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Research Article

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Novel Methyl 4,6-O-Benzylidene-α-D-Glucopyranoside Derivatives: Synthesis, Structural Characterization and Evaluation of Antibacterial Activities

Yeni Metil 4,6-O-Benziliden–α-D-Glucopyranoside Türevi: Sentezi, Yapısal Karakterizasyonu ve Antibakteriyel Aktivitesinin Değerlendirilmesi

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ABSTRACT

Carbohydrates are the most abundant and the most diverse biopolymers in nature. Due to the importance of carbohydrates it is necessary to develop a new method for the synthesis of carbohydrate based drugs of the current global situation for health and disease. In this present work we demonstrate the synthesis of methyl 4,6-O-benzylidene-α-D-glucopyranoside derivatives by direct acylation method. The structures of the newly prepared compounds have been characterized and elucidated using various physico-chemical and spectroscopic methods including elemental analysis, melting point determination, infrared and proton NMR spectroscopy. A number of acyl derivatives were prepared in order to obtain a series of newer components for antibacterial screening experiments. These acylated derivatives were evaluated for in vitro antibacterial screening studies against four human pathogenic bacteria by disc diffusion method.

Key Words
Synthesis, benzylidene, acylation, structure, pathogens.

ÖZ

Karbonhidratlar, doğadaki en bol ve en çeşitli biyopolimerlerdir. Karbonhidratların önemi nedeniyle, sağlık ve hastalık için mevcut küresel durumdaki karbonhidrat bazlı ilaçların sentezi için yeni bir yöntem geliştirmek gereklidir. Bu çalışmada, metil 4,6-O-benziliden-α-D-glucopyranosit türevlerinin doğrudan asilasyon yöntemiyle sentezi gösterilmiştir. Yeni hazırlanan bileşiklerin yapıları, element analizi, erime noktası tayini, kızılötesi ve proton NMR spektroskopisi dahil olmak üzere çeşitli fiziko-kimyasal ve spektroskopik yöntemler kullanılarak tanımlanmış ve açıklanmıştır. Antibakteriyel tarama deneyleri için bir dizi daha yeni bileşen elde etmek için birkaç asil türevi hazırlandı. Bu asillenmiş türevler, dört insan patojenik bakterisine karşı in vitro antibakteriyel tarama çalışmaları için disk difüzyon yöntemiyle değerlendirilmiştir.

Anahtar Kelimeler
Sentez, benziliden, asilasyon, yapı, patojenler.

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INTRODUCTION

Carbohydrates are the most abundant and the most diverse biopolymers in nature. Due to their highly specific interactions with physiological receptors, they participate in many crucial biological processes. All these processes are potential targets for therapeutic intervention and carbohydrate-based drugs are rapidly being engaged by the modern biotechnology and pharmaceutical industry [1]. Chemists and biochemists have developed new methods to rapidly synthesize oligosaccharides, enabling them to generate complex polysaccharides and analogues of natural products. In addition to extending our knowledge, these findings have enabled the development of carbohydrate-based drugs and vaccines [2]. Carbohydrates provide an excellent platform to tailor molecular diversity by appending desired substituents at selected positions around the sugar scaffold. The presence of five functionalized and stereo-controlled centers on the sugar scaffolds gives the chemist scope to custom design molecules to a pharmacophore model [3].

The importance of carbohydrates in many biological systems and are often associated with many specific recognition and signaling processes that lead to important biological functions and diseases. Considerable efforts have been directed toward understanding and mimicking such recognition processes and developing effective agents to control these events. The pace of discovery research in glycobiology and development of carbohydrate-based therapeutics, however, has been relatively slow compared to that of other classes of biomolecules due to the lack of appropriate strategies and methods available for carbohydrate-related research. This is mainly due to the practical synthetic and analytical difficulties. Recent advances in the field of carbohydrate synthesis, however, have demonstrated that many of these problems can be circumvented, and evidences the importance of carbohydrates as bioactive substances, with regard to antibacterial, antiviral, antineoplastic, antiprotozoal, antifungal activity [4-11]. This has led us to find our interest in the search for new carbohydrates i.e., D-glucopyranoside derivatives that may be screened for broad-spectrum antibacterial activity.

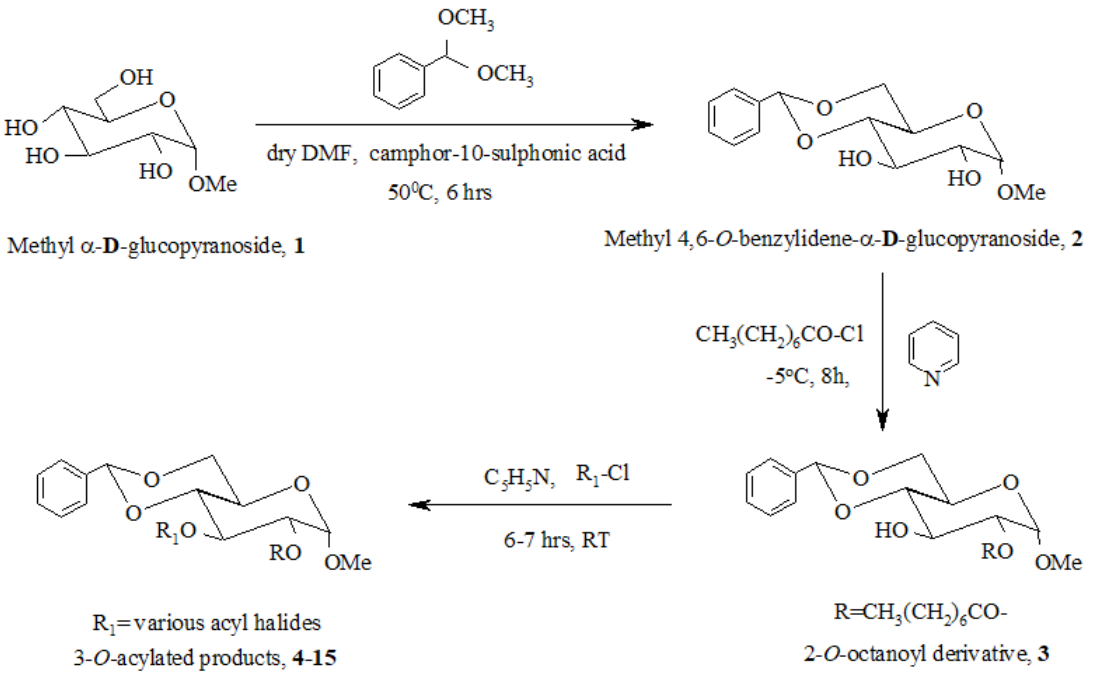
A number of fruitful and efficient methods for selective acylation were reported by many carbohydrate chemists using many acylating agents and varying reaction conditions [12, 13]. However, most of these methods are based on the blocking and deblocking of the hydroxyl groups which are not directly involved in the reaction [14, 15]. Of these, direct method is considered as one of the most effective [16] for selective acylation of carbohydrates and nucleosides.

Literature survey revealed that a large number of biologically active compounds possess aromatic and heteroaromatic nucleus and acyl substituents [17, 18]. It is also known that, if an active nucleus is linked to another nucleus, the resulting molecule may possess greater potential for biological activity [19]. The benzene and substituted benzene nuclei play important role as common denominator of various biological activities [20]. Results of an ongoing research work on selective acylation of carbohydrates [21, 22] and nucleosides [23, 24] and also evaluation of antimicrobial activities reveal that in many cases the combination of two or more acyl, aromatic or heteroaromatic nuclei [19]. It is also found that nitrogen, sulfur and halogen containing substitution products showed marked antimicrobial activities i.e., enhance the biological activity of the parent compound [25, 30]. Encouraged by literature reports and our own findings, we synthesized a series of D-glucopyranoside derivatives (Scheme 1 and Figure 1) deliberately incorporating a wide variety of probable biologically active components. Antibacterial screening of these compounds were carried out using a variety of human pathogenic bacteria.

MATERIALS and METHODS

Materials and Chemicals

^{1}H-NMR (400 MHz) Spectra were recorded in $CDCl_3$, using tetramethylsilane (TMS) as internal standard with a Bruker DPX-400 spectrometer (400 MHz) at the Wazed Miah Science Research (WMSRC) Centre, Savar, Dhaka, Bangladesh. FTIR spectra were recorded by KBr disc at the Chemistry Department, University of Chittagong, Bangladesh, with an IR Affinity Fourier Transform Infrared Spectrophotometer (SHIMADZU, Japan). All reagents used were commercially available (Sigma-Aldrich) and were used as received, unless otherwise specified. Melting points were determined on an electro-thermal melting point apparatus (England). Evaporations were carried out under reduced pressure using VV-1 type vacuum rotary evaporator (Germany) with a bath temperature below 40°C. Thin layer chromatography (TLC) was performed on Kieselgel GF_{254} and spots were detected by spraying



Scheme 1. Reaction scheme for synthesize of the D-glucopyranoside derivatives.

Compound no.	R_1	Compound no.	R_1
3.	H	10.	$C_6H_5SO_2$-
4.	CH_3CO	11.	2-Br.C_6H_4CO-
5.	$CH_3(CH_2)_3CO$-	12.	4-Br.C_6H_4CO-
6.	$CH_3(CH_2)_5CO$-	13.	4-Cl.C_6H_4CO-
7.	$CH_3(CH_2)_8CO$-	14.	4-$(CH_3)_3CC_6H_4CO$-
8.	$CH_3(CH_2)_{12}CO$-	15.	C_6H_5CH=CHCO-
9.	$(CH_3)_3CCO$-		

Figure 1. Structure of the glucopyranoside derivatives (compounds 3-15).

the plates with 1% H_2SO_4 and heating at 150-200°C until coloration took place. Column chromatography was performed with silica gel G_{60}. Solvent system employed for TLC analyses was methanol-chloroform in different proportions.

Synthesis

Methyl 4,6-O-benzylidene-α-D-glucopyranoside 2

A solution of methyl-α-D-glucopyranoside (1) (5 gm, 25.74 mmol) in dry DMF (30 ml) was treated with benzaldehyde dimethyl acetal (5 ml, 33.5 mmol) and camphor-10-sulphonic acid (100 mg) and the mixture was heated at 50°C for 6 hours. After cooling to room temperature, the mixture was neutralized with Et_3N, diluted with EtOAc, washed with saturated $NaHCO_3$ and brine and dried over Na_2SO_4. The progress of the reaction was monitored by TLC (ethyl acetate-hexane, 3:1) and the solvent was then removed. The residue was purified by passage through a silica gel column with ethyl acetate-hexane (3:1) as an eluant to afford methyl 4,6-O-benzylidene-α-D-glucopyranoside 2 (5.5 gm, 76%) as a white crystalline solid, mp 160-163°C. This compound was sufficiently pure for its use as the starting material for the acylation reactions as reported in this work. The structure of this compound was conformed previously by NMR spectrum [Lit. 31].

Methyl 4,6-O-benzylidine-2-O-octanoyl-α-D-glucopyranoside 3

A solution of methyl 4,6-O-benzylidene-α-D-glucopyranoside (2) (200 mg, 0.71 mmol) in dry pyridine (3 ml) was cooled to -5°C whereupon octanoyl chloride (0.13 ml, 1.1 molar eq.) was added to it. The reaction mixture was continuously stirred at the same temperature for 6 hours and then the reaction mixture was standing for overnight at room temperature with continuous stirring. The progress of the reaction was monitored by TLC (CH_3OH-$CHCl_3$, 1:14), which indicated full conversion of the starting material into a single product (R_f = 0.52). A few pieces of ice was added to the flask and then extracted the product mixture with chloroform (3×10 ml). The combined chloroform layer was washed successively with dilute hydrochloric acid (10%), saturated aqueous sodium hydrogen carbonate ($NaHCO_3$) solution and distilled water. The chloroform layer was dried with anhydrous magnesium sulphate ($MgSO_4$), filtered and the filtrate was concentrated under reduced pressure to leave a syrup. The syrup was passed through a silica gel column and eluted with CH_3OH-$CHCl_3$ (1:14) provided the octanoyl derivative (3) as crystalline solid. Recrystallization from chloroform–hexane gave the methyl 4,6-O-benzylidene-2-O-octanoyl-α-D-glucopyranoside (3). The compound was sufficiently pure for use in the next stage without further purification and identification.

Yield (141 mg, 70.5%) as needles, m.p. 149-151°C, R_f 0.51 (CH_3OH:$CHCl_3$, 1:14). Anal. calcd. for $C_{22}H_{32}O_7$: C, 64.68; H, 7.89%. Found: C, 64.70; H, 7.91%. FTIR ν 3318-3421 (br -OH), 1718 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.50 (2H, m, Ar-H), 7.37 (3H, m, Ar-H), 5.51 (1H, s, PhCH-), 4.72 (1H, dd, J = 3.7 Hz, and 9.8 Hz, H-2), 4.27 (1H, d, J = 3.8 Hz, H-1), 3.92 (1H, t, J =9.8 Hz, H-3), 3.77 (1H, dd, J = 4.7 and 10.1 Hz, H-6a), 3.75 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.58 (1H, t, J = 10.2 Hz, H-6b), 3.45 (1H, t, J = 9.8 Hz, H-4), 3.40 (3H, s, 1-OCH_3), 2.32 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.62 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.28 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 0.88 {3H, m, $CH_3(CH_2)_6CO$-}.

General procedure for the synthesis of D-glucopyranoside derivatives 4-15

A solution of 2-O-octanoyl derivative (3) (138 mg, 0.34 mmol) in anhydrous pyridine (3 ml) was cooled to 0°C when acetic anhydride (0.11 ml, 1.1 molar eq.), pentanoyl chloride (0.14 ml, 1.1 molar eq.), heptanoyl chloride (0.23 ml, 1.1 molar eq.), decanoyl chloride (0.16 ml, 1.1 molar eq.), myristoyl chloride (0.33 ml, 1.1 molar eq.), pivaloyl chloride (0.11 ml, 1.1 molar eq.), benzenesulfonyl chloride (0.18 ml, 1.1 molar eq.), 2-bromobenzoyl chloride (0.16 ml, 1.1 molar eq.), 4-bromobenzoyl chloride (0.35 ml, 1.1 molar eq.), 4-chlorobenzoyl chloride (0.16 ml, 1.1 molar eq.), 4-t-butylbenzoyl chloride (0.23 ml, 1.1 molar eq.) and cinnamoyl chloride (0.32 ml, 1.1 molar eq.) were separately added to it, respectively. The mixture was stirred at 0°C for 6~7 hours and then overnight at room temperature. TLC. examination (EtOAc-n-C_6H_{14}, 1:9) showed complete conversion of reactant into a single product. A few pieces of ice were added to the reaction flask in order to destroy the excess reagent and the reaction mixture was processed as usual. Percolation of the resulting syrup by passage through a silica gel column with EtOAc-n-C_6H_{14} (1:9) as eluant afforded the acetyl derivative (4). Similarly isolate the pentanoyl derivative (5), heptanoyl derivative (6), decanoyl derivatives as (7), myristoyl derivative (8), pivaloyl derivative (9), benzenesulfonyl derivative (10), 2-bromobenzoyl derivative (11), 4-bromobenzoyl derivative (12), 4-chlorobenzoyl derivative (13), 4-t-butylbenzoyl derivative (14), cinnamoyl derivative (15), successfully.

Methyl 3-O-acetyl-4,6-O-benzylidine-2-O-octanoyl-α-D-glucopyranoside 4

Yield (129 mg, 93.47%) as pasty mass which could not be crystallized, R_f 0.52 (EtOAc-n-C_6H_{14}, 1:9). Anal. calcd. for $C_{24}H_{34}O_8$: C, 63.98; H, 7.60%. Found: C, 63.99; H, 7.62%. FTIR ν 1708 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.40 (2H, m, Ar-H), 7.17 (3H, m, Ar-H), 5.62 (1H, t, J =9.8 Hz, H-3), 5.53 (1H, s, PhCH-), 4.97 (1H, d, J = 3.6 Hz, H-1), 4.22 (1H, dd, J = 3.6 Hz, and 9.8 Hz, H-2), 3.97 (1H, dd, J = 4.7 and 10.1 Hz, H-6a), 3.80 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.68 (1H, t, J = 10.2 Hz, H-6b), 3.44 (1H, t, J = 9.8 Hz, H-4), 3.36 (3H, s, 1-OCH_3), 2.12 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 2.08 (3H, s, CH_3CO-), 1.65 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.28 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 0.87 {3H, m, $CH_3(CH_2)_6CO$-}.

Methyl 4,6-O-benzylidine-3-O-pentanoyl-2-O-octanoyl-α-D-glucopyranoside 5

Yield (128 mg, 90.78%) as needless, m.p.152-154°C, R_f 0.50 (EtOAc-n-C_6H_{14}, 1:1). Anal. calcd. for $C_{27}H_{40}O_8$: C, 65.83; H, 8.18%. Found: C, 65.86; H, 8.19%. FTIR ν 1722 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.51 (2H, m, Ar-H), 7.39 (3H, m, Ar-H), 5.64 (1H, t, J =9.8 Hz, H-3), 5.54 (1H, s, PhCH-), 5.17 (1H, d, J = 3.7 Hz, H-1), 5.02 (1H, dd, J = 3.6 Hz, and 9.8 Hz, H-2), 4.87 (1H, dd, J = 4.7 and 10.1 Hz, H-6a), 4.68 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 4.16 (1H, t, J = 10.2 Hz, H-6b), 3.64 (1H, t, J = 9.8 Hz, H-4), 3.45

(3H, s, 1-OCH_3), 2.36 {2H, m, $CH_3(CH_2)_2CH_2CO$-}, 2.34 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.66 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.64 (2H, m, $CH_3CH_2CH_2CH_2CO$-), 1.28 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 1.26 {2H, m, $CH_3CH_2(CH_2)_2CO$-}, 0.86 {3H, m, $CH_3(CH_2)_3CO$-}, 0.87 {3H, m, $CH_3(CH_2)_6CO$-}.

Methyl 4,6-O-benzylidine-3-O-heptanoyl-2-O-octanoyl-α-D-glucopyranoside 6

Yield (156 mg, 90.80%) as semi solid, R_f 0.52 (EtOAc-n-C_6H_{14}, 1:9). Anal. calcd. for $C_{29}H_{44}O_8$: C, 66.89; H, 8.51%. Found: C, 66.92; H, 8.53%. FTIR ν 1706 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.51 (2H, m, Ar-H), 7.40 (3H, m, Ar-H), 5.65 (1H, t, J =9.9 Hz, H-3), 5.56 (1H, s, PhCH-), 4.96 (1H, d, J = 3.7 Hz, H-1), 4.81 (1H, dd, J = 3.7 Hz, and 9.9 Hz, H-2), 4.30 (1H, dd, J = 4.8 and 10.2 Hz, H-6a), 4.19 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.80 (1H, t, J = 10.3 Hz, H-6b), 3.55 (1H, t, J = 9.8 Hz, H-4), 3.41 (3H, s, 1-OCH_3), 2.42 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 2.34 {2H, m, $CH_3(CH_2)_4CH_2CO$-}, 1.67 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.63 {2H, m, $CH_3(CH_2)_3CH_2CH_2CO$-}, 1.30 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 1.24 {6H, m, $CH_3(CH_2)_3CH_2CH_2CO$-}, 0.90 {3H, m, $CH_3(CH_2)_6CO$-}, 0.88 {3H, m, $CH_3(CH_2)_5CO$-}.

Methyl 4,6-O-benzylidine-3-O-decanoyl-2-O-octanoyl-α-D-glucopyranoside 7

Yield (81 mg, 89.20%) as colourless needles, m.p. 155-158°C, R_f 0.50 (EtOAc-n-C_6H_{14}, 1:1). Anal. calcd. for $C_{32}H_{50}O_8$: C, 68.29; H, 8.95%. Found: C, 68.31; H, 8.97%. FTIR ν 1701 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.51 (2H, m, Ar-H), 7.39 (3H, m, Ar-H), 5.56 (1H, t, J =9.7 Hz, H-3), 5.53 (1H, s, PhCH-), 4.82 (1H, d, J = 3.6 Hz, H-1), 4.33 (1H, dd, J = 3.6 Hz, and 9.8 Hz, H-2), 3.96 (1H, dd, J = 4.7 and 10.1 Hz, H-6a), 3.83 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.78 (1H, t, J = 10.2 Hz, H-6b), 3.67 (1H, t, J = 9.8 Hz, H-4), 3.40 (3H, s, 1-OCH_3), 2.31 {2H, m, $CH_3(CH_2)_7CH_2CO$-}, 2.28 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.66 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.65 {2H, m, $CH_3(CH_2)_6CH_2CH_2CO$-}, 1.26 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 1.25 {12H, m, $CH_3(CH_2)_6CH_2CH_2CO$-}, 0.88 {3H, m, $CH_3(CH_2)_6CO$-}, 0.88 {3H, m, $CH_3(CH_2)_8CO$-}.

Methyl 4,6-O-benzylidine-3-O-myristoyl-2-O-octanoyl-α-D-glucopyranoside 8

Yield (144 mg, 96.64%) as needles, m.p. 146-149°C, R_f 0.53 (EtOAc-n-C_6H_{14}, 1:10). Anal. calcd. for $C_{36}H_{58}O_8$: C, 69.86; H, 9.44%. Found: C, 69.87; H, 9.46%. FTIR ν 1711 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.45 (2H, m, Ar-H), 7.36 (3H, m, Ar-H), 5.64 (1H, t, J =9.8 Hz, H-3), 5.52 (1H, s, PhCH-), 4.97 (1H, d, J = 3.6 Hz, H-1), 4.92 (1H, dd, J = 3.6 Hz, and 9.8 Hz, H-2), 4.33 (1H, dd, J = 4.7 and 10.1 Hz, H-6a), 3.93 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.79 (1H, t, J = 10.2 Hz, H-6b), 3.68 (1H, t, J = 9.8 Hz, H-4), 3.42 (3H, s, 1-OCH_3), 2.34 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 2.31 {2H, m, $CH_3(CH_2)_{11}CH_2CO$-}, 1.64 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.60 {2H, m, $CH_3(CH_2)_{10}CH_2CH_2CO$-}, 1.32 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 1.28 {20H, br m, $CH_3(CH_2)_{10}CH_2CH_2CO$-}, 0.90 {3H, m, $CH_3(CH_2)_6CO$-}, 0.86 {3H, t, J = 6.8 Hz, $CH_3(CH_2)_{12}CO$-}.

Methyl 4,6-O-benzylidine-2-O-octanoyl-3-O-pivaloyl-α-D-glucopyranoside 9

Yield (96 mg, 94.12%) as pasty mass, R_f 0.51 (EtOAc-n-C_6H_{14}, 1:1). Anal. calcd. for $C_{27}H_{40}O_8$: C, 65.83; H, 8.18%. Found: C, 65.85; H, 8.20%. FTIR ν 1706 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.51 (2H, m, Ar-H), 7.39 (3H, m, Ar-H), 5.55 (1H, t, J =9.7 Hz, H-3), 5.53 (1H, s, PhCH-), 4.81 (1H, d, J = 3.5 Hz, H-1), 4.31 (1H, dd, J = 3.5 Hz, and 9.7 Hz, H-2), 3.97 (1H, dd, J = 4.6 and 10.1 Hz, H-6a), 3.82 (1H, ddd, J = 4.7, 9.7 and 14.1 Hz, H-5), 3.66 (1H, t, J = 10.1 Hz, H-6b), 3.63 (1H, t, J = 9.7 Hz, H-4), 3.47 (3H, s, 1-OCH_3), 2.27 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.64 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.26 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 1.20 {9H, s, $(CH_3)_3CCO$-}, 0.88 {3H, m, $CH_3(CH_2)_6CO$-}.

Methyl 3-O-benzenesulfonyl-4,6-O-benzylidine-2-O-octanoyl-α-D-glucopyranoside 10

Yield (153 mg, 94.15%) as thick syrup, R_f 0.52 (EtOAc-n-C_6H_{14}, 1:8). Anal. calcd. for $C_{28}H_{36}O_9S$: C, 61.29; H, 6.61%. Found: C, 61.31; H, 6.63%. FTIR ν 1716 (C=O), 1363 (-SO_2) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.51 (2H, m, Ar-H), 7.45 (2H, m, Ar-H), 7.44 (1H, m, Ar-H), 7.37 (3H, m, Ar-H), 7.26 (2H, m, Ar-H), 5.63 (1H, t, J =9.8 Hz, H-3), 5.52 (1H, s, PhCH-), 4.96 (1H, d, J = 3.6 Hz, H-1), 4.92 (1H, dd, J = 3.6 Hz, and 9.8 Hz, H-2), 4.33 (1H, dd, J = 4.7 and 10.1 Hz, H-6a), 3.94 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.79 (1H, t, J = 10.2 Hz, H-6b), 3.66 (1H, t, J = 9.8 Hz, H-4), 3.42 (3H, s, 1-OCH_3), 2.32 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.63 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.25 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 0.88 {3H, m, $CH_3(CH_2)_6CO$-}.

Methyl 4,6-O-benzylidine-3-O-(2-bromobenzoyl)-2-O-octanoyl-α-D-glucopyranoside 11

Yield (129 mg, 88.96%) as pasty mass, R_f 0.50 (EtOAc-n-C_6H_{14}, 1:9). Anal. calcd. for $C_{29}H_{35}O_8Br$: C, 58.88; H, 5.96%. Found: C, 58.90; H, 5.98%. FTIR ν 1704 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.81 (1H, d, J = 7.8 Hz, Ar-H), 7.67 (2H, m, Ar-H), 7.42 (1H, m, Ar-H), 7.40 (2H, m, Ar-H), 7.17 (3H, m, Ar-H), 5.61 (1H, t, J =9.8 Hz, H-3), 5.53 (1H, s, PhCH-), 4.97 (1H, d, J = 3.6 Hz, H-1), 4.21 (1H, dd, J = 3.6 Hz, and 9.8 Hz, H-2), 3.97 (1H, dd, J = 4.7 and 10.1 Hz, H-6a),

3.81 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.68 (1H, t, J = 10.2 Hz, H-6b), 3.41 (1H, t, J = 9.8 Hz, H-4), 3.31 (3H, s, 1-OCH_3), 2.12 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.66 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.26 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 0.88 {3H, m, $CH_3(CH_2)_6CO$-}.

Methyl 4,6-O-benzylidine-3-O-(4-bromobenzoyl)-2-O-octanoyl-α-D-glucopyranoside 12

Yield (145.2 mg, 91.64%) as semi solid mass, R_f 0.52 (EtOAc-n-C_6H_{14}, 1:6). Anal. calcd. for $C_{29}H_{35}O_8Br$: C, 58.88; H, 5.90%. Found: C, 58.90; H, 5.91%. FTIR ν 1708 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.96 (2H, m, Ar-H), 7.87 (2H, m, Ar-H), 7.55 (2H, m, Ar-H), 7.17 (3H, m, Ar-H), 5.59 (1H, t, J =9.6 Hz, H-3), 5.27 (1H, s, PhCH-), 5.24 (1H, d, J = 3.6 Hz, H-1), 5.08 (1H, dd, J = 3.6 Hz, and 9.8 Hz, H-2), 4.21 (1H, dd, J = 4.7 and 10.1 Hz, H-6a), 3.97 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.47 (1H, t, J = 10.2 Hz, H-6b), 3.38 (1H, t, J = 9.8 Hz, H-4), 3.35 (3H, s, 1-OCH_3), 2.75 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.66 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.30 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 0.90 {3H, m, $CH_3(CH_2)_6CO$-}.

Methyl 4,6-O-benzylidine-3-O-(4-chlorobenzoyl)-2-O-octanoyl-α-D-glucopyranoside 13

Yield (141.2 mg, 92.59%) as pasty mass, R_f 0.51 (EtOAc-n-C_6H_{14}, 1:9). Anal. calcd. for $C_{29}H_{35}O_8Cl$: C, 63.67; H, 6.44%. Found: C, 63.69; H, 6.47%. FTIR ν 1700 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.91 (2H, m, Ar-H), 7.86 (2H, m, Ar-H), 7.41 (2H, m, Ar-H), 7.10 (3H, m, Ar-H), 5.63 (1H, t, J =9.8 Hz, H-3), 5.56 (1H, s, PhCH-), 4.99 (1H, d, J = 3.7 Hz, H-1), 4.26 (1H, dd, J = 3.7 Hz, and 9.8 Hz, H-2), 3.98 (1H, dd, J = 4.8 and 10.2 Hz, H-6a), 3.81 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.72 (1H, t, J = 10.2 Hz, H-6b), 3.47 (1H, t, J = 9.8 Hz, H-4), 3.35 (3H, s, 1-OCH_3), 2.28 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.66 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.26 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 0.86 {3H, m, $CH_3(CH_2)_6CO$-}.

Methyl 4,6-O-benzylidine-3-O-(4-t-butylbenzoyl)-2-O-octanoyl-α-D-glucopyranoside 14

Yield (130.5 mg, 93.88%) as pasty mass, R_f 0.50 (EtOAc-n-C_6H_{14}, 1:2). Anal. calcd. for $C_{33}H_{44}O_8$: C, 69.69; H, 7.79%. Found: C, 69.72; H, 7.81%. FTIR ν 1712 (C=O) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.52 (2H, d, J =8.5 Hz), 7.38 (2H, d, J =8.5 Hz), 7.28 (2H, m, Ar-H), 7.16 (3H, m, Ar-H), 5.60 (1H, t, J =9.8 Hz, H-3), 5.50 (1H, s, PhCH-), 4.80 (1H, d, J = 3.6 Hz, H-1), 4.32 (1H, dd, J = 3.6 Hz, and 9.8 Hz, H-2), 4.01 (1H, dd, J = 4.7 and 10.1 Hz, H-6a), 3.81 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 3.75 (1H, t, J = 10.2 Hz, H-6b), 3.64 (1H, t, J = 9.8 Hz, H-4), 3.46 (3H, s, 1-OCH_3), 2.75 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.64 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.31 {(9H, s, $(CH_3)_3C$-}, 1.28 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 0.88 {3H, m, $CH_3(CH_2)_6CO$-}.

Methyl 4,6-O-benzylidine-3-O-cinnamoyl-2-O-octanoyl-α-D-glucopyranoside 15

Yield (216.5 mg, 92.17%) as as pasty, R_f 0.51 ((EtOAc-n-C_6H_{14}, 1:4). Anal. calcd. for $C_{31}H_{38}O_8$: C, 69.12; H, 7.11%. Found: C, 69.15; H, 7.13%. FTIR ν 1705 (C=O), 1633 (-CH=CH-) cm^{-1}. ^1H NMR ($CDCl_3$, ppm): δ_H = 7.70 (1H, d, J = 12.0 Hz, PhCH=CHCO-), 7.55 (2H, m, Ar-H), 7.40 (2H, m, Ar-H), 7.21 (3H, m, Ar-H), 7.17 (3H, m, Ar-H), 6.86 (1H, d, J = 12.1 Hz, PhCH=CHCO-), 5.90 (1H, t, J =9.8 Hz, H-3), 5.60 (1H, s, PhCH-), 5.19 (1H, d, J = 3.6 Hz, H-1), 5.13 (1H, dd, J = 3.6 Hz, and 9.8 Hz, H-2), 5.08 (1H, dd, J = 4.7 and 10.1 Hz, H-6a), 5.01 (1H, ddd, J = 4.8, 9.8 and 14.2 Hz, H-5), 4.30 (1H, t, J = 10.2 Hz, H-6b), 3.45 (1H, t, J = 9.8 Hz, H-4), 3.36 (3H, s, 1-OCH_3), 2.74 {2H, m, $CH_3(CH_2)_5CH_2CO$-}, 1.67 {2H, m, $CH_3(CH_2)_4CH_2CH_2CO$-}, 1.31 {8H, m, $CH_3(CH_2)_4(CH_2)_2CO$-}, 0.86 {3H, m, $CH_3(CH_2)_6CO$-}.

Bacterial Human Pathogens

All thirteen newly synthesized compounds (3-15) were evaluated for their in vitro antibacterial activity against Gram-positive and Gram-negative bacterial strains (Table 1). Azithromycin was used as the reference standard. The results of the in vitro antibacterial activity screening of the novel series of acylated D-glucopyranosides are summarized in Figure 2-5.

Antibacterial Assay

The in vitro antibacterial spectrum of the newly synthesized D-glucopyranoside derivatives (3-15) was done by disc diffusion method [32] with little modification [33]. Sterilized paper discs of 4 mm in diameter and Petri dishes of 150 mm in diameter were used throughout the experiment. The autoclaved Mueller-Hinton agar medium cooled to 45˚C, was poured into sterilized Petri dishes to a depth of 3 to 4 mm and after solidification of the agar medium; the plates were transferred to an incubator at 37˚C for 15 to 20 minutes to dry off the moisture that developed on the agar surface. The plates were inoculated with the standard bacterial suspensions (as McFarland 0.5 standard) followed by spread plate method and allowed to dry for three to five minutes. Dried and sterilized filter paper

Table 1. List of tested bacterial human pathogens.

Types of bacteria	Name of tested bacteria	Strain no.
Gram-positive	*Bacillus subtilis*	BTCC 17
	Bacillus cereus	BTCC 19
Gram-negative	*Escherichia coli*	ATCC 25922
	Salmonella paratyphi	AE 14612

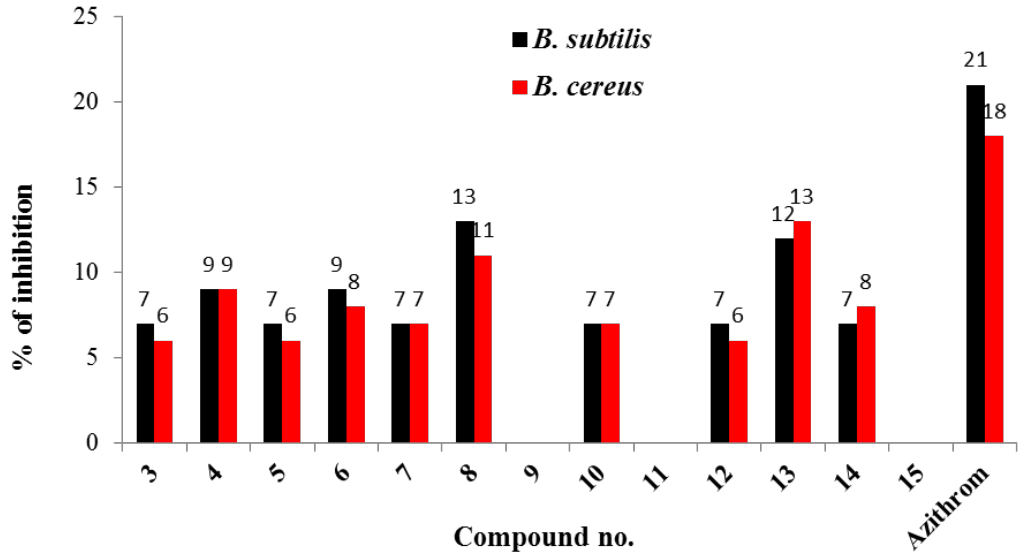


Figure 2. Column diagram of inhibition zone against Gram positive bacteria by acylated D-glucopyranoside derivatives (experiments are repeated in thrice).

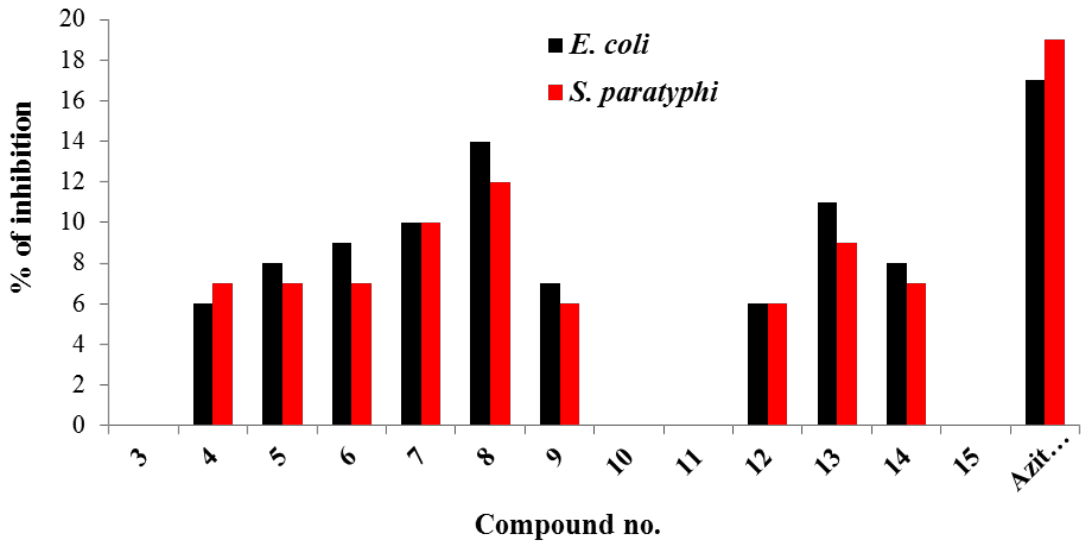


Figure 3. Column diagram of inhibition zone against Gram negative bacteria by different acylated D-glucopyranoside derivatives (experiments are repeated in thrice).

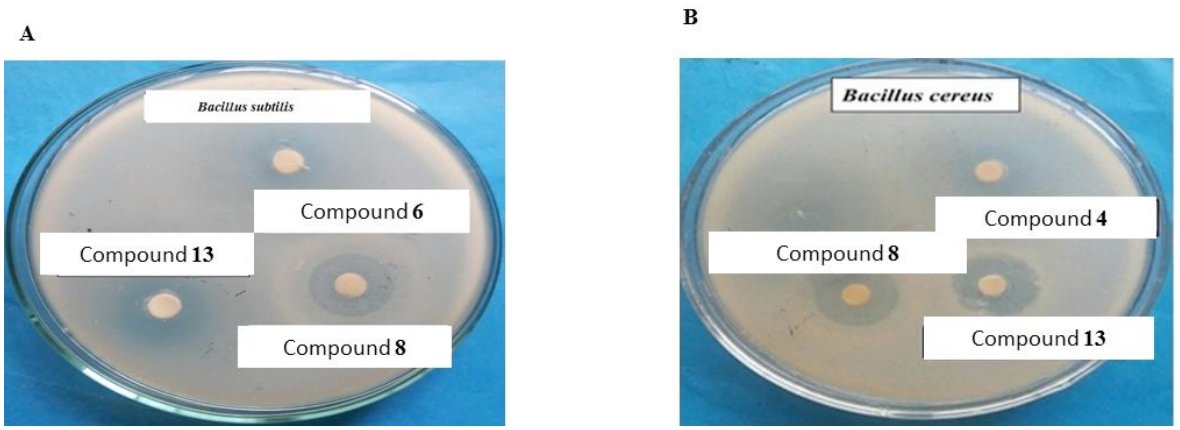


Figure 4. % Zone of inhibition of the compounds 6, 8 and 13 against *B. subtilis* (A) and the compounds 4, 8 and 13 against *B. cereus* (B).

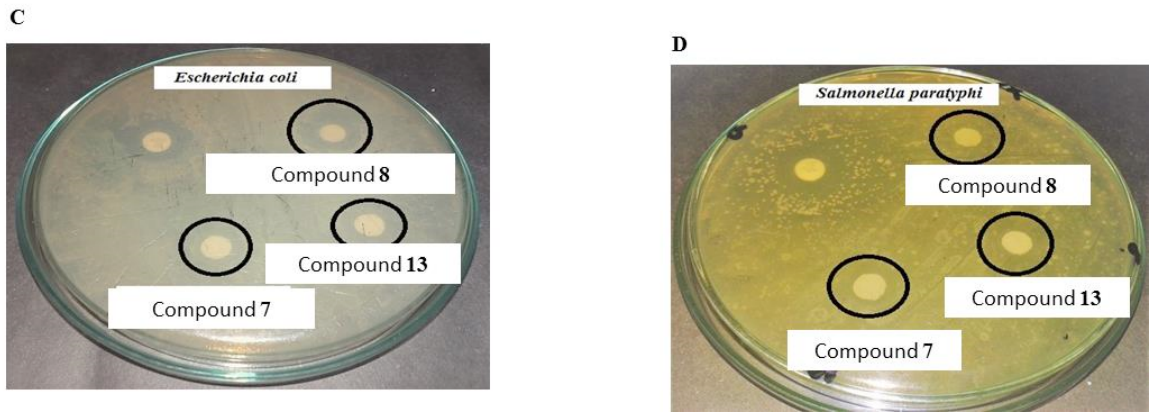


Figure 5. % Zone of inhibition of the compounds 7, 8 and 13 against *E. coli* (C) and *S. paratyphi* (D).

discs were treated separately with 50 µg dry weight/ disc from 2% solution (in $CHCl_3$) of each test chemical using a micropipette, dried in air under the aseptic condition and were placed at equidistance in a circle on the seeded plate. A control plate was also maintained in each case without any test chemical. These plates were kept for 4-6 hours at low temperature (4-6˚C) and the test chemicals diffused from disc to the surrounding medium by this time. The plates were then incubated at 35±2˚C for 24 hours to allow maximum growth of the organisms. The antibacterial activity of the test agent was determined by measuring the mean diameter of zone of inhibitions in millimeter. Each experiment was repeated thrice. All the results were compared with the standard antibacterial antibiotic Azithromycin (20 µg/ disc, ACI Ltd., Bangladesh).

Statistical Analysis

Statistical analyses were done by using Student's t-test with organism's significant appropriate values.

RESULTS and DISCUSSION

Synthesis and Structural Characterization

The present work reported here involves initial synthesis of methyl 4,6-O-benzylidene-α-D-glucopyranoside (2). Thus, reaction of methyl-α-D-glucopyranoside (1) with benzaldehyde dimethyl acetal and camphor-10-sulphonic acid in dry DMF provided the benzylidene derivative (2) in 76% yield. The structure of this compound was ascertained by analyzing its ^{1}H-NMR spectra [31]. We then converted to the methyl 4,6-O-benzylidene-2-O-octanoyl-α-D-glucopyranoside (3) with octanoyl chloride using literature procedure [34]. The FTIR and ^{1}H-NMR spectra of the 2-O-octanoyl derivative thus obtained was compatible with that reported [34]. A series of acylating agents were employed to derivatise the octanoate 3 at position-3. The octanoate 3 and its derivatives (4-15) were subjected to antibacterial screening studies against a number of human pathogenic bacteria.

After usual work-up and silica gel chromatographic purification, compound 3 was obtained in 70.5% yield as needles, m.p. 149-151^{0}C. Its FTIR spectrum displayed the absorption bands at 1718 cm^{-1} for C=O stretching and 3318 cm^{-1} for –OH stretching. In its ^{1}H-NMR spectrum, two two-proton multiplets at δ 2.32 {$CH_3(CH_2)_5CH_2CO$-} and 1.62 {$CH_3(CH_2)_4CH_2CH_2CO$-}, an eight-proton multiplet at δ 1.28 {$CH_3(CH_2)_4(CH_2)_2CO$-} and a three-proton multiplet at δ 0.88 {$CH_3(CH_2)_6CO$-} were due to the presence of one octanoyl group to the molecule. The introduction of this group to position 2 was shown by deshielding of the C-2 proton to δ 4.72 (as dd, J = 3.7 and 9.8 Hz) from its value (~4) in the precursor diol (2). Complete analysis of the FTIR and ^{1}H-NMR spectrum led us to establish its structure as methyl 4,6-O-benzylidene-2-O-octanoyl-α-D-glucopyranoside (3).

The octanoate 3 was easily converted to the 3-O-acetyl (4) derivative using literature procedure [34]. The FTIR spectrum, of compound 4 showed the following absorption bands: 1708 cm^{-1} (due to -CO) stretching. The attachment of one acetyl group in the molecule was demonstrated by the appearance of a three-proton singlet at δ 2.08 in its ^{1}H-NMR spectrum. Also the C-3 proton resonated downfield to δ 5.62 (as t, J = 9.8 Hz) as compared to the precursor compound 3 (δ 3.92, t, J = 9.8 Hz), thereby suggesting the introduction of the acetyl group at position 3. By complete analysis of the FTIR and ^{1}H-NMR spectrum, the structure of this compound was assigned as methyl 3-O-acetyl-4,6-O-benzylidene-2-O-octanoyl-α-D-glucopyranoside (4). The infrared spectrum of compound 5 showed characteristic absorption band at 1722 cm^{-1} for carbonyl stretching. In its ^{1}H-NMR spectrum, the resonance peaks at δ 2.36 {as 2H, m, $CH_3(CH_2)_2CH_2CO$-}, 1.64 (as 2H, m, $CH_3CH_2CH_2CH_2CO$-), 1.26 {as 2H, m, $CH_3CH_2(CH_2)_2CO$-} and 0.86 {as 3H, m, $CH_3(CH_2)_3CO$-} showed the presence of one pentanoyl group in the molecule. The downfield shift H-3 to δ 5.64 (as t, J = 9.8 Hz) from its value in the precursor compound 3 (δ 3.92, t, J = 9.8 Hz), indicated the introduction of the pentanoyl group at position 3. Thus, by complete analysis of the FTIR and ^{1}H-NMR spectrum, we were able to propose a structure of this compound as methyl 4,6-O-benzylidine-3-O-pentanoyl-2-O-octanoyl-α-D-glucopyranoside (5).

We then performed heptanoylation (6) and decanoylation (7) of the octanoyl derivative (3) using similar reaction, work-up and purification procedures. The FTIR spectrum, of this compound showed absorption bands at 1706 cm^{-1} (C=O), thereby suggesting the introduction of carbonyl hydroxyl group. The ^{1}H-NMR spectrum, of compound 6 showed characteristics two two-proton multiplets at δ 2.34 {$CH_3(CH_2)_4CH_2CO$-} and δ 1.63 {$CH_3(CH_2)_3CH_2CH_2CO$-}, a six-proton multiplet at δ 1.24 {$CH_3(CH_2)_3CH_2CH_2CO$-} and one three-proton multiplet at δ 0.88 {$CH_3(CH_2)_5CO$-} indicating the attachment of one heptanoyl group in the molecule. The resonance for C-3 protons appeared at δ 5.65 (as t, J =9.9 Hz) which shifted downfield from their precursor compound 3 suggesting the attachment of the heptanoyl group at position 3. Complete analysis of the FTIR and ^{1}H-NMR spectrum of this compound led us to propose its structure as methyl 4,6-O-benzylidine-3-O-heptanoyl-2-O-octanoyl-α-D-glucopyranoside (6). As same as complete analysis of the compound 7 and their FTIR and ^{1}H-NMR spectra was consistent with the structure of the compound assigned as methyl 4,6-O-benzylidine-3-O-decanoyl-2-O-octanoyl-α-D-glucopyranoside (7).

The structure of compound 3 was further supported by its transformation to and identification of a fatty acid derivative using myristoyl chloride. The ^{1}H-NMR spectrum, displayed a two two-proton multiplet at δ 2.31 {$CH_3(CH_2)_{11}CH_2CO$-}, and δ 1.64 {$CH_3(CH_2)_{10}CH_2CH_2CO$-}, a twenty-proton (br) multiplet at δ 1.28 {$CH_3(CH_2)_{10}CH_2CH_2CO$-}, and a three-proton triplet at δ 0.86 {$CH_3(CH_2)_{12}CO$-} suggested the attachment of one myristoyl group in the compound. Complete analysis of the FTIR and ^{1}H-NMR spectrum of this compound established its structure as methyl 4,6-O-benzylidine-3-O-myristoyl-2-O-octanoyl-α-D-glucopyranoside (8). Similarly, pivaloyl derivative (9) was isolated in 94.12% yield as thick syrup. In its ^{1}H-NMR spectrum, the presence of one characteristic nine-proton singlet at δ 1.20 was due to one pivaloyl group. Complete analysis of the FTIR and ^{1}H-NMR spectrum enabled us to assign its structure as methyl 4,6-O-benzylidine-2-O-octanoyl-3-O-pivaloyl-α-D-glucopyranoside (9). Encouraged by the results obtained so far, we then transformed to the benzenesulfonyl derivative and its ^{1}H-NMR spectrum, the peaks at δ 7.51 (2H, m), δ 7.44 (1H, m) and δ 7.26 (2H, m) corresponded the protons of one phenyl group. By complete analysis of its FTIR and ^{1}H-NMR spectrum and by analogy with similar derivatives described earlier, the structure of this compound was confidently assigned as methyl 3-O-benzenesulfonyl-4,6-O-benzylidine-2-O-octanoyl-α-D-glucopyranoside (10).

The octanoyl derivative (3) was then converted to the 2-bromobenzoyl (11), 4-bromobenzoyl (12) and 4-chlorobenzoyl) (13) derivatives by using similar reaction procedures. The structures of these derivatives were confidently assigned by completely analyzing their FTIR and ^{1}H-NMR spectra. In these cases, the introduction of the substituent at C-3 was ascertained. By complete analysis of the spectra of these compounds established their structures as methyl 4,6-O-benzylidine-3-O-(2-bromobenzoyl)-2-O-octanoyl-α-D-glucopyranoside (11), methyl 4,6-O-benzylidine-3-O-(4-bromobenzoyl)-2-O-octanoyl-α-D-glucopyranoside (12) and methyl 4,6-O-benzylidine-3-O-(4-chlorobenzoyl)-2-O-octanoyl-α-D-glucopyranoside (13).

Compound 3 was then allowed to react with 4-t-butylbenzoyl chloride in dry pyridine and after usual work-up and chromatographic purification, we obtained compound 14. The FTIR spectrum of this compound showed absorption bands at 1712 cm^{-1} for due to carbonyl stretching. In its ^{1}H-NMR spectrum, the characteristic peaks at δ 7.52 (2H, d, J = 8.5 Hz), δ 7.38 (2H, d, J = 8.5 Hz) and δ 1.31 (9H, s) were due to the presence of one 4-t-butylbenzoyl group in the molecule. The incorporation of the 4-t-butylbenzoyl group at C-3 was ascertained by considerable downfield shift H-3 to δ 5.60 (as t, J = 9.8 Hz) as compared to its precursor 3 (δ 3.92, t, J = 9.8 Hz). Finally, we used cinnamoyl chloride for derivatizing compound 3 and furnished the cinnamoyl derivative (15). FTIR spectrum, showed absorption bands at 1705 cm^{-1} (for -CO stretching) and 1633 cm^{-1} (for –CH=CH- stretching). In the ^{1}H-NMR spectrum, one one-proton doublet at δ 7.70 (as d, J = 12.0 Hz, PhCH=CHCO-) and also one one-proton doublet at δ 6.86 (as d, J = 12.1 Hz, PhCH=CHCO-) due to the presence of one cinnamoyl group in the molecule. In addition a two-proton multiplet at δ 7.55 (as m, Ar-H) and a three-proton multiplet at δ 7.21 (as, m, Ar-H) due to the one aromatic ring protons. Complete analysis of its FTIR and ^{1}H-NMR spectrum, the structure of this compound was confidently assigned as methyl 4,6-O-benzylidine-3-O-cinnamoyl-2-O-octanoyl-α-D-glucopyranoside (15).

Evaluation of Antibacterial Activity

The results of antibacterial screening of the test compounds and the standard antibiotic, Azithromycin are presented in Figure 2-5. The results revealed that most of the derivatives were prone to antibacterial action against most of the Gram-positive and Gram-negative bacteria. From the experimental results found that the selectively acylated derivatives 8 and 13 showed highest inhibition against Gram-positive bacteria while compounds 7 and 8 were also very active against Gram-negative bacteria. The inhibition of *B. subtilis* by 8 (13.0 mm), *B. cereus* by 13 (13.0 mm), E. coli 8 (14.0 mm), of S. paratyphi by 8 (12 mm) were highest remarkable inhibition. The inhibitions of growth of bacteria were very remarkable in many cases which were in conformity with our previous work [35-37].

In general, it has been observed that antibacterial results of the selectively acylated monosaccharide derivatives obtained by using various acylating agents follow the order for Gram-positive organisms: 8 > 13 > 4 > 6 > 5 = 10 = 14 > 7 = 12 and Gram-negative bacteria follow the order: 8 > 7 > 13 > 6 > 5 = 14 > 9 > 4 = 12.

However, compounds 11 and 15 were found insensitive towards all the Gram-positive and Gram-negative bacteria. We also observed that the compound 8 is highly active against both the Gram-positive and Gram-negative organisms. Thus, a comparative study on antibacterial activities of a number of selectively acylated derivatives of methyl 4,6-O-benzylidene-α-D-glucopyranoside (2) has been carried out successfully.

However, this series of test chemicals was found to show very good antibacterial activity, particularly the presence of different acyl groups e,g. decanoyl, myristoyl, 4-chlorobenzoyl groups improved the antibacterial activity by a very good margin which was in accordance with published reports [38-40]. The results reported in Figures 2-3 revealed that the hydrophobicity is the primary contributor to antibacterial activity. Here the hydrophobicity of the molecules increased gradually from compound 3 to 15. The hydrophobicity of materials is an important parameter with respect to such bioactivity as toxicity or alteration of membrane integrity, because it is directly related to membrane permeation [41]. Hunt [42] also proposed that the potency of aliphatic alcohols is directly related to their lipid solubility through the hydrophobic interaction between alkyl chains from alcohols and lipid regions in the membrane. We believe that a similar hydrophobic interaction might occur between the acyl chains of uridine accumulated in the lipid like nature of the bacteria membranes. As a consequence of their hydrophobic interaction, bacteria lose their membrane permeability, ultimately causing death of the bacteria [41-43]. Meanwhile, the inhibitions of growth of bacteria were very remarkable in many cases which were in conformity with our previous lab won works [44-45].

CONCLUSION

In summary, the design and synthesis of novel series of methyl 4,6-O-benzylidene-α-D-glucopyranoside from simple starting material and under mild reaction conditions has been reported. The antibacterial properties of these novel compounds were evaluated. The results revealed that the D-glucopyranoside derivatives; methyl 4,6-O-benzylidine-3-O-decanoyl-2-O-octanoyl-α-D-glucopyranoside (7) and methyl 4,6-O-benzylidine-3-O-(4-chlorobenzoyl)-2-O-octanoyl-α-D-glucopyranoside (13) exhibited greater degrees of antibacterial activities, whereas methyl 4,6-O-benzylidine-3-O-myristoyl-2-O-octanoyl-α-D-glucopyranoside (8) showed promising highest antibacterial activities against all of the microorganisms tested. So these compounds may be targeted for future studies for their usage as broad spectrum antibiotics. Further studies on their DFT computational studies, molecular docking and drug targeting research are currently underway in our laboratory and will be reported in due time.

Acknowledgments

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