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Phytoconstituents and the study of antioxidant, antimalarial and antimicrobial activities of *Rhus tripartita* growing in Egypt

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Abstract
Phytochemical investigation of the alcoholic extract of *Rhus tripartita* resulted in the isolation of six compounds, gallocatechin [1], quercetin [2], myricetin [3], Kampferol-3-*O*-*α*-L-rhamnopyranoside [4], Kampferol-7-*O*-*α*-L-rhamnopyranoside [5], β-sitosteryl-3-*O*-*β*-glucopyranoside [6]. The structures of these compounds were assigned on the basis of NMR spectroscopic data and MS analysis. The alcoholic extract exhibited good antioxidant activity towards DPPH radical with IC_{50} value 16.80µg/mL and higher antimalarial activity against both chloroquine-sensitive and chloroquine-resistant strains of *Plasmodium falciparum* with IC_{50} values in the range of 3.9µg/mL. The alcoholic extract also exhibited antimicrobial activity against methicillin resistant *Staphylococcus aureus* (MRSA) and *Staphylococcus aureus* (non-MRSA) with IC_{50} values of 10.5 and 11.2µg/mL, respectively.

Keywords: *Rhus tripartita*, phytoconstituents, biological activities.

1. Introduction
One of the most important genus in the Anacardiaceae family is *Rhus* which includes more than 250 species [1]. Sumac is the common name for a genus *Rhus*, which are found in temperate and tropical regions, worldwide. *Rhus tripartitum* is belonging to family Anacardiaceae and it is distributed primarily in North Africa [1]. *Rhus tripartita* fruits are consumed fresh, soaked in sour milk or added to drinking water to offer an acceptable taste [2]. *Rhus tripartita* and other *Rhus* species are widely used in food, and in modern and traditional medicine. They have been used for the treatment of diarrhea, colitis, GIT diseases, inflammatory diseases, diabetes, dysentery, haemoptysis, conjunctivitis, animal bites and poisons, hemorrhoids, sexual disease, fever, pain and various cancers [3-8]. The antioxidant, anti-inflammatory, antiulcerogenic, antimalarial, antimicrobial, antitumor, antiviral, anticonvulsant and hypoglycaemic activities of *Rhus tripartita* have been investigated [2, 8-14]. Concerning the chemical studies of this plant, several compounds such as flavonoids, biflavonoids, isobiflavonoids, catechin, epicatechin-3-*O*-gallate, proanthocyanidin oligomers and polymers, polysaccharides, condensed tannins have been isolated from different parts of the plant [14-17]. This report describes the isolation and identification of bioactive constituents [1-6] from the herbs of *Rhus tribartita*. The antioxidant, antimalarial and antimicrobial activities of the alcoholic extract were also evaluated.

2. Experimental
2.1. General experimental procedures
UV spectra were determined with a Hitachi 340 spectrophotometer. IR spectra were obtained using a Bruker Tensor 27 instrument. ESIMS were measured on a TSQ Quantum (Thermo Electron Corporation) instrument. EIMS was carried on Shimadzu, GC/MS-Q P5050A spectrometer. NMR spectra were recorded on a Varian Mercury 400 or JEOL 500 spectrophotometers at 400 or 500 for ^1H and 100 or 125 MHz for ^{13}C, in CD_3OD or DMSO-d_6 solution, and chemical shifts were expressed in δ (ppm) with reference to TMS, and coupling constant (*J*) in Hertz. Si gel (Si gel 60, Merck) and Sephadex LH-20 (Pharmacia) were used for open column chromatography. Solid phase extraction was performed on SPE-C_{18} cartridges (Strata columns). TLC was carried out on precoated silica gel 60 F_{254} (Merck) plates. Developed chromatograms were visualized by spraying with 1% vanillin-H_2SO_4, followed by heating at 100 ^{0}C for 5 min.

2.2 Plant material

Rhus tripartita leaves were collected from Wadi Maear, Altoor, South Sinai, Egypt, in April, 2013, and were kindly identified by Dr. Ibraheem El-Garf, Professor of Plant Taxonomy, Faculty of Science, Cairo University, Egypt. A voucher specimen has been deposited in the Pharmacognosy Department, Faculty of Pharmacy, Al-Azhar University, Cairo, Egypt.

2.3 Extraction and isolation

The air dried powdered leaves of *Rhus tripartita* (1.5 kg) were subjected to exhaustive extraction with 70% ethyl alcohol (5L x 3). The combined ethanolic extracts were concentrated under vacuum at 40 ^{o}C to dryness (180 g). The concentrated ethanolic extract was suspended in distilled water (500 ml) and defatted with n-hexane (18 g). The defatted crude extract was partitioned successively with ethyl acetate (15 g) and *n*-butanol (53 g). The EtOAc fraction (15 g) was applied to Si gel column and eluted with chloroform-methanol (100:0→70:30) to give six fractions of A (1.4 g), B (970 mg), C (1.6 g), D (1.1 g), E (1.8 g) and F (890 mg). Fraction C (1.6 g) was rechromatographed over Si gel column eluted with chloroform-methanol (95:5→ 90:10) to give five sub fractions of C1 (110 mg), C2 (200 mg), C3 (180 mg), C4 (330 mg) and C5 (240 mg). Sub fractions C2 (180 mg) and C5 (240 mg) were subjected separately to Sephadex LH-20 column, eluted with methanol to give compound [1] (25 mg) and compound [2] (28 mg), respectively. Fraction D (1.1 g) was rechromatographed over Si gel column eluted with chloroform-methanol (95:5→ 90:10) to give five sub fractions of D1 (56 mg), D2 (60 mg), D3 (170 mg), D4 (99 mg) and D5 (278 mg). Sub fraction D5 (278 mg) was purified by Sephadex LH-20 column (MeOH) to give compound [3] (32 mg). Fraction E (1.8 g) was rechromatographed over Si gel column eluted with chloroform-methanol (90:10-80:20) to give six sub fractions of E1 (70 mg), E2 (120 mg), E3 (82 mg), E4 (390 mg), E5 (600 mg) and E6 (150 mg). Sub fraction E1 (70 mg) was subjected to Sephadex LH-20 column (MeOH) to give compound [6] (30 mg). Sub fraction E-2 (120 mg) was subjected to solid phase extraction using 100% water - 70% water in MeOH to give two sub fractions of E-2a (42 mg) and E-2b (35 mg). Sub fractions E-2a and E-2b were finally purified on a Sephadex LH-20 column eluted with MeOH to give compound [4] (22 mg) and compound [5] (19 mg), respectively.

Gallocatechin [1]**:** Fine yellow crystals [MeOH]; UV λ_{max} (MeOH) nm: 227, 280; ^{1}H NMR (*CD$_3$OD*, 500 MHz) and ^{13}C NMR (*CD$_3$OD*, 125 MHz) see tables 1 and 2; EIMS *m/z* 305.

Quercetin [2]: Yellow amorphous; UV λ_{max} (MeOH) nm: 255, 268sh, 367, λ_{max} (AcONa) nm: 258sh, 274, 330, 400, λ_{max} (AcONa/boric acid) nm: 260, 384, λ_{max} ($AlCl_3$) nm: 272, 302sh, 332, 433, λ_{max} ($AlCl_3$/HCl) nm: 270, 302sh, 358, 398, λ_{max} (MeONa) nm: 262, 300sh, 394; IR υ_{max} (KBr) cm^{-1}: 3420 (OH), 1645 (C=O), 1580, 1510 (C=C aromatic); ^{1}H NMR (DMSO-*d$_6$*, 400 MHz) and ^{13}C NMR (DMSO-*d$_6$*, 100 MHz) see tables 1 and 2; EIMS *m/z* 302 $[M]^+$.

Myricetin [3]**:** Yellow needle crystals [MeOH]; UV λ_{max} (MeOH) nm: 254, 272sh, 300sh, 375, λ_{max} (AcONa) nm: 270, 335, λ_{max} (AcONa/boric acid) nm: 257, 394, λ_{max} ($AlCl_3$) nm: 272, 315sh, 445, λ_{max} ($AlCl_3$/HCl) nm: 267, 275sh, 360sh, 420, λ_{max} (MeONa) nm: 263sh, 286sh, 323, 420; IR υ_{max} (KBr) Cm^{-1}: 3455 (OH), 1645 (CO), 1612, 1587 (C=C aromatic); ^{1}H NMR (DMSO-*d$_6$*, 500 MHz) and ^{13}C NMR (DMSO-*d$_6$*, 125 MHz) see tables 1 and 2; EIMS *m/z* 318.

Kampferol-3-*O*-*α*-L-rhamnopyranoside [4]**:** Yellow amorphous; UV λ_{max} (MeOH) nm: 255, 265sh, 315sh, 350, λ_{max} (AcONa) nm: 275, 301, 398, λ_{max} (AcONa/boric acid) nm: 265, 352, λ_{max} ($AlCl_3$) nm: 276, 300, 354, 400, λ_{max} ($AlCl_3$/HCl) nm: 276, 298sh, 348, 398, λ_{max} (MeONa) nm: 273, 324, 399; IR υ_{max} (KBr) cm^{-1}: 3400 (OH), 1645 (CO), 1610, 1590 (C=C aromatic); ^{1}H NMR (DMSO-*d$_6$*, 400 MHz) and ^{13}C NMR (DMSO-*d$_6$*, 100 MHz) see tables 1 and 2; ESI-MS m\z 431 $[M-H]^-$.

Kampferol-7-*O*-*α*-L-rhamnopyranoside [5]**:** Yellow amorphous; UV λ_{max} (MeOH) nm: 266, 322, 364, λ_{max} (AcONa) nm: 260, 322, 385, 410, λ_{max} (AcONa/boric acid) nm: 265, 372, λ_{max} ($AlCl_3$) nm: 266, 298sh, 352, 422, λ_{max} ($AlCl_3$/HCl) nm: 266, 300sh, 350, 420, λ_{max} (MeONa) nm: 245, 267, 335sh 425; IR υ_{max} (KBr) cm^{-1}: 3450 (OH), 1642 (CO), 1610, 1595 (C=C aromatic); ^{1}H NMR (*CD$_3$OD*, 400 MHz) and ^{13}C NMR (*CD$_3$OD*, 100 MHz) see tables 1 and 2; ESI-MS m\z 433 $[M+H]^+$.

β-sitosteryl-3-*O*-*β*-glucopyranoside [6]**:** White amorphous powder; IR υ_{max} (KBr) cm^{-1}: 3430, 1635; ^{1}H NMR (DMSO-*d$_6$*, 400 MHz) δ 0.63 (s, Me-18), 0.76 (d, *J*=6.5 Hz, Me-27), 0.78 (t, *J*=7.0 Hz, Me-29), 0.80 (d, *J*=6.5 Hz, Me-26), 0.87 (d, *J*=6.5 Hz, Me-21), 0.93 (s, Me-19), 3.02-3.39 (m, H-2`-H-5`), 3.41 (m, H-6`b), 3.44 (m, H-3), 3.61 (dd, *J*=10.7, 5.8 Hz, H-6`a), 4.18 (d, *J*=6.5 Hz, H-1`), 5.30 (m, H-6); ^{13}C NMR (DMSO-*d$_6$*, 100.0 MHz) δ 12.1 (C-18), 12.2 (C-29), 19.0 (C-21), 19.3 (C-27), 19.5 (C-19), 20.1 (C-26), 20.9 (C-11), 23.0 (C-28), 24.1 (C-15), 28.5 (C-23), 28.6 (C-16), 29.1 (C-25), 31.1 (C-2), 31.5 (C-7), 31.8 (C-8), 33.7 (C-22), 35.9 (C-20), 36.6 (C-1), 36.7 (C-10), 36.9 (C-4), 38.7 (C-12), 42.2 (C-13), 45.5 (C-24), 49.7 (C-9), 55.4 (C-17), 56.5 (C-14), 61.2 (C-6`), 70.3 (C-4`), 73.6 (C-2`), 76.9 (C-3`, 5`), 77.9 (C-3), 101.1 (C-1`), 121.1 (C-6), 140.0 (C-5); ESI-MS m\z 577 $[M+H]^+$.

2.4 Acid hydrolysis of compounds 4, 5 and 6.

Five mg of each compound was separately refluxed with 2M HCl in MeOH (5 ml) at 80 ^{0}C for 5h in a water bath. The reaction mixture was evaporated, and the hydrolysate after dilution with H_2O (10ml) was extracted with $CHCl_3$ (3 x 10 ml). The $CHCl_3$ extracts were evaporated to afford the aglycons, which were identified as kampferol for 4 and 5 and β-sitosterol for 6 by comparison with authentic samples. The aqueous layer was neutralized with sodium carbonate and concentrated to 1 ml under reduced pressure. The residue was compared with standard sugars by Si gel TLC [($CHCl_3$-MeOH-H_2O:30:12:4), 9 ml of lower layer and 1 ml of HOAc], which indicated the sugar of 4 and 5 to be rhamnose and the sugar of 6 is glucose.

2.5 Determination of antioxidant activity

The free radical scavenging activity of the alcoholic extract of *R. tripartita* was measured by using 1, 1-diphenyl-2-picryl-hydrazyl (DPPH) assay [18].

2.6 Determination of antimalarial activity

Antimalarial activity of the alcoholic extract of *R. tripartita* was determined *in vitro* against chloroquine sensitive (D6, Sierra Leone) and resistant (W2, Indochina) strains of *Plasmodium falciparum* by measuring plasmodial LDH activity as reported previously [19]. Chloroquine was used as a positive control.

2.7 Determination of antimicrobial activity

The alcoholic extract of *R. tripartita* was tested for antimicrobial activity against *Staphylococcus aureus* ATCC 29213, methicillin-resistant *Staphylococcus aureus* ATCC 33591 (MRSA), *Escherichia coli* ATCC 35218, *Pseudomonas aeruginosa* ATCC 27853, *Mycobacterium intracellulare* ATCC 23068, *Candida albicans* ATCC 90028, *Candida glabrata* ATCC 90030, *Candida krusei* ATCC 6258, *Cryptococcus neoformans* ATCC 90113, and *Aspergillus fumigatus* ATCC 204305, ciprofloxacin and amphotericin B were used as positive controls for bacteria and fungi, respectively [19].

3. Results and discussion

Chromatographic investigation of *Rhus tripartita* yielded six compounds (Fig. 1) identified as gallocatechin [1], quercetin [2], myricetin [3], Kampferol-3-*O*-*α*-L-rhamnopyranoside [4], Kampferol-7-*O*-*α*-L-rhamnopyranoside [5], β-sitosteryl-3-*O*-*β*-glucopyranoside [6] on the bases of physical and spectroscopic analysis.

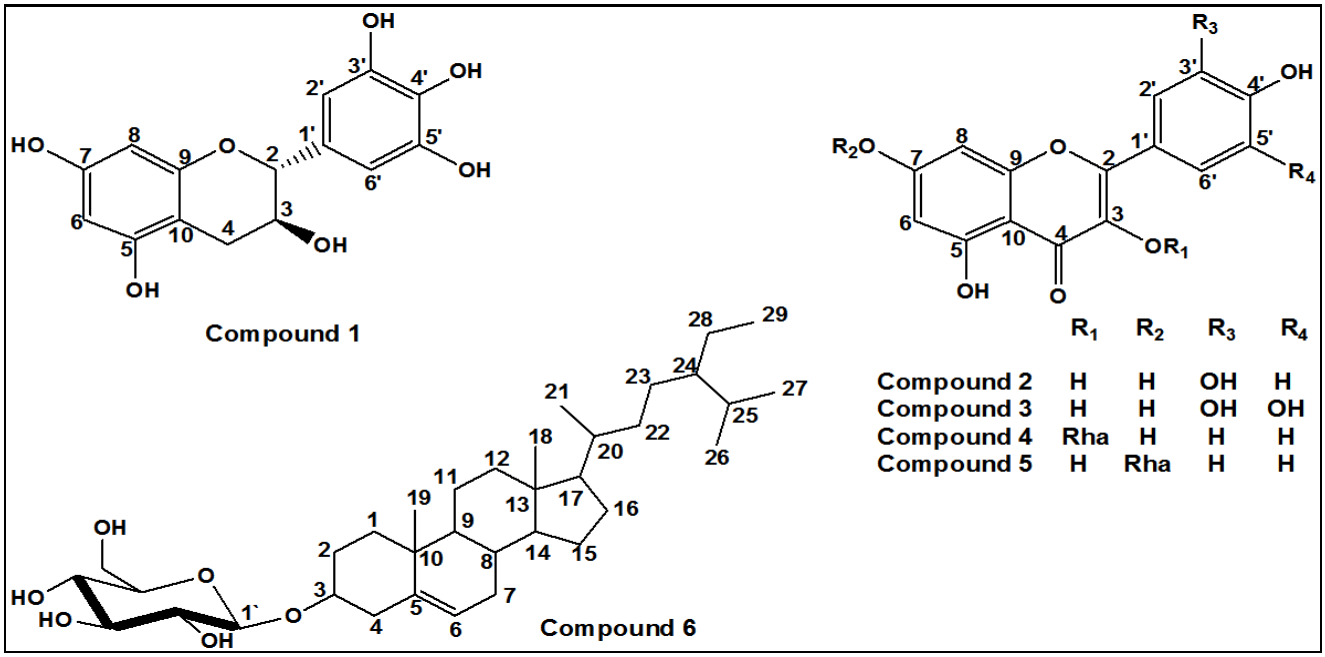

Fig 1: Compounds 1-6

Compound 1 was isolated as yellow needle crystals. Its UV spectrum showed absorbance maxima at 224 and 282 nm characteristic for a flavan-3-ol [20]. The ESI-MS of [1] showed a molecular ion peak at *m/z* 307 $[M+H]^+$, indicated the molecular formula $C_{15}H_{14}O_7$. The ^1H NMR spectrum of 1 clearly showed signals characteristic for gallocatechin; δ 5.91 (1H, H-6) and 5.86 (1H, H-8) of the A ring, δ 6.41 (2H, s, H-2`, 6`) indicative of a 3`, 4`, 5`-substituted B ring, δ 4.51 (d, *J* = 7.6 Hz, H-2), 3.96 (m, H-3), 2.82 (dd, *J* = 5.3, 16.0 Hz, H-4α) and 2.51 (dd, *J* = 7.6, 16.0 Hz, H-4β) of C ring protons. The ^{13}C NMR spectrum of 1 showed 13 signals of gallocatechin (Table 2) of which upfield carbon signals associated with the heterocyclic C ring at δ 28.0 (C-4), 68.7 (C-3) and 82.8 (C-2) were observed. The large coupling constants between H-2 and H-3 and H-3 and H-4 (7.6 Hz) and the pronounced downfield shifts for C-2 (δ 82.8) and C-3 (δ 68.7) versus those reported for epigallocatechin indicating a 2, 3-*trans* stereochemistry [21]. On the bases of the mentioned data and comparison with literatures, compound 1 was identified as gallocatechin [21].

Compounds 2 and 3 were obtained as fine yellow crystals while 4 and 5 were obtained as pale yellow amorphous powder. IR of compounds 2-5 showed the same absorption patterns, suggesting the presence of hydroxyl and carbonyl groups. In addition, their UV absorption patterns were nearly identical to each other and similar to those of flavonoids [20]. The EIMS of 2 and 3 showed peaks corresponding to $[M]^+$ at *m/z* 302 and 318, showing the molecular formula of 2 to be $C_{15}H_{10}O_7$ and that of 3 to be $C_{15}H_{10}O_8$ which were in accordance with quercetin and myricetin, respectively. The ESIMS of 4 and 5 showed the same molecular ions $[M+H]^+$ at *m/z* 432, which were in accordance with kampferol rhamnosides and appropriate for the molecular formula $C_{21}H_{20}O_{10}$.

The ^1H NMR spectrum of 2 (Table 1) showed two *meta*–coupled protons at δ 6.17 (1H, d, *J*=2.4 Hz, H-6) and 6.39 (1H, d, *J*=1.8 Hz, H-8) of A ring and a typical ABX system at δ 7.65 (1H, d, *J*=1.8 Hz, H-2`), 7.52 (1H, dd, *J*=8.4, 2.3 Hz, H-6`) and 6.86 (1H, d, *J*=8.4 Hz, H-5`) corresponding to three aromatic protons of B ring. The ^{13}C NMR spectrum of 2 revealed the presence of 15 carbon signals (Table 2), characteristics for quercetin. On the bases of the above data and comparison with those of quercetin [22, 23], compound 2 was distinguished as quercetin.

The ^{1}H NMR spectrum of 3 showed two *meta*–coupled protons at δ 6.13 (brs, H-6) and 6.34 (brs, H-8) of A ring and one singlet at δ 7.17 (H-2`, 6`), corresponding to the two equivalent protons of a 3`, 4`, 5`-substituted B ring. The $^{13}$C NMR spectrum of 3 revealed the presence of 13 carbon signals, from which two signals were corresponding to two pairs of equivalent carbons at δ 146.02 (C-3`, 5`) and 107.53 (C-2`, 6`). The ^{1}H NMR and ^{13}C NMR spectral data of 3 were consistent with those reported for myricetin [24, 25].

The ^{1}H NMR spectra of 4 and 5 showed the expected kaempferol rhamnoside proton pattern of signals. Two *meta*-coupled protons were assigned to H-6 and H-8 of A ring and the disubstituted aromatic B ring appeared as AA`BB` spin system each 2H, J_{AB}= 8.4 Hz (Table 1). ^{13}C NMR spectral analysis further confirmed the structure of 4 and 5. It displayed 19 signals but it was obvious that two signals at δ 130.6 (C-2`, 6` of 4) and 115.4 (C-3`, 5` of 4) and 130.5 (C-2`, 6` of 5) and 116.2 (C-3`, 5` of 5) had intensities suggesting that they represent two carbons each (Table 2). The ^{1}H NMR spectra of 4 and 5 exhibited one anomeric proton signal of rhamnose at δ 5.28 (brs, H-1`` of 4) and 5.0 (brs, H-1`` of 5). In addition the appearance of the strong sharp doublet signal for the secondary CH_3 of rhamnose at δ 0.78 (*J* = 6.0 Hz, H-6`` of 4) and 1.15 (*J* = 6.4 Hz, H-6`` of 5) confirmed the rhamnose unit. The ^{13}C NMR spectra of 4 and 5 also revealed that sugar moiety consisted of one molecule of rhamnose, based on the existence of one anomeric carbon signal at δ 101.8 (C-1`` of 4) and 95.4 (C-1`` of 5) and the signals at δ 17.5 and 18.0 for C-6`` of rhamnose of 4 and 5, respectively. Acid hydrolysis of 4 and 5 afforded L-rhamnose as sugar components and kampferol as the aglycon by comparison with authentic samples. The rhamnose was determined to be in the pyranose form from its ^{13}C NMR data. Furthermore the anomeric configurations for the sugar moiety was fully defined from its chemical shift and $^{3}J_{H1,\ H2}$ coupling constant. Accordingly the rhamnose was established to be in the *α*-configuration [26]. The only difference between 4 and 5 is the site of rhamnosylation. It was established that 4 is rhamnosylated at C-3 position and 5 is rhamnosylated at C-7 position. Rhamnosylation at the 3-hydroxyl of kaempferol in 4 was deduced from the UV shift reagents (see experimental) and from the upfield shift of the C-3 (δ 134.2) carbon resonance and the recognized downfield shift of the C-2 (δ 157.3) carbon resonance as compared with 5. Furthermore, an HMBC correlation between the anomeric proton of rhamnose (δ 5.28) and C-3 (δ 134.2) of the aglycon clearly revealed the rhamnose unit attached to the C-3 carbon in the kaempferol moiety in 4. Similarly, rhamnosylation at the 7-hydroxyl of kaempferol in 5 was deduced from the UV shift reagents (see experimental) and from the HMBC long-range correlation observed between the anomeric proton of rhamnose (δ 5.0) and C-7 (δ 165.3) of the aglycon. Thus, compounds 4 and 5 were identified as kaempferol-3-*O*-α-rhamnoside and kaempferol-7-*O*-α-rhamnoside, respectively, and in good agreement with the reported literatures [23, 27].

Compound 6 was obtained as a white powder. It displayed a $[M+H]^+$ ion at *m/z* 577 in ESI-mass spectrum, consistent with the molecular formula $C_{35}H_{60}O_6$. Its IR spectrum indicating the presence of hydroxyl and C=C groups. The ^{1}H NMR spectrum displayed signals for an olefinic proton (H-6) at δ 5.3, H-3 at δ 3.4 (*m*), Me-18 at δ 0.63 (*s*), Me-19 at δ 0.93 (*s*), Me-21 at δ 0.87 (*d, J* = 6.5 Hz), Me-27 at δ 0.76 (*d, J* = 6.5 Hz), Me-26 at δ 0.80 (*d, J* = 56. Hz) and Me-29 at δ 0.78 (*t, J* = 7.0 Hz) were also observed. The presence of a sugar moiety in the molecule attested due to the presence of an anomeric proton at δ 4.18 (*d, J* = 7.5 Hz), and an anomeric carbon at δ 100.74 in NMR spectra. Acid hydrolysis of 6 furnished β-sitosterol as aglycon and glucose as a sugar component identified by co-TLC analysis with authentic samples. The ^{13}C NMR spectrum showed 35 signals, 29 were assigned for the aglycon and 6 were assigned for the sugar moiety. These spectral data and by comparison with literature 6 was identified as β-sitosteryl-3-*O*-*β*-glucopyranoside (Daucosterol) [28, 29].

Table 1: ^{1}H NMR spectral data of compounds **1-5**.

	^{1}H (*J* in Hz)				
Position	**1**	**2**	**3**	**4**	**5**
2	5.41, d, 7.6	-	-	-	-
3	3.96, m	-	-	-	-
4a 4b	2.82, dd, 16.05, 5.3 2.51, dd, 16.05, 7.6	-	-	-	-
6	5.91, d, 2.3	6.18, d, 1.6	6.13, brs	6.21, brs	6.05, brs
8	5.86, d, 2.3	6.41, d, 1.6	6.34, brs	6.41, brs	6.25, brs
2`	6.41, s	7.67, brs	7.17, s	7.74, d, 8.4	7.92, d, 8.4
3`	-	-	-	6.90, d, 8.4	6.78, d, 8.4
5`	-	6.89, d, 8.4	-	6.90, d, 8.4	6.78, d, 8.4
6`	6.41, s	7.55, d, 8.4	7.17, s	7.74, d, 8.4	7.92, d, 8.4
1``	-	-	-	5.28, brs	5.0 , brs
2``-5``	-	-	-	3.07-3.66	3.21-3.80
6``	-	-	-	0.78, d, 6.0	1.15, d, 6.4
5-OH	-	12.49, brs		12.62, brs	-

Table 2: ^{13}C NMR spectral data of compounds **1-5**.

Position	1	2	3	4	5
2	82.8	147.2	147.1	157.3	148.0
3	68.7	136.1	136.1	134.2	136.9
4	28.0	176.2	176.0	177.7	177.1
5	157.5	161.1	160.9	161.3	162.1
6	96.3	98.6	98.6	98.8	99.2
7	157.7	164.3	164.4	164.3	165.3
8	95.5	93.8	93.7	93.8	94.4
9	156.8	156.5	156.4	156.5	158.0
10	100.7	103.4	103.2	104.1	104.4
1`	131.5	122.4	121.1	120.5	123.5
2`	107.2	115.4	107.5	130.6	130.5
3`	146.8	145.5	146.0	115.4	116.2
4`	133.9	148.1	136.2	160.0	160.2
5`	146.8	116.0	146.0	115.4	116.2
6`	107.2	120.4	107.5	130.6	130.5
1``	-	-	-	101.8	95.4
2``	-	-	-	70.6	72.9
3``	-	-	-	70.3	72.0
4``	-	-	-	71.2	74.0
5``	-	-	-	70.1	69.0
6``	-	-	-	17.5	18.0

3.1 Antioxidant activity

In this paper, the scavenging activities of the alcoholic extract of *R. tripartita* toward the DPPH (1, 1-diphenyl-2-picrylhydrazyl) radical were determined (Table 3). In comparison with the value of quercetin, the alcoholic extract showed a higher antioxidant activity with IC_{50} values of 16.80µg/mL.

3.2 Antimalarial activity

The alcoholic extract of *R. tripartita* as compared with chloroquine, appeared to be very active against both chloroquine-sensitive and chloroquine-resistant strains of *Plasmodium falciparum* with IC_{50} values of 3.9µg/mL without showing any cytotoxicity to mammalian cells (Table 3).

Table 3: Antioxidant and antimalarial activities of the alcoholic extract

Samples	Antioxidant activity (IC_{50} µg/mL)	Antimalarial activity (IC_{50} µg/mL)
alcoholic extract	16.80	3.9
Quercetin	37.08	-
Chloroquine	-	

3.3 Antimicrobial activity

The alcoholic extract was evaluated for its antimicrobial activity. It showed activity against methicillin resistant *Staphylococcus aureus* (MRSA) and *Staphylococcus aureus* (non-MRSA) with IC_{50} values of 10.5 and 11.2µg/mL, respectively.

4. Acknowledgment

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