *q* and *t* at around δ 4.0 and 1.25 corresponding to OCH_2 and OCH_2CH_3 respectively; and appearance of a *m* at δ 3.7 for the CH_2OH confirms the reduction of esters to the respective alcohols. Further in ^{13}C NMR spectrum appearance of a peak at around δ 60 corresponding to CH_2OH carbon and disappearnce of signals for OCH_2CH_3 and carbonyl carbon, clearly confirms the formation of alcohols.

As evident from Table 2 out of all the compounds screened against glucose-6-phosphatase, glycogen phosphorylase and α-glucosidase only compounds **6**,**10**, **13**, **21**, **24** and **25** exhibited activity againast all or two of the enzymes while other compounds did not show any significant activity. Compound **7** inhibited only α-glucosidase to the extent

of 82 % while compounds **21** and **25** possesing allyl group as substituent in either of the sugar ring were found to be good inhibitor of glycogen phosphorylase. In the present study, there were five synthetic molecules having more than 50 % inhibition on glucose-6-phosphatase. These molecules have the potential to be developed as antidiabetic agent as these compounds will possibly reduce the hepatic glucose production. These agents may suppress glucose production in liver as evidenced by reduction in the activities of glucose-6-phosphatase.

Table 2. Biological activity of disaccharide analogs against different enzymes

S. No.	Compound	% Inhibition		
		Glucose-6-phosphatse	Glycogen Phosphorylase	α-Glucosidase
1	**5**	nd	Nd	+1.98
2	**6**	22.5	45.9	10.1
3	**7**	31.6	NIL	**82.3**
4	**8**	nd	Nd	nd
5	**9**	nd	Nd	nd
6	**10**	33.8	29.7	29.8
7	**11**	nd	Nd	nd
8	**12**	nd	Nd	2.83
9	**13**	30.9	16.2	16.0
10	**14**	30.2	Nd	3.65
11	**15**	nd	Nd	3.68
12	**16**	nd	Nd	+3.68
13	**17**	nd	Nd	nd
14	**18**	30.9	40.5	+26.4
15	**19**	35.2	18.9	56.2
16	**20**	nd	Nd	nd
17	**21**	25.3	**72.9**	+7.58
18	**22**	39.4	5.40	+1.96
19	**23**	nd	Nd	+1.98
20	**24**	nd	Nd	nd
21	**25**	27.4	**94.6**	nd
22	**26**	nd	Nd	6.51

All the compounds were tested at the concentration of 100 µg/mL, nd=not done

EXPERIMENTAL

General methods. Thin-layer chromatography was carried out on silica gel (Kiesel 60-F254, Merck) and spots were developed in iodine vapours and also by spraying with 5% sulfuric acid in alcohol followed by heating at 100 ºC. Column chromatography was carried out on flash silica gel (230-400 mesh, Merck) using the indicated eluent. IR spectra were recorded as thin films on KBr plates with a Perkin Elmer 881 spectrophotometer. NMR spectra were recorded on Bruker spectrometers 200 and 300 MHz and reference used was $CDCl_3$. Chemical shifts were given as δ ppm values and '*J*' values were given in Hertz (Hz). Elemental analyses were performed on a Perkin-Elmer 2400 II elemental analyzer. The optical rotations were measured in a 1.0 dm tube with Jasco dip-140 polarimeter in chloroform. The excess of the reagents or solvents were evaporated under reduced pressure at a bath temperature between the ranges 55-60 ºC.

General procedure for the preparation of the compounds (5-15):

Ethyl(1*R*, 2*R*, 3*S*, 4*R*, 5*S*)- 3-*O*-benzyl-5-[N-(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-benzyl- α-D-xylofuranos-4'-yl)]amino-(1,2-*O*-isopropylidene-1,4-tetrahydrofuranos-4-yl)heptanoate (5). To the magnetically stirred slurry of 4A^{o} M.S.(6.0g) in dry chloform 3-*O*-benzyl-1,2-*O*- isopropylidene-α-D-xylofuranos-5-ulose, **1a** (1.0 g, 3.59 mmol) in chloroform (5.0 mL) and (1R, 2R,3S,4R,5S/R)-ethyl-5-amino-3-*O*-benzyl-5,6-dideoxy-1,2-*O*-iopropylidene-tetrahydrofuranos-4-yl-heptanoate, **2a** (1.31, 3.59 mmole) in chloroform (7.0 mL) were added at 0 ^{0}C, stirring continued for 30 minute at same temperature followed by 6 h at room temperature, till the disappearance of aldehyde (tlc). Reaction mixture was concentrated under reduced pressure and residue was dissolved in methanol (15.0 mL) and sodium borohydride (0.136 g, 3.70 mmole) was added at 0 ^{0}C and stirring continued for 3 h at r.t.. Excess of sodiumboro hydride was quenched by adding saturated ammonium chloride solution and the reaction mixture was filtered. The solid cake was washed with methanol and the combined filtrate was concentrated, extrated with ethyl acetate (2 x 50 mL) washed with water (2 x 12.5 mL). The organic layer was dried (Na_2SO_4) and concentrated under reduced pressure to give a crude mass (2.20) which was chromatographed over SiO_2 column using hexane / ethyl acetate (4:1) as eluent to give **5** as colourless oil. Yield 97.4%; $[\alpha]_D^{20}$ -52.5º (*c* 0.80,

chloroform); MS (FAB): m/z 628$(M+H)^+$;IR(Neat): ν_{max} (cm^{-1}) 1730.4, 3341.6; ^1H NMR (200MHz, $CDCl_3$): δ 7.31 (m, 5H,Ar-H); 5.90 (two d, *J* = 3.9, 3.6Hz, 2H, H-1, H-1'), 4.69-4.42(m, 4H, CH_APh, H-2, H-2', OCH_BPh), 4.26 (d, *J*=2.7,1H, H-4), 4.16 (d, *J*=2.7, 1H, H-4'), 4.04 (q, *J* = 4.2 Hz, 2H, O*CH*$_2$$CH_3$), 3.90 (m, 2H, H-3, H-3'), 3.50 (m, 1H, H-5), 3.04 (m, 2H, CH_2NH), 2.36 (m, 2H, H-6), 1.59 (bs,exchangeable H, NH), 1.47, 1.25 (each s, each 6H, $(CH_3)_2C$), 1.19 (t, (*J* = 6.6Hz 3H, CH_3); ^{13}C NMR (50Mz, $CDCl_3$): δ 172.0 (C=O), 138, 128 (Ar-C), 111.9 $(CH_3)_2C$, 105 (C-1), 82.7 (C-2), 82.3 (C-4), 80.6 (C-3), 72.2 (Ar-CH_2), 60.7(O<u>CH$_2$</u>CH_3), 54.8 (C-5), 45.8 (CH_2 NH), 36.7 (C-6), 27.1, 26.7 ($C(CH_3)_2$) , 14.5 (CH_3) . Anal. Calcd for $C_{34}H_{45}O_{10}N$; C, 65.07, H 7.17, N, 2.20. Found: C, 65.10, H, 7.10, N 2.17.

Ethyl (1*R*, 2*R*, 3*S*, 4*R*, 5*S*)- 3-*O*-benzyl-5-[N-(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-methyl- α-D-xylofuranos-4'-yl)]-amino-(1,2-*O*-isopropylidene-1, 4-tetrahydrofuranos 4-yl)heptanoate (6). Reaction of amino ester **3a** (1.39 g, 4.95 mmol) with aldehyde**, 1b** (1.0 g, 4.95 mmol)in presence of $NaBH_4$ (0.139 g, 3.6mmol) as described above gives the compound (**6**) as colourless oil. Yield – 90.0%; $[\alpha]_D$: -87^0 (c 0.10, chloroform); MS (FAB), 551$(M+H)^+$; IR (Neat): ν_{max} cm^{-1} 1731.3, 3345.7), ^1H NMR (200 MHz, $CDCl_3$): δ 7.32-7.26 (m, 5H, Ar-H), 5.93 (d, *J* = 3.6, 1H, H-1'), 5.86 (d, *J* = 3.8, 1H, H-1), 4.66-4.48 (d, *J* = 11.8 ,CH_APh), 4.62 (d, *J* = 4.0,1H, H-2'), 4.53 (d, *J* = 3.8,1H, H-2), 4.43 (d, 1H *J* = 11.8, CH_BPh), 4.42-4.10 (m, 2H, H-4, H-4'), 4.08 (q, J = 7.2Hz, 2H, O*CH*$_2$$CH_3$), 3.91 (m, 2H, H-5), 2.36 (m,2H,H-6), 2.95 (d, J = 6.4, 2H, CH_2NH), 2.36 (m, 2H, H-6), 1.62 (bs exchangeable H, -NH), 1.48, 1.30 (each s,each 3H, $(CH_3)_2C$), 1.25-1.19 (m, 8H, $(CH_3)_2C$, C-6), 0.86 (t, J = 7.2 Hz, 3H, OCH_2CH_3); ^{13}C NMR (50Mz, $CDCl_3$): δ 172.0 (C=O), 137.4, 128.9, 128.2, (Ar-C), 112.0 $(CH_3)_2C$, 105.2 (C-1), 84.4 (C-2), 82.5 (C-4), 80.4 (C-3), 71.8 (Ar-CH_2), 60.7(O*CH*$_2$$CH_3$), 58.0(-$OCH_3$, 54.4(C-5), 45.4($CH_2$ NH), 36.5(CH_2CO), 27.1,26.6 $C(CH_3)_2$, 14.5(CH_3) . Anal. Calcd for $C_{28}H_{41}O_{10}N$; C, 60.90, H, 7.44, N, 2.50. Found: C, 60.92, H, 7.40, N, 2.54. .

Ethyl (1*R*, 2*R*, 3S, 4*R*, 5*S*)- 3-*O*-benzyl-5-[N-(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-allyl- α-D-xylofuranos-4'-yl)]-amino-(1,2-*O*-isopropylidene-1, 4-tetrahydrofuranos-4-yl)-heptanoate (7).

Reaction of aldehyde**, 1c** (1.0 g, 4.38 mmol) with amino ester, **3b** (1.60 g, 4.38 mmol) in presence of $NaBH_4$ (0.168 g, 4.38mmol) as described above gives the above compound (7) as colourless oil. Yield – 75%; $[\alpha]_D$ -52°(0.10, chloroform); MS(FAB): 578$(M+H)^+$; IR(Neat): ν_{max} cm^{-1} 1457, 1732; ^{1}H NMR (200MHz, $CDCl_3$): δ 7.32,7.27(m, 5H, Ar-H), 5.90-5.87(m, 3H, H-1, H-1', $CH_2CH{=}CH_2$); 5.20 (t, 2H, allyl=CH_2) ; 4.71-4.41(M, 3H, OCH_2Ph, H-2), 4.20-4.06 (m, 6H, C-4,C-4', OCH_2CH_3), 3.90 (d, *J* = 3.2, 1H, H-3'), 3.83(d, *J* = 3.2, 1H, H-3), 3.30(m, 1H, H-5), 2.90(m, 2H, H-5'), 2.36(m, 2H, H-6),1.75(bs,exchangeable H, NH), 1.47, 1.19(m,15H , $(CH_3)_2C$), CH_3), ^{13}C NMR (200MHz, $CDCl_3$): δ172.1(C=O), 138.0, 128.8(Ar-C), 133.95 (=CH-allyl), 118.4(=CH_2.allyl), 111.90$(CH_3)_2C$, 105.2(C-1), 83.2,82.2 (C-2, C-4), 80.6(C-3), 72.7(OCH_2Ph), 71.3(allyl OCH_2), 60.8($O\underline{CH_2}CH_3$), 54.7(C-5), 45.9($\underline{CH_2}NH$), 36.7(C-6), 27.1, 26.7 $C(CH_3)_2$, 14.5(CH_3). Anal. Calcd for $C_{30}H_{43}O_{10}N$; C, 62.40, H, 7.40, N, 2.40. Found: C, 62.45, H, 7.42, N, 2.38. .

Ethyl(1*R*, 2*R*,3*S*,4*R*,5*R*/*S*)-3-*O*-benzyl-5-[N-(6'-deoxy-1',2',3',4'-di-*O*-isopropylidene-α-D-galactopyranos-5'-yl)]-amino-(1,2-*O*-isopropylidene-1,4-tetrahydrofuranos-4-yl)-heptanoate (8). Reaction of amino ester **3a** (2.80 g, 7.75 mmol) with aldehyde**, 2** (2.09 g, 7.75 mmol) in presence of $NaBH_4$ (0.25 g, 6.61mmol) as described above gives the above compound (**8**) as colourless oil. Yield – 85%; $[\alpha]_D$ –64.0(c 0.10, chloroform); MS(FAB) 608$(M+H)^+$; IR(Neat): ν_{max} cm^{-1} 1732.8, 1457 ; ^{1}HNMR (200MHz,$CDCl_3$): δ 7.34-7.28 (m, 5H, Ar-H), 5.96 (d, *J* = 3.6, 1H, H-1), 5.53 (d, *J* = 5.1, 1H, H-1'), 4.71-4.56 (m, 3H, OCH_APh, H-2, H-3'), 4.49(d, *J* = 11.7, 1H, CH_BPh), 4.30-4.20 (m, 2H, H-2', H-4'), 3.95 (q, 2H, OCH_2), 3.80-3.70(m, 2H, H-3, H-5'), 3.50 (m,1H, H-5), 2.90(m, 2H, H-6'), 2.30 (m, 2H, H-6),1.69(bs, exchangeable H, NH), 1.55, 1.501.44(each s, each 3H,$(CH)_3C$), 1.32 (s, 9H, $(CH_3)_2C$, 1.24 (t, 3H, CH_3); ^{13}C NMR (50MHz, $CDCl_3$): δ 172.2(C=O), 137.6,128.8, 128.1(Ar-C), 111.9,109.4,108.8 $(CH_3)_2C$, 105.3 (C-1), 96.7(C-1'), 82.4(C-4), 82.2 (C-3), 72.0, 71.9, 71.2, 70.0 (C-2', C-4', C-3', OCH_2Ph), 67.4(C-5'), 60.7($O\underline{CH_2}CH_3$), 54.0(C-5), 47.1(CH_2NH), 36.5(C-6), 27.1, 26.4, 24.8

$C(CH_3)_2$, 14.5(CH_3). Anal. Calcd for $C_{31}H_{45}O_{11}N$; C, 61.28, H, 7.41, N, 2.31. Found: C, 61.20, H, 7.46, N, 2.26. .

Ethyl (1*R*, 2*R*, 3*S*, 4*R*, 5*R*/*S*)- 3-*O*-methyl-5-[N-(6'-deoxy-1',2', 3',4'-di-*O*-isopropylidene - α-D-galactopyranos-5'-yl)]amino-(1,2-*O*-isopropylidene-1, 4-tetrahydrofuranos-4-yl]heptanoate (9).

Reaction of aldehyde**, 2** (1.09 g, 3.87 mmol) with amino ester 3b (1.13 g, 3.87 mmol) in presence of $NaBH_4$ (0.15 g, 3.96mmol) as described above gives the above compound (9) as colourless oil. Yield – 75.4%, $[\alpha]_D$ –81.3^o (c 0.15, chloroform); MS (FAB) 532 $(M+H)^+$; ν_{max} (cm^{-1}) 1785, 3346.6; ^{1}HNMR (200MHz, $CDCl_3$): δ 5.90 (d, *J* = 4.0 Hz, 1H, H-1); 5.53(d, *J* = 3.6Hz, 1H, H-1'), 4.60-4.56 (m, 2H, H-3', H-2), 4.31(d, *J*=2.0 Hz, 1H, H-2'), 4.21(m, 3H, H-4', OCH_2CH_3), 3.90 (m, 1H, H-4), 3.86-3.60(m,3H,H-7, H-5'), 3.60(d, *J*=2.0Hz,1H, H-3),3.41 (s, 3H, OCH_3), 3.10(m,1H, H-5), 2.98(m,2H, H-6'), , 1.90(m, 2H, H-6), 1.70(bs, exchangeable H, -NH), 1.53, 1.48, 1.43(each s, each 3H, $(CH)_3C$), 1.23 (s, 9H, $(CH_3)_2C$), 1.26 (t, *J* = 7.2Hz, 3H, O*CH*$_2$$CH_3$); ^{13}C NMR (50MHz, $CDCl_3$): δ 111.8,109.6,108.9 $(CH_3)_2C$, 104.8 (C-1), 96.7(C-1), 84.3(C-2'), 82.2-81.5(C-4, C-3'), 72.2(C-3), 71.2, 70.9 (C-2, C-5'), 67.9(C-5'), 62.6 (O*CH*$_2$$CH_3$), 57.8(-$OCH_3$),; 47.8($CH_2NH$), 30.2(C-6), 27.1, 26.4, 24.8 $C(CH_3)_2$, 14.5 (OCH_2*CH*$_3$).

Anal. Calcd for $C_{25}H_{41}O_{11}N$; C,56.49, H, 7.72, N, 2.63. Found: C, 56.40, H, 7.70 , N, 2.60. .

Ethyl-(1*R*, 2*R*, 3*S*, 4*R*, 5S)-3-*O*-Allyl-5-[N-(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-benzyl-α-D-xylofuranos-4'-yl)]-amino-(1,2-*O*-isopropylidene1,4-tetrahydropyranos-4-yl)-heptanoate (10). Reaction of aldehyde**, 1a** (1.0 g, 3.59 mmol) with amino ester **3c** (1.13 g, 3.59 mmol) in presence of $NaBH_4$ (0.137 g, 3.70 mmol) as described above gave the above compound as colourless oil. Yield – 93.8%; $[\alpha]_D$, -58^o(c, 0.10, chloroform); MS(FAB), 578$(M+H)^+$; νmax (cm^{-1}) 1730.8, 3629.9; ^{1}H NMR (200MHz,$CDCl_3$): δ 7.33-7.26 (m, 5H,Ar-H), 5.92-5.81 (m, 3H, H-1,H-1', CH_2=*CH*CH_2), 5.23 (dd, *J*=19.0 Hz, 1.4Hz, 2H, CH_2CH=*CH*$_2$), 4.75-4.52 (m, 4H, CH_APh, CH_BPh, H-2, H-2'), 3.92-3.89 (m, 4H, OCH_2CH_3, H-4, H-4'), 3.90 (m, 1H, H-3'), 3.83-3.76 (m,4H, H-3, H-3', *OCH2* –CH=CH_2), 3.20(m, H-5), 3.06(m,2H, CH_2NH), 2.80 (bs, exchangeable H, -OH), 1.90-1.60(m, 2H, H-7_A, H-7_B), 1.70(bs, exchangeable H, -NH), 1.57,1.31(each s,6H, $(CH)_2C$),

1.22-1.19 (t, 3H,H-6), ^{13}C NMR(50MHz, $CDCl_3$): δ 137.9,(=CH-allyl), 133.9, 128.8, 127.9 (Ar-C), 118.5(=CH_2-allyl), 111.9 $(CH_3)_2C$, 105.2 (C-1), 82.5, 82.3, 81.9 (C-2, C-4,C-3), 80.3 (C-3'), 72.0 (OCH_2Ph), 62.3(C-7), 60.8(OCH_2CH_3), 57.4(C-5), 44.4(CH_2NH), 30.1(C-6), 27.1, 26.6, 24.9 $C(\underline{C}H_3)_2$, 14.5 (CH3). Anal. Calcd for $C_{30}H_{43}O_{10}N$ C, 62.39; H, 7.45; N, 2.23; Found: C,62.30; H, 7.40; N, 2.20. .

Ethyl(1R, 2R, 3S, 4R, 5S)-3-*O*-Allyl-5-[N-(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-methyl- α-D-xylofuranos-4'-yl)]amino-(1,2-O-isopropylidene-1,4-tetrahydrofuranos-4-yl)-heptanoate (11). Reaction of aldehyde**, 1b** (1.0 g, 4.95 mmol) with amino ester **3c** (1.56 g, 4.95mmol) in presence of $NaBH_4$ (0.37 g, 5.01mmol) as described above gives the above compound (9) as colourless oil. Yield – 82.2%; $[\alpha]_D$ -52^0 (c, 0.10, chloroform); MS(FAB): m/z 502 $(M+H)^+$, IR (neat) ν_{max}: 1780, 3788 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$): δ 5.92 (two d, *J* = 3.8Hz , 2H, H-1, H-1'), 5.87 (m, 1H, $OCH_2\underline{CH}=CH_2$) , 5.23(t, *J* =8.2 Hz 2H, $OCH_2CH=CH_2$), 4.54(two d, each 1H, *J* = 5Hz, C-2, C-2'), 4.16 (m, 2H, C-4, C-4'), 4.14 (q, 2H, $O\underline{CH_2}CH_3$), 3.78 (d, *J*=3.2 Hz, 1H, H-3), 3.68 (d, 1H, *J* = 3.2 Hz, H-3'), 3.39 (s, 3H, -OCH_3), 3.20 (m, 1H, H-5'), 3.04 (d, 1H, *J* = 6.4 Hz, 2H, H-5'), 2.70 (bs, exchangeable H, NH), 1.65 (m, 2H, H-6), 1.49, 1.30 (each, s, 6H , $(CH_3)_2C$), 1.12 ($OCH_2C\underline{H_3}$), ^{13}C NMR (50MHz, $CDCl_3$): δ 133.95 (CH_2=CH CH_2), 118.4($CH_2CH=\underline{CH_2}$), 111.9$(CH_3)_2C$, 105.1 (C-1), 84.5 (C-2); 82.3, 81.7(C-4, C-3'), 80.1 (C-3), 71.1 ($OCH_2CH=CH_2$), 57.9 (OCH_3), 57.0 (C-5), 44.1 ($\underline{CH_2}$NH), 36.5 (OCH_2) 30.1 (C-6), 27.1, 26.3 $C(CH_3)_2$, 14.5 ($OCH_2\underline{CH_3}$).
Anal. Calcd for $C_{23}H_{37}NO_{10}$: C, 56.66; H, 7.65; N, 2.87; Found: C, 56.66; H, 7.65; N, 2.87.

Ethyl (1R, 2R, 3S, 4*S*, 5*R*, 6*R/S*)-6-[N-(5'-deoxy-1',2'-*O*-isopropylidene –3'-*O*-benzyl-α-D-xylofuranose-4'-yl)]amino –(1,2,3, 4-di--*O*-isopropylidene-1, 5-pentahydro- pyranos-5-yl)octanoate (12). Reaction of aldehyde**, 1a** (2.0 g, 7.19 mmol) with amino ester **4** (2.50 g, 7.19 mmol) in presence of $NaBH_4$ (0.270 g, 7.10mmol) as described above gives the above compound (12) as colourless oil. Yield – 80%, $[\alpha]_D$ -40^o(c, 0.01, chloroform); MS(FAB) 607$(M+H)^+$; ν_{max}(cm^{-1}) 1725, 2935, 2928; ^{1}H NMR (200MHz,$CDCl_3$): δ 7.35-7.27(m, 5H, Ar-H),5.93(d, *J*=3.9Hz,1H, H-1'),

5.52(d,*J*=5.1Hz,1H, H-1), 4.63-4.54(m ,4H,H-2 ,CH_APh, CH_BPh,H-3,H-2') , 4.37-4.30 (m,3H,H-2,H-4,H-4'), 4.08(q,2H, O*CH*$_2$$CH_3$), 3.96(d, *J*=3.0 Hz,1H,H-3'), 3.90(d, *J*=7.2 Hz, 1H,H-5), 3.40(m, 1H, H-6), 3.0(m,2H,H-5'), 2.60-2.40(m,2H,H-7_A,H-7_B), 1.63(b.s. NH) 1.50-1.22 (m,15H,$(CH)_3C,CH_3$); ^{13}C NMR (50MHz, $CDCl_3$): δ172.5(C=O), 138.1, 128.9, 129.0,127.9 (Ar-C), 111.9,109.6,108.6 $(CH_3)_2C$, 105.3 (C-1); 96.9(C-1'), 82.7,82.5(C-2',C-4'), 80.4 (C-3'); 72.3 (OCH_2Ph), 71.7,68.8(C-2,C-4,C-3) 68.8(C-5), 60.7 (O*CH*$_2$$CH_3$), 56.1(C-6), 45.5($CH_2NH$), 35.9(C-7), 27.1,24.7 $C(CH_3)_2$.

Anal. Calcd for $C_{31}H_{45}NO_{11}$: C, 61.27; H, 7.46; N, 2.30; . Found: C, 61.22; H, 7.40; N, 2.38.

Ethyl(1*R*, 2*R*, 3*S*, 4S, 5R,6S)- 6-[N-(5'-deoxy-1',2'-*O*-isopropylidene –3'-O-methyl-α-D-xylofuranos-4'-yl)]-amino-(1,2,3,4-di-*O*-isopropylidene-1, 5- pentahydro-pyranos-5-yl)-octanoate (13). Reaction of aldehyde**, 1b**(1.50 g, 7.42 mmol) with amino ester **4** (2.70 g, 7.42 mmol) in presence of $NaBH_4$ (0.250 g, 6.61mmol) as described above gives the above compound (**13**) as colourless oil. Yield – 59.2%, $[\alpha]_D$ –23.7^o(c 0.12, chloroform); MS(FAB) 532 $(M+H)^+$; νmax (cm^{-1}) 1726.3, 3361.8; ^{1}HNMR (200MHz,$CDCl_3$): δ 5.87(d, *J*=3.8,1H, H-1'), 5.50(d, *J*=5.0,1H, H-1), 4.61-4.49(m, 3H, H-2, H-2', H-3), 4.28-4.25(m, 2H, H-4, H-4'), 4.13(q, 2H, O$\underline{CH_2}$$CH_3$ 3.74 (m, 2H, H-3', H-5), 3.40(s, 2H OCH_3), 3.60(m,1H, H-6), 2.94(m,2H, H-5'), 2.40-2.20(m, 2H, H-7), 1.63(bs, 1H, -NH), 1.48-1.21(m,15H,$(CH)_3C,CH_3$); ^{13}C NMR (50MHz, $CDCl_3$): δ 173.0(C=O), 111.9,109.3,108.8 $(CH_3)_2C$, 105.2 (C-1'), 96.9(C-1), 84.2(C-2'), 82.0(C-4), 80.0, 79.9(C-3, C-3'), 71.2, 70.8 (C-2, C-4), 68.7(C-5), 60.4(O$\underline{CH_2}$$CH_3$), 58.1(-$OCH_3$), 54.4(C-6); 44.1($CH_2NH$), 34.7(C-7); 27.1, 26.4, 24.9 $C(CH_3)_2$, 14.6(CH_3).

Anal. Calcd for $C_{25}H_{41}NO_{11}$:C, 56.48; H, 7.77; N, 2.63;. Found: C, 56.43; H, 7.70; N, 2.68;.

Ethyl (*1R*, 2*R*, 3*S*, 4*S*, 5*R*, 6*S*)-6-[N-(5'-deoxy-1' 2' –*O*-isopropylidene-3'-*O*-allyl-α-D-xylofuranos-4'-yl)]-amino-(1,5-pentapyranos-5-yl)-octanoate (14).

Reaction of aldehyde, 1c (0.73 g, 3.30 mmol) with amino ester 4 (1.10 g, 3.30 mmol) in presence of $NaBH_4$ (0..140 g, 5.2mmol) as described above gives the above compound (14) as colourless oil. Yield – 88%; $[\alpha]_D$, –82^o(c 0.10, chloroform); MS(FAB), 558$(M+H)^+$; ν_{max} (cm^{-1}) 1731.5, 3679.5; ^{1}H NMR (200MHz,$CDCl_3$): δ 5.91 (d,

J=3.6Hz, 1H, H-1'); 5.55(d, *J*=5.2Hz, 1H, H-1), 5.25 (dd, *J*=19.0, 1.4Hz, 2H, $OCH_2CH=CH_2$), 4.59-4.53 (m, 2H, H-3, H-2'), 4.33 (d, *J*=2.0 Hz, 1H, H-2), 4.17-4.10(q, 2H, OCH_2CH_3), 4.0 (m, 2H, H-4, H-4'), 3.90(m, 1H, H-3'), 3.86 (m,3H, H-8, H-4), 3.11-3.05 (m, 3H, CH_2NH, H-6), 2.91(m,1H, H-5), 2.40(bs, exchangeable H, -OH), 1.90-1.60 (m, 2H, H-7_A, H-7_B), 1.70 (bs, exchangeable H, -NH), 1.49-1.44 (each s, 9H, $(CH)_3C$), 1.31 (s, 9H, $(CH_3)_2C$, 1.25 (t, 3H, OCH_2CH_3; ^{13}C NMR (50MHz, $CDCl_3$): δ 134.4 ($CH_2=CHCH_2O$-), 118.2 (-$OCH_2CH=CH_2$), 111.8,109.6,108.8 $(CH_3)_2C$, 105.2 (C-1'), 96.9(C-1), 82.7, 82.1, 79.9 (C-2',C-4',C-3'), 71.4, 71.1, 70.9 (C-8, C-3, C-2,C-5) , 68.8(C-3), 60.7 (OCH_2CH_3), 57.7 (C-6), 43.6 (CH_2NH), 28.4(C-7), 27.1, 26.7, 24.9 $C(CH_3)_2$, 14.5 (CH_3). Anal. Calcd for $C_{27}H_{43}NO_{11}$: C, 58.15; H, 7.77; N, 2.51;. Found: C, 58.20; H, 7.82; N, 2.46.

Ethyl (1*R*, 2*R*, 3*S*, 4*S*, 5*R*, 6S)-6-[N-(6'-deoxy-1',2', 3',4'-di-*O*-isopropylidene- α-D-galactopyranos-5'-yl)]amino-(1,5-pentahydropyanos-5-yl)-heptanoate (15). Reaction of aldehyde**, 2** (2.0 g, 7.75 mmol) with amino ester **4** (2.70 g, 7.75 mmol) in presence of $NaBH_4$ (0.29 g, 7.86mmol) as described above gives the above compound (6) as colourless oil. Yield: 90%; $[\alpha]_D$ –54°(c 0.10, chloroform); MS(FAB) 588$(M+H)^+$; IR(Neat), $\nu_{max}(cm^{-1})$ 1726, 2928, 3445; ^1H NMR (200MHz, $CDCl_3$): δ 5.56 (two d, *J* = 5.0, 2H, H-1, H-1'), 4.56 (d,d, *J* = 6.0, 2.0Hz, 2H, H-3, H-3'), 4.37-4.26 (m, 4H, H-2, H-2', H-5, H-5'), 4.13 (q, 2H, OCH_2), 3.8 (d, *J*=6.6 Mz, 2H, H-4, H-4'), 3.32 (m, 1H, H-6), 2.86-2.33 (m, 4H, H-6, H-7), 1.85 (bs, exchangeable 1H, NH), 1.53-1.21 [m, 15H, $(CH_3)_2C$, CH_3], ^{13}C NMR (50 MHz, $CDCl_3$): 172.7 (C=O), 109.56 [$(CH_3)_2C$], 96.67 (C-1), 78.0. 77.4, 76.7 (C-2, C-4, C-3), 68.6 (C-5'), 62.6 (C-7), 55.4 (C-6), 46.5 ($C\underline{H}_2NH$), 36.0 ($OC\underline{H}_2CH_3$), 26.4-24.7 [$(CH_3)_2C$]; 14.5 (CH_3).

Anal. Calcd for $C_{28}H_{45}NO_{12}$C, 57.23; H, 7.72; N, 2.38;. Found: C, 57.20; H, 7.76; N, 2.40.

General procedure for the preparation of the compounds (16-26):

(1*R*, 2*R*, 3*S*, 4*R*, 5*S*)- 3-*O*-benzyl-5-[N-(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-benzyl- α-D-xylofuranos-4'-yl)]amino-(1,2-*O*-isopropylidene-1, 4-tetrahydrofuranos-4-yl]heptanol (16). To magnetically stirred slurry of LAH in dry THF, ethyl(1*R*, 2*R*, 3*S*, 4*R*, 5*S*)- 3-*O*-benzyl-5-[N-(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-benzyl- α-D-xylofuranos-4'-yl)]amino-(1,2-*O*-isopropylidene-1, 4-tetrahydrofuranos-4-yl)

heptanoate(5) (1.5 g,2.39 mmol) was added dropwise at 0 ^{o}C, stirring continued for 30 minute at r.t. followed by 5 h at room temperature . Excess LAH was quenched by adding saturated sodium sulphate solution, slightly alkalined with sodium hydroxide and the reaction mixture was filtered. The solid cake was washed with THF and the filtrate concentrated. The later was extrated with chloroform (2x25 ml) and water(12.5ml). The organic layer was dried (Na_2SO_4) and concentrated under reduced pressure to give a crude mass which was chromatographed over SiO_2 column using chloroform/methanol (98/2) as eluent to give **16** as colourless oil. Yield – 80%; R_f 0.5 (methanol / chloroform, 1:24); $[\alpha]_D^{20}$, -61.8º (*c* 0.22, chloroform); MS(FAB) 585$(m+H)^+$; IR(Neat) ν_{max} (cm^{-1}): 3332.0, 3678.3; ^{1}H NMR (200MHz, $CDCl_3$): δ 7.31 (m, 5H,Ar-H); 5.90 (two d, *J* = 3.9, 3.6 Hz, 2H, H-1, H-1'), 4.71-4.51(m, 4H, CH_APh, H-2, H-2',OCH_BPh), 4.17(m, 2H, H-4, H-4'), 3.90 (d, *J* = 3.2, 1H, H-3), 3.82 (d, *J* = 3.2, 1H, H-3'), 3.72 (m, 2H,H-7), 3.30 (m, 1H, H-5), 3.0 (m, 2H, H-5'), 1.91(bs,,exchangeable H, NH), 1.47 (s, 6H, $(CH_3)_2C$), 1.32-1.25 (8H, $CH_3)_2C$, H-6); ^{13}C NMR (50Mz, $CDCl_3$): δ 137.9, 128.9, 128.1 (Ar-C), 111.9 $(CH_3)_2C$, 105 (C-1), 82.9, 82.6, 82.2 (C-2, C-4, C-3), 72.3 (Ar-CH_2), 62.5(C-5), 57.2(C-7), 44.2 (CH_2 NH), 30.0(C-6), 27.1, 26.7($C(CH_3)_2$) . Anal. Calcd for $C_{32}H_{43}NO_9$: C, 65.64; H, 7.35; N, 2.39; Found: C, 65.10; H, 7.25; N, 2.38.

(1*R*, 2*R*, 3*S*, 4*R*, 5*S*)- 3-*O*-Benzyl-5-[N-(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-methyl-α-D-xylofuranos-5'-yl)]amino-(1,2-*O*-isopropylidene-1,4-tetrahydrofuranos-4-yl)-heptanol (17). Reduction of amino ester **6** (4.0 g, 7.85 mmol) $LiAlH_4$**,** (0.59 g, 15.7 mmol) and work up as described above afforded glycosyl amino alcohol **17** as colourless oil. Yield 77.5%; R_f, 0.5 (methanol/ chloroform,1:24); $[\alpha]_D$ –43^o (c, 0.10, chloroform); MS (FAB) 510 $(m+1)^+$; IR (Neat) ν_{max} cm^{-1} 3339, 3754 ; ^{1}H NMR (200MHz, $CDCl_3$): δ 7.33, 7.26 (m, 5H, Ar-H), 5.93 and 5.87(two d, each *J* = 3.7 Hz, 2H, H-1,and H-1'), 4.66-4.63(m, CH_APh, andH-2'), 4.55 (d, *J* = 3.8 Hz,1H, H-2), 4.42 (d, 1H *J* = 11.6 Hz, OCH_BPh), 4.22-4.10(m, 2H, H-4 and H-4'), 3.81 (d, 1H, *J* = 3.2, H-3), 3.70 (m, 1H, H-7), 3.67 (d, 1H, *J* = 3.2 Hz, H-3), 3.37 (s, 3H, -OCH_3); 3.32(m, 1H, H-5), 3.02 (m, 2H, CH_2NH), 2.70 (bs, exchangeable-H, –NH), 1.48 (s, 6H , $(CH_3)_2C$), 1.32-1.22 (m, 8H, $(CH_3)2$; C ^{13} NMR (50 MHz, $CDCl_3$), 137.3, 128.9, 128.2, (Ar-C), 112.0$(CH_3)_2C$, 105.2(C-1), 84.4(C-2), 82.5 (C-4), 81.7 (C-3), 72.1 (Ar-CH_2), 62.5 (C-7), 57.9

(OCH_3), 57.1(C-5), 43.8 (CH_2NH), 29.8 (C-6), 27.1, 26.6 ($C(CH_3)_2$) . Anal. Calcd for $C_{26}H_{39}NO_9$: C, 61.29; H, 7.66; N, 2.75; Found: C, 61.14; H, 7.26; N, 2.30

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(1*R*, 2*R*, 3S, 4*R*, 5*S*)- 3-*O*-Benzyl-5[N(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-allyl- α-D-xylofuranos-5'-yl)amino-(1,2-*O*-isopropylidene-1,4-tetrahydrofuranos-4-yl)-heptanol (18). Reduction of amino ester **7** (1.0 g, 1.73 mmol) $LiAlH_4$**,** (0.14 g, 3.46 mmol) and work up as described above afforded glycosyl amino alcohol **18** as colourless oil, Yield – 60%; $[\alpha]_D$ -68°(0.10, chloroform); MS (FAB) 536$(M+H)^+$; IR(Neat): ν_{max} (cm^{-1}) 3347.1, 3757.7; ^{1}H NMR (200 MHz, $CDCl_3$), δ 7.32, 7.27 (m, 5H, Ar-H), 5.90, 5.87(m, 3H, H-1, H-1', allyl=CH); 5.20 (dd, J=19.0 Hz, 1.4Hz, 2H, allyl=CH_2) ; 4.71-4.41(m, 3H, OCH_2Ph, H-2); 4.20-4.06 (m, 2H, C-4, C-4'), 3.90 (d, *J* = 3.2Hz, 1H, H-3'), 3.83(d, *J* = 3.2Hz, 1H, H-3), 3.30 (m, 1H, H-5), 2.90 (m, 2H, CH_2NH), 2.36 (m, 2H, H-6), 1.75 (bs,exchangeable H, NH), 1.47 (s, 6H $(CH_3)_2$C), 1.32-1.30 (m, 8H, $(CH_3)_2$C); ^{13}C NMR (200MHz, $CDCl_3$): δ172.1(C=O), 138.0, 128.8(Ar-H); 133.95(=CHallyl), 118.4(=CH_2allyl), 111.9$(CH_3)_2$C, 105.2(C-1), 83.2,82.2 (C-2, C-4), 80.6(C-3), 72.7(OCH_2Ph), 71.3(allyl OCH_2), 62.5(C-7), 54.7(C-5), 45.9(CH_2NH), 36.7(C-6), 27.1, 26.7 $C(CH_3)_2$. Anal. Calcd for $C_{28}H_{41}NO_9$: C, 62.80; H, 7.66; N, 2.62; Found: C, 62.32; H, 7.26; N, 2.38.

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(1*R*, 2*R*, 3*S*, 4*R*, 5*S*)- 3-*O*-benzyl-5-[N-(6'-deoxy-1',2', 3',4'-di-*O*-isopropylidene - α-D-galactopyranos-6'-yl)]amino-(1,2-*O*-isopropylidene-1, 4-tetrahydrofuranos-4-yl]heptanol (19). Reduction of amino ester **8**(1.5 g, 2.47 mmol) $LiAlH_4$, (0.18 g, 4.49 mmol) and work up as described above afforded glycosyl amino alcohol **19** as colourless oil. Yield – 65%; $[\alpha]_D$, –76°(c 10mg, chloroform; MS(FAB): 566$(M+H)^+$; ν_{max}(cm^{-1}) 1457, 3343 ; ^{1}HNMR (200MHz,$CDCl_3$): δ 7.35-7.32(m, 5H, Ar-H); 5.93(d, J=3.9,1H, H-1'); 5.53(d, J=4.8,1H,H-1'); 4.70-4.53(m,3H, OCH_APh,H-2, H-3'); 4.40(d, *J*=11.7Hz, 1H, CH_BPh); 4.28(dd, *J*=4.8,2.4, 1H, H-2'); 4.16(m, 2H, H-4,H-4'); 3.80 (d, *J*=2.7,1H,H-3); 3.75(m, 2H, H-7); 3.31(m,1H, H-5); 2.97(m,2H,H-6); 1.90(bs, exchangeable H, NH); 1.50-1.24(m, 14H, $(CH)_3$C, H-6); ^{13}C NMR (50MHz, $CDCl_3$); δ 137, 128.9, 128.8(Ar-C); 111.9,109.6,108.9 $(CH_3)_2$C; 105.1 (C-1); 96.7(C-1'), 82.2, 81.8(C-2,C-4); 72.2, 71.2, 70.8 (C-2', C-4',C-3, OCH_2Ph); 66.0(C-3); 62.7(C-5);

57.2(C-7); 45.7(CH_2NH); 29.9(C-6); 27.1, 26.4, 24.9 $C(CH_3)_2$. Anal. Calcd for $C_{29}H_{43}NO_{10}$: C, 61.59; H, 7.61; N, 2.48; Found: C, 61.04; H, 7.26; N, 2.38.

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(1*R*, 2*R*, 3*S*, 4*R*, 5*R*/*S*)- 3-*O*-methyl-5[N-(6'-deoxy-1',2', 3',4'-di-*O*-isopropylidene -α-D-galactopyranos-6'-yl)amino-(1,2-*O*-isopropylidene-1, 4-tetrahydrofuranos-4-yl]heptanol (20). Reduction of amino ester **9** (0.8 g, 0.37 mmol) $LiAlH_4$**,** (0.12 g, 0.74 mmol) and work up as described above afforded glycosyl amino alcohol **20** as colourless oil. Yield – 60%, $[\alpha]_D$ –50°(c 0.12, chloroform); MS(FAB) 490$(M+H)^+$; νmax (cm^{-1}) 1469.9, 3346.6; ^{1}HNMR (200MHz,$CDCl_3$): δ 5,90(d, J=4.0Hz,1H, H-1); 5.53(d, *J*=2.6Hz,1H, H-1'); 4.60-4.56(m, 2H, H-3', H-2); 4.31(d, J=2.0 Hz, 1H,H-2'); 4.21(m, 1H, H-4'); 3.90 (m, 1H, H-4); 3.86-3.60(m,3H,H-7, H-5'); 3.60 (d, J= 2.0Hz,1H, H-3);3.41 (s, 3H, OCH_3); 3.10(m,1H, H-5); 2.98(m,2H, H-6'); 2.40(bs, exchangeable H, -OH); 1.90(m, 2H, H-6); 1.70(bs, exchangeable H, -NH); 1.62-1.25(m,20H,$(CH)_3C$,H-6); ^{13}C NMR (50MHz, $CDCl_3$); δ 111.8,109.6,108.9 $(CH_3)_2C$; 104.8 (C-1); 96.7(C-1), 84.3(C-2'); 82.2-81.5(C-4, C-3'); 72.2(C-3); 71.2, 70.9(C-2, C-5') ; 67.9(C-5'); 62.6(C-7); 57.8(-OCH_3); 47.8(CH_2NH); 30.2(C-6); 27.1, 26.4, 24.8 $C(CH_3)_2$.
Anal. Calcd for $C_{23}H_{39}NO_{10}$: C, 56.44; H, 7.97; N, 2.86; Found: C, 56.14; H, 7.26; N, 2.38.

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(1*R*, 2*R*, 3*S*, 4*R*,5S)-3-O-Allyl-5[N-(5'-deoxy-1' 2' –*O*-isopropylidene-3'-*O*-benzyl-α-D-xylofuranos-5'-yl)-amino-(1,2-O-isopropylidene1,4-tetrahydropyranos-4-yl)-heptanol (21). Reduction of amino ester **10** (1.1 g, 1.90 mmol) $LiAlH_4$**,** (0.14 g, 3.80 mmol) and work up as described above afforded glycosyl amino alcohol **21** as colourless oil. Yield – 60%; $[\alpha]_D$ -50°(c, 0.10, chloroform); MS(FAB), 536$(M+H)^+$; IR (Neat) ν_{max} (cm^{-1}) 3368.1, 3678.3; ^{1}H NMR (200MHz, $CDCl_3$): δ 7.33-7.26(m, 5H, Ar-H) 5.92-5.81(m, 3H, H-1, H-1', allyl =CH); 5.23 (dd, J=19.0, 1.4Hz, 2H, allyl=CH_2); 4.75-4.52(m, 4H, CH_APh, CH_BPh, H-2, H-2'); 3.92-3.89(m, 4H, H-7, H-4, H-4'); 3.90(m, 1H, H-3'); 3.83-3.76(m, 4H, H-3, H-3', OCH_2 allyl); 3.20(m,1H, H-5); 3.06(m, 2H, CH_2NH); 2.80(bs, exchangeable H, -OH); 1.90-1.60(m, 2H, H-7_A, H-7_B); 1.70(bs, exchangeable H, -NH); 1.57,1.31(each s, 6H, $(CH_3)_2C$), 1.22(m, 8H, $(CH_3)_2CH$-6); ^{13}C NMR(50MHz,

$CDCl_3$): δ 137.9(=CH-allyl), 133.9, 128.8, 127.9(Ar-C), 118.5(=CH_2-allyl), 111.9 $(CH_3)_2C$, 105.2 (C-1), 82.5, 82.3, 81.9(C-2, C-4, C-3); 80.3 (C-3') ; 72.0 (O*C*H_2Ph; 62.3 (C-7), 62.4 (OCH_2-allyl), 57.4(C-5), 44.4(CH_2NH), 30.1(C-6), 27.1, 26.6, 24.9 C($\underline{C}H_3)_2$. Anal. Calcd for $C_{28}H_{41}NO_9$: C, 62.80; H, 7.66; N, 2.61; Found: C, 62.12; H, 7.66; N, 2.38.

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(1R, 2R, 3S, 4R, 5S)- 3-*O*-Allyl-5-[N-(5'-deoxy-1',2'-*O*-isopropylidene-3'-*O*-methyl-α-D-xylofuranos-5'-yl)]amino-(1,2-O-isopropylidene-1, 4-tetrahydrofuranos-4-yl)-heptanol (22). Reduction of amino ester **11** (1.3 g, 2.59 mmol) $LiAlH_4$**,** (0.197 g, 5.18 mmol) and work up as described above afforded glycosyl amino alcohol **22** as colourless oil. Yield – 70%; $[\alpha]_D$ -65^0(0.10, chloroform); MS(FAB): 460 $(M+H)^+$; ν_{max}(cm^{-1}, neat) 3332.9 ,2991.1 , 2936.9 ; ^{1}H NMR (200MHz, $CDCl_3$); δ 5.92(m, 2H, H-1, H-1'), 5.87 (m, 1H, allyl=CH) , 5.23(t, 2H, allyl=CH_2), 4.54(two d, each 1H, *J*=5, C-2, C-2'), 4.16 (m, 3H, C-4, C-4'), 3.87(m, 2H, C-7); 3.78(d, *J*=3.2, 1H, H-3), 3.68(d, 1H, *J*=3.2, H-3'), 3.39 (s, 3H, -OCH_3), 3.20(m, 1H, H-5'), 3.04(d, 1H, *J*=6.4, 2H, H-5'),2.70(bs, exchangeable H, NH), 1.65 (m, 2H, H-6), 1.49, 1.30(each, s, 6H , $(CH_3)_2C$); ^{13}C NMR(50MHz, $CDCl_3$), δ 133.95(=CH allyl), 118.4(=CH_2allyl), 111.90$(CH_3)_2C$, 105.19(C-1), 84.5(C-2); 82.3,81.7(C-4, C-3'), 80.1(C-3), 71.1(allyl OCH_2), 62.3(C-7), 57.9(OCH_3), 57.0(C-5), 44.1($\underline{CH_2}$NH), 30.1(C-6), 27.1, 26.3 $C(CH_3)_2$. Anal. Calcd for $C_{22}H_{37}NO_9$: C, 57.51; H, 8.06; N, 3.05; Found: C, 57.04; H, 8.26; N, 2.78.

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(1R, 2R, 3S, 4S,5R, 6S)-6-[N-(5'-deoxy-1' 2'-O-isopropylidene-3'-O-benzyl-α-D-xylofuranos-5'-yl)]-amino-(1,5-heptapyranos-5-yl)-octanol (23). Reduction of amino ester **12** (2.2 g, 3.62 mmol) $LiAlH_4$, (0.27 g, 7.24 mmol) and work up as described above afforded glycosyl amino alcohol **23** as colourless oil. Yield – 60%; $[\alpha]_D$, -67.1^O(c 0.14, chloroform); MS(FAB): 566 $(M+H)^+$; IR(Neat) ν_{max} (cm^{-1}) 1458.8, 3367.5 ; ^{1}HNMR (200MHz,$CDCl_3$): δ 7.34-7.26(m, 5H, Ar-H); 5.93(d, *J*=4,1H, H-1'); 5.49(d, *J*=5.2,1H, H-1); 4.68-4.56(m, 4H, OCH_APh, H-2', H-3, CH_BPh); 4.32-4.23(m, 3H, H-2, H-4', H-5'); 3.93(d, *J*=3.4,1H, H-3'); 3.83-3.77(m,3H, H-4, H-8); 3.13(m,2H, H-6, CH_AN); 2.50(m,1H, CH_BN); 2.25(bs, 1H, -OH); 1.48(bs, exchangeable H, NH); 1.46-

1.26(m,14H,$(CH)_3C$,H-7); ^{13}C NMR (50MHz, $CDCl_3$); δ 138, 128.8, 128.0(Ar-C); 111.9,109.8,109.1 $(CH_3)_2C$; 105.3 (C-1); 96.9(C-1), 82.6(C-4); 80.0(C-4); 72.2, 71.2, 70.8 (C-2', C-4',C-3, OCH_2Ph); 68.3(C-3'); 62.4(C-8); 57.7(C-6); 43.7(CH_2NH); 28.4(C-7); 27.1, 26.4, 24.9 $C(CH_3)_2$. Anal. Calcd for $C_{29}H_{43}NO_{10}$: C, 61.59; H, 7.61; N, 2.48; Found: C, 61.78; H, 7.26; N, 2.38.

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(1*R*, 2*R*, 3*S*, 4S, 5R,6S)- 6-[N-(5'-deoxy-1',2'-*O*-isopropylidene –3'-O-methyl- α-D-xylofuranos-5'-yl)amino-(1,2,3,4-di-*O*-isopropylidene-1, 5-pentahydrofuranos-5-yl)-octanol (24). Reduction of amino ester **13** (2.70 g, 5.1 mmol) $LiAlH_4$**,** (0.38 g, 10.2 mmol) and work up as described above afforded glycosyl amino alcohol **24** as colourless oil. Yield – 55%, $[\alpha]_D$ –61.25(c 0.16, chloroform); MS(FAB) 490$(M+H)^+$; ν_{max} (cm^{-1}) , 3290.2, 3728,6; ^{1}HNMR (200MHz,$CDCl_3$): δ 5.87(d, *J*=3.8,1H, H-1'), 5.50(d, *J*=5.0,1H, H-1), 4.61-4.49(m, 3H, H-2, H-2', H-3), 4.28-4.25(m, 4H, H-4, H-4', H-6), 3.74 (m, 2H, H-3', H-5), 3.40(s, 2H OCH_3), 3.60(m,1H, H-6), 2.94(m,2H, H-5'), 2.40-2.20(m, 2H, H-7), 1.63(bs, 1H, -NH), 1.43,1.32 (each s, each 3H,$(CH)_3C$), 1.26 (s, 12H, $(CH_3)_2C$; ^{13}C NMR (50MHz, $CDCl_3$): δ 173.0(C=O), 111.9, 109.3, 108.8 $(CH_3)_2C$, 105.2 (C-1'), 96.9 (C-1), 84.2 (C-2'), 82.0 (C-4), 80.0, 79.9 (C-3, C-3'), 71.2, 70.8 (C-2, C-4), 68.7(C-5), 62.4(C-6), 58.1(-OCH_3), 54.4(C-6); 44.1(CH_2NH), 34.7(C-7); 27.1, 26.4, 24.9 $C(CH_3)_2$.

Anal.Calcd.C23H39NO10: C, 56.43; H, 8.03; N, 2.86; Found:C, 56.43; H, 8.03; N, 2.86;

***(1R*,2*R*,3*S*,4*S*,5*R*,6*S*)-6[N-(5'-deoxy-1'2'-*O*-isopropylidene-3'-*O*-allyl-α-D-xylofuranos-5'-yl)-amino-(1,5-pentapyranos-5-yl)-octanol (25).** Reduction of amino ester **14** (1.2 g, 2.15 mmol) $LiAlH_4$**,** (0.16 g, 4.30 mmol) and work up as described above afforded glycosyl amino alcohol **25** as colourless oil

Yield – 60%; $[\alpha]_D$, –65^o(c 0.10, chloroform); MS(FAB), 516$(M+H)^+$; νmax (cm^{-1}) 1469.9, 3346.6; ^{1}H NMR(200MHz,$CDCl_3$): δ 5.91(d, J=3.6Hz, 1H, H-1'); 5.55(d, *J*=5.2Hz, 1H, H-1); 5.25(dd, J=19.0, 1.4Hz, 2H, allyl=CH_2); 4.59-4.53(m, 2H, H-3, H-2'); 4.33(d, J=2.0, 1H, H-2); 4.21(m, 1H, H-4); 4.10 (m, 1H, H-4'); 3.90(m, 1H, H-3'); 3.86(m,3H, H-8, H-4); 3.11-3.05(m, 3H, CH_2NH, H-6); 2.91(m,1H, H-5); 2.40(bs, exchangeable H, -OH); 1.90-1.60(m, 2H, H-7_A, H-7_B); 1.70(bs, exchangeable H, -NH); 1.62-1.25(m,14H, $(CH)_3C$,H-7); ^{13}C NMR(50MHz, $CDCl_3$); δ 134.4,(=CH-allyl);

118.2(=CH_2-allyl); 111.8,109.6,108.8 $(CH_3)_2C$; 105.2 (C-1'); 96.9(C-1), 82.7, 82.1, 79.9(C-2',C-4',C-3'); 71.4, 71.1, 70.9(C-8, C-3, C-2,C-5) ; 68.3(C-4); 62.4(OCH_2-allyl); 57.7(C-6); 43.6(CH_2NH); 28.4(C-7); 27.1, 26.7, 24.9 $C(CH_3)_2$.

Anal. Calcd for $C_{25}H_{41}NO_{10}$: C, 58.25; H, 7.96; N, 2.48; Found: C, 58.04; H, 7.26; N, 2.38.

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(1*R*, 2*R*, 3*S*, 4*S*, 5*R*, 6*S*)-6-[N-(6'-deoxy-1',2', 3',4'-di-*O*-isopropylidene - α-D-galactopyranos-5'-yl)]amino-(1,5-pentahydropyranos-5-yl)-heptanol (26). Reduction of amino ester **15** (1.72 g, 2.93 mmol) $LiAlH_4$**,** (0.22 g, 5.86 mmol) and work up as described above afforded glycosyl amino alcohol **26** as colourless oil

Yield: 50%; $[\alpha]_D$: -48^0 (c 0.12, chloroform), MS(FAB): 545 $(M+H)^+$; IR(Neat), $\nu_{max}(cm^{-1})$, 1458, 3679; ^{1}H NMR (200MHz,$CDCl_3$): δ 5.52(two d, *J* = 5.0, 2H, H-1, H-1'), 4.56 (d,d, *J* = 6.0, 2.0, 2H, H-3, H-3'), 4.33-4.28 (m, 4H,H-2, H-2',H-8), 3.82 (m, 4H, H-4,H-4', H-5, H-5'), 2.6 (m, 1H, H-6), 2.50-2.40(m, 2H,CH_AN,CH_BN), 1.53 (m, 2H, H-7), 1.54-1.25 (m, 12H,$(CH_3)_2C$), ^{13}C NMR ($CDCl_3$, 50MHz), δ 109.7 ($(CH_3)_2C$), 96.8 (C-1), 78.0,76.7 (C-3, C-2, C-4), 67.9(C-5), 62.8(C-8), 57.4(C-6), 44.2 $(CH_2)NH$, 28.4 (C-7), 26.4-24.8 ($(CH_3)_2C$).

Anal. Calcd for $C_{26}H_{43}NO_{11}$: C, 57.23; H, 7.94; N, 2.57; Found: C, 57.04; H, 8.26; N, 2.38.

Glucose-6-Phosphatase (D-Glucose-6-phosphate Phosphorylase; EC 3.1.3.9) activity determination [12]

The liver of over night fasted Wistar rat was excised and a 10% homogenate was prepared in 150 mM KCl (w/v) using Potter Elvejhem glass homogenizer fitted with Teflon pestle. The homogenate was centrifuged at 1000xg for 15 min at 4^0C, supernatant was decanted and used as enzyme source.

The effect of test compound was studied by pre-incubating 100 μM of the compound in 1.0 ml reaction system for 10 min and then determining the residual glucose-6-Phosphatase activity according to the method of Hubscher and West (1965). The assay system contained 0.3 M citrate buffer (pH6.0), 28 mM EDTA, 14 mM NaF,

200 mM glucose-6-phosphate and appropriate amount of enzyme protein. The mixture was incubated at 37^0C for 30 min after which reaction was stopped by addition of 1.0 ml of 10% TCA. Estimation of inorganic phosphate (Pi) in protein free supernatant was done according to the method of Taussky and Shorr (1953). Glucose-6-Phosphatase activity was defined as μM of Pi release per min per mg protein.

Glycogen Phosphorylase (α-1,4 D-Glucan: Orthophosphate α- glucosyl Transferase, EC 2.4.1.1) activity determination [13]

Liver of Wistar strain of albino rats were excised. 10 % homogenate (w/v) was prepared in 150 mM KCl using Potter Elvejhem glass homogenizer fitted with Teflon pestle. The homogenate was centrifuged at 1000×g for 15 min at 4^0C; supernatant was decanted and used as an enzyme source.

The effect of the test compound was studied by pre-incubating 100μM of the compound in 1.0 ml reaction system for 10 min and then determining the residual glycogen phosphorylase activity according to the method of Rall *et al.* (1957). Assay mixture contained 0.2 ml mixture A [Glycogen 57mg, G-1-P 188 mg, NaF 42 mg and 5' AMP (4mM) in 10 ml distilled water] and 0.1 ml mixture B, enzyme protein. It was incubated at 37^0C for 30 min after which reaction was stopped by addition of 0.1 ml of 10% TCA and then 0.4 ml sodium acetate (100 mM) was added to prevent the spontaneous hydrolysis of G-1-P present in the reaction mixture. The estimation of inorganic phosphate in protein free supernatant was done according to the method of Taussky and Shorr (1953). Glycogen phosphorylase activity was defined as μM of Pi release per min per mg protein.

α-Glucosidase (EC 3.2.1.20) activity determination [14]

Intestine of male albino rat (CF strain) was excised, opened and the mucosa was collected and pooled. A 10% homogenate was prepared in 150 mM KCl using Potter Elvejhem glass homogenizer fitted with Teflon pestle. The homogenate was centrifuged at 1000xg for 15 min and the supernatant was decanted and stored at 4^0C. The supernatant was dialyzed at 4^0C against 50 mM Tris-HCl buffer pH 7.0 with two or three changes of buffer. The dialyzed supernatant was saturated with ammonium sulphate to the final concentration of 30%. The sample was kept at 4^0C overnight and then

centrifuged to collect the supernatant and precipitate separately. 30% ammonium sulphate saturated supernatant was further saturated to 60 % with ammonium sulphate. Again the precipitate and supernatant were separated by centrifugation. Finally the 60% ammonium sulphate saturated supernatant was further saturated to 100% with further addition of ammonium sulphate. The precipitate and supernatant was once again separated and all the samples were analyzed for α-Glucosidase activity using p-nitrophenyl-α-D- glucopyranoid (PNPG) as substrate. The enzyme activity was found maximum in 60-100% ammonium sulphate precipitate and this fraction was used as source of enzyme for studying the effect of the test compounds.

100 µl of purified α-Glucosidase (0.1 mg/ml) and 25µl of glutathione (1.0 mg/ml) were added and the total volume was made up to 1 ml by adding 0.67 mM phosphate buffer (pH 6.8). The reaction mixture was incubated at room temperature for 10 min with the desired test compound (10 mM) dissolved in 100% DMSO. Reaction was started by the addition of 50 µl p-nitrophenyl-α-D-glucopyranoside (3 mg/ml) and increase in absorbance was recorded at 400 nm for a period of 5 min at the interval of 30 seconds (Lebovitz, 1997).

Protein Estimation [15]

Proteins of liver homogenate was precipitated with an equal volume of 10 % TCA (w/v), washed twice with 5 % TCA, dissolved in 0.1 N NaOH and estimated according to the method of Lowry *et al*. (1951) using bovine serum albumin as standard.

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