

Antibacterial and Antioxidant Activities of *Synedrella nodiflora* (L.) Gaertn. (Asteraceae)

by Sumi Wijaya

| | | | |
|----------------|-----------------------------------|-----------------|-------|
| FILE | 1-ANTIBACTERIAL_AND.PDF (401.44K) | WORD COUNT | 5093 |
| TIME SUBMITTED | 05-DEC-2019 02:15PM (UTC+0700) | CHARACTER COUNT | 26955 |
| SUBMISSION ID | 1227565169 | | |

Journal of Complementary and Integrative Medicine

Volume 8, Issue 1

2011

Article 13

Antibacterial and Antioxidant Activities of *Synedrella nodiflora* (L.) Gaertn. (Asteraceae)

Sumi Wijaya, *The University of Nottingham Malaysia
Campus*

Ting Kang Nee, *The University of Nottingham Malaysia
Campus*

Khoo Teng Jin, *The University of Nottingham Malaysia
Campus*

Lim Kuan Hon, *The University of Nottingham Malaysia
Campus*

Loh Hwei San, *The University of Nottingham Malaysia
Campus*

Christophe Wiart, *The University of Nottingham Malaysia
Campus*

Recommended Citation:

Wijaya, Sumi; Nee, Ting Kang; Jin, Khoo Teng; Hon, Lim Kuan; San, Loh Hwei; and Wiart, Christophe (2011) "Antibacterial and Antioxidant Activities of *Synedrella nodiflora* (L.) Gaertn. (Asteraceae)," *Journal of Complementary and Integrative Medicine*: Vol. 8: Iss. 1, Article 13.
DOI: 10.2202/1553-3840.1499

Antibacterial and Antioxidant Activities of *Synedrella nodiflora* (L.) Gaertn. (Asteraceae)

Sumi Wijaya, Ting Kang Nee, Khoo Teng Jin, Lim Kuan Hon, Loh Hwei San,
and Christophe Wiart

Abstract

The hexane, ethyl acetate, ethanol and water extracts of *Synedrella nodiflora* (L.) Gaertn. (Asteraceae) were assessed for their antibacterial and antioxidant capacities. The antioxidant capacities were evaluated using the ferric reducing antioxidant power (FRAP) and β -carotene bleaching assays. The antimicrobial activities were assessed using the classical pour-plate disc diffusion, minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC) and death kinetic assays, against six bacterial strains. The ethanol extract displayed significant antioxidant capacities both in the FRAP and β -carotene bleaching assays. The ethanol extract abrogated the growth of all the bacteria tested. Folin-Ciocalteu and aluminium chloride spectrometry assays indicated the presence phenolic compounds, including flavonoids in the ethanol extract.

KEYWORDS: antibacterial, antioxidant, Asteraceae, *Synedrella nodiflora*

Author Notes: The first author would like to thank the Indonesian Government for financing the study.

1. Introduction

The Asteraceae family consists of herbs which are known to accumulate substantial amount of flavonoids and to display anti-inflammatory, antioxidant, antimicrobial, analgesic and antipyretic properties (Odom, et al., 2000). *Synedrella nodiflora* (L). Gaertn. (Asteraceae) or Cinderella weed, is native to tropical America and grows in Malaysian plantation crops (Holm, et al., 1997).

Traditionally, the leaves are used as poultice for rheumatism and the juice of the leaves is used for earache in India (Rathi & Gopalakrishnan, 2006). In Ghana, this weed is used for the treatment of epilepsy and pain (Idu & Onyibe, 2007). In Nigeria, the plant is used to heal putrefied wounds (Burkill, 1985). In Malaysia and Indonesia, the plant is used for headaches, earaches, stomachaches and rheumatism (Woode, et al., 2010).

Extracts of *Synedrella nodiflora* (L). Gaertn. displayed anti-inflammatory, analgesic, antinociceptive, antipyretic and insecticidal properties (Abad, et al., 1996; Forestieri, et al., 1996; Rathi & Gopalakrishnan, 2006; Woode, et al., 2010). The aim of the present study is to demonstrate that the antiseptic and anti-inflammatory uses of *Synedrella nodiflora* (L). Gaertn. are owed to antibacterial and antioxidant phenolic compounds including flavonoids.

Epidemiological studies indicate that dietary antioxidants are highly associated with reduced risks of chronic diseases such as heart disease, cancer, diabetes, neurological disease, immune diseases, and eye diseases (Willcox, et al., 2004; Temple, 2000; Slavin, et al., 1997; Grundman, 1997; Block, et al., 1992). According to Sanchez-Moreno et al. (1999), natural antioxidants from plants have become a prominent area of scientific research, as plants offer a wide range of secondary metabolites with high antioxidant potential.

According to the World Health report of infectious diseases 2000, overcoming antibiotic resistance is one of the major issues of the WHO for the present millennium. Hence, the last decade witnessed an increase in the investigation of plants as a source of human disease management (Prashanth, et al., 2001). Plant synthesizes a broad array of secondary metabolites, which play a key role in the natural defence mechanism against microorganisms and insects (Cowan, 1999). Traditional medicine derived from plants source are still used to treat various infectious diseases (Rios & Recio, 2005).

2. Materials and Methods

2.1. Plants collection and extraction

Synedrella nodiflora (L.) Gaertn. was collected in Broga, Selangor, Malaysia. A Voucher specimen (UNMC51W) was deposited in the herbarium of the School of

Pharmacy, Faculty of Science, University of Nottingham Malaysia Campus. The air-dried and finely milled sample (300 g) was extracted by hexane (the extract yield was 4.05 %), ethyl acetate (1.21 %), ethanol (3.66 %) and water (3.51 %) sequentially. The extracts were concentrated using rotary evaporator (Buchi, USA) under reduced pressure at 47 °C. Dried extracts were kept at -20 °C until further tests. For stock solutions, 100 mg/mL of each extract was dissolved in DMSO (dimethyl sulfoxide).

2.2. Antioxidant activity

2.2.1. Ferric reducing power antioxidant (FRAP) assay

The antioxidant activity of the extracts was estimated by the FRAP method of Benzie & Strain (1996) with slight modifications. The working FRAP reagent was prepared freshly by mixing 300 mM acetate buffer (pH 3.6), 10 mM 2,4,6-tripyridyl-s-triazine (TPTZ) and 20 mM $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ in a 10:1:1 ratio. Briefly, 30 μL of the FRAP reagent was mixed with 20 μL of the test sample, so the final dilution of the test sample in the reaction mixture was 1/10. Readings were taken after 90 minutes (at 600 nm) using spectrophotometer (Dynex MRX-Revelation, USA). Fe(II) concentrations in the range 1 μM – 125 μM ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) were used for calibration. Trolox and quercetin were used as positive controls. FRAP value was calculated as Ferrous Equivalents, the concentration of trolox/quercetin or extracts which produced an absorbance value equal to that of 1 mM FeSO_4 .

2.2.2. β -Carotene bleaching assay

β -Carotene bleaching assay was conducted according to Miller (1971) with some modifications. A solution of β -carotene was prepared by dissolving 2 mg of β -carotene in 10 mL chloroform. Two mL of this solution was pipetted into a 100 mL round-bottom flask. After the chloroform was removed at 22-30 °C under vacuum, 40 mg of linoleic acid, 400 mg of tween 80, and 100 mL of distilled water were added to the flask with vigorous shaking. A 96-wells microtiter plate was used for this method. As soon as the emulsion was added to each well, the zero time absorbance was measured at 490 nm using spectrophotometer (Dynex MRX-Revelation, USA). Absorbance readings were recorded at 20 min intervals for 240 minutes. A blank, devoid of β -carotene, was prepared for background subtraction. Percentage of antioxidant activity (AA) was calculated using the following equation (Mayachiew & Devahastin, 2008): % AA = ((DR control-DR sample) / DR control) x 100, where DR is degradation rate of sample ($\text{DR} = \ln(\text{initial absorbance (490 nm) at time zero}) / (\text{absorbance at 240 minutes}) / t$ (time in minutes)). EC_{50} (the concentration exhibiting 50 % of the percentage

antioxidant activity) of samples were calculated from the graph of antioxidant activity percentage against concentration of the extracts.

2.3. Antibacterial properties

Six strains of human pathogenic bacteria were used in this assay. Two Gram-negative: *Citrobacter freundii* ATCC 8299 and *Escherichia coli* ATCC 8739 and four Gram-positive: *Staphylococcus aureus* ATCC 11632, *Staphylococcus epidermidis* ATCC 12228, *Bacillus subtilis* ATCC 6633 and *Bacillus cereus* ATCC 11778 were used.

2.3.1. Pour-plate disc diffusion method

The antibacterial activity was carried out using the pour-plate disc diffusion method. The soft Mueller Hinton Agar (MHA) inoculated with 100 µL of inocula (1×10^8 microorganism/mL) was spread on MHA. Sterile filter paper discs (6 mm) were impregnated with plant extracts (5 mg and 3 mg) before they were placed on the surface of the inoculated agar plates. The plates were incubated at 37°C for 24 hours (Mayachiew & Devahastin, 2008). The results were obtained by measuring the inhibition zone diameter around the paper disc with a calliper. The experiment was carried out in duplicate in three independent experiments and the results were presented as diameter zone of inhibition \pm SD (standard deviation). Streptomycin (1 µg), tetracyclin (1 µg) and ampicillin (1 µg) were used as antibiotic controls.

2.3.2. Determination of minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC)

This assay was conducted according to Ozturk & Ercisli (2006). The extracts were prepared at the concentration ranging from 23 µg/mL to 3000 µg/mL in a 96-well micro plate. Each well were inoculated with 5×10^5 microorganism/mL. The micro plate wells were incubated on an incubator shaker at 180 rpm at 37°C for 24 hours. The turbidity of the well indicated the level of the growth of bacteria. The turbidity was measured by reading the absorbance at 600 nm using spectrophotometer (Dynex MRX-Revelation). The MIC of each extract was recorded as the lowest concentration that showed no growth. The extracts tested on this study were done in three independent experiments for each microorganism. Serial dilution of streptomycin (0.78125-100 µg/mL), ampicillin (0.78125-100 µg/mL) and tetracycline (0.15625-20 µg/mL) were used as standard drugs.

From MIC result, 10 µL were taken and spread on MHA. The number of colony was counted after 18 hours - 24 hours of incubation at 37° C as a result for MBC value.

2.3.3. Death kinetic assay

From the stock solution, a required volume of plant extracts was pipetted into MHB to obtain a concentration range of 0.01 mg/mL up to 10 mg/mL. Readings of the absorbance were taken at 0 min and every 30 minutes for 16 hours. EC₅₀ values of the plant extracts, which is the concentration of sample (plant extracts or antibiotics) that kills 50 % of the population of microorganism, was calculated from the graph of dose against percentage of survival index (SI) (Noga, et al., 1994).

$$SI = \frac{OD_{600} \text{ of test sample at corresponding time point}}{OD_{600} \text{ at mid-log of control bacterial growth}} \times 100$$

2.4. Phytochemical screening

Phytochemical analysis was carried out according to Odebiyi & Sofowora (1978) and Trease & Evans (1989).

2.5. Total phenolic contents

The total phenolic contents of *Synedrella nodiflora* (L.) Gaertn. was determined using Folin-Ciocalteu assay, as described by Slinkard and Singleton (1977). Briefly, 20 µL of diluted extracts (1 mg/mL) were mixed with 1.58 mL of water and 100 µL of Folin-Ciocalteu reagent. After standing for 5 minutes at room temperature, 170 µL of sodium carbonate (20 % w/v) were added. The solutions were mixed and allowed to stand for 30 minutes at 40° C. Changes in absorbance were determined at 765 nm against the blank using a UV-Vis Spectrophotometer (Biochrom LibS12, USA). Gallic acid (50, 100, 150, 250 mg/mL) was used as a calibration standard curve. Results were expressed in mg gallic acid equivalents/g of sample.

2.6. Total flavonoid contents

Estimation of total flavonoid contents in the plant extracts was carried out using the method described by Froehlicher et al. (2009). The flavonoid amount was expressed in mg of quercetin/g of plant extracts.

16

2.7. Statistical analysis

All data were expressed as mean \pm standard deviation. Data were analyzed using one way anova followed by Tukey test using GraphPad Prism5 software. A significant difference was considered at the level of $P < 0.05$.

3. Results

3.1. Antioxidant properties

The reducing ability of the *Synedrella nodiflora* (L.) Gaertn. extracts was in the range of 1.21 mg/mL – 18.88 mg/mL. The water extract exhibited the strongest reducing ability, with a value of 1.24 mg/mL (Table 1). The rank order of potency observed in the β -carotene bleaching assay was trolox > quercetin > ethanol > water > ethyl acetate > hexane extract.

10

Table 1

Antioxidant properties, total phenolic contents (TPC), and total flavonoid contents (TFC) of plant extracts

| Sample | FRAP assay | β -carotene bleaching assay |
|---------------|-------------------------------|-----------------------------------|
| | FRAP value (mg/mL) | EC ₅₀ (mg/mL) |
| Hexane | 18.88 \pm 0.01 ^c | 170.2 \pm 0.83 ^c |
| Ethyl acetate | 3.94 \pm 0.02 ^d | 16.68 \pm 0.44 ^d |
| Ethanol | 1.21 \pm 0.06 ^{cb} | 0.29 \pm 0.15 ^a |
| Water | 1.89 \pm 0.08 ^c | 6.15 \pm 0.34 ^b |
| Trolox | 1.14 \pm 0.02 ^{ca} | 0.05 \pm 0.17 ^a |
| Quercetin | 1.31 \pm 0.02 ^c | 0.13 \pm 0.17 ^a |

Data were obtained from three independent experiments, each performed in triplicates (n=9) and represented as mean \pm SD. Data with different letters in the individual plant extracts are significantly different (< 0.05) according to Tukey multiple comparison test

3.2. Antibacterial properties

Table 2
Inhibition zone diameter of *Synedrella nodiflora* (L.) Gaertn. extracts

| Sample | Dose (mg) | Inhibition zone (mm) | | | | | |
|---------------|-----------|----------------------|--------------|--------------|-------------|--------------|--------------|
| | | Ec | Cf | Sa | Se | Bs | Bc |
| Hexane | 1 | 6.00 ± 0.00 | 6.58 ± 0.19 | 8.55 ± 1.19 | 6.48 ± 0.49 | 6.65 ± 1.04 | 7.41 ± 0.67 |
| | 3 | 7.25 ± 1.45 | 6.55 ± 0.47 | 8.43 ± 1.77 | 6.98 ± 0.30 | 9.17 ± 1.59 | 7.75 ± 1.71 |
| Ethyl acetate | 1 | 6.00 ± 0.00 | 6.45 ± 0.53 | 9.46 ± 1.29 | 6.68 ± 0.42 | 6.90 ± 0.98 | 7.82 ± 1.32 |
| | 3 | 6.00 ± 0.00 | 6.68 ± 0.31 | 7.45 ± 0.97 | 7.15 ± 1.05 | 7.30 ± 1.01 | 6.98 ± 0.33 |
| Ethanol | 1 | 6.30 ± 0.36 | 6.54 ± 0.36 | 9.20 ± 1.95 | 6.90 ± 0.54 | 6.58 ± 0.76 | 7.15 ± 0.85 |
| | 3 | 7.75 ± 2.18 | 6.78 ± 0.31 | 11.65 ± 1.21 | 7.28 ± 1.76 | 9.37 ± 1.10 | 7.80 ± 1.43 |
| Water | 1 | 6.00 ± 0.00 | 6.00 ± 0.00 | 6.00 ± 0.00 | 6.00 ± 0.00 | 6.43 ± 0.85 | 7.53 ± 1.39 |
| | 3 | 7.13 ± 0.90 | 6.58 ± 0.15 | 7.90 ± 1.69 | 6.00 ± 0.00 | 7.47 ± 0.75 | 7.88 ± 1.59 |
| S | 0.1 | 11.40 ± 0.66 | 12.70 ± 0.26 | 6.60 ± 1.41 | 6.00 ± 0.00 | 16.44 ± 0.54 | 14.47 ± 1.25 |
| A | 0.1 | 7.07 ± 0.62 | 6.00 ± 0.00 | 10.45 ± 0.69 | 9.42 ± 0.45 | 10.77 ± 1.24 | 6.00 ± 0.00 |
| T | 0.1 | 15.89 ± 1.68 | 21.21 ± 1.38 | 20.64 ± 1.39 | 6.00 ± 0.00 | 24.15 ± 0.97 | 20.20 ± 1.85 |

Data were obtained from three independent experiments where each experiment done in duplicate

Ec: *Escherichia coli*; Cf: *Citrobacter freundii*; Sa: *Staphylococcus aureus*; Se: *Staphylococcus epidermidis*; Bs: *Bacillus subtilis*; Bc: *Bacillus cereus*; S: Streptomycin; A: Ampicillin; T: Tetracycline

Table 3
Minimum inhibitory concentrations and Minimum bactericidal concentration
value of *Synedrella nodiflora* (L.) Gaertn. extracts

| Sample | ^a MIC and ^b MBC value (mg/mL) | | | | | |
|--------|---|-------------------------|------------------------|-------------------------|-------------------------|--|
| | Cf | Sa | Se | Bs | Bc | |
| HE | n.a | 3 | n.a | 1.5 | 3 | |
| EAE | 6 | n.a | n.a | 6 | 0.38 | |
| EE | 6 | 6 | 6 | 6 | 0.75 | |
| WE | n.a | n.a | n.a | n.a | n.a | |
| S | 6.25 x 10 ⁻³ | 3.13 x 10 ⁻³ | 2.5 x 10 ⁻² | 3.13 x 10 ⁻³ | 3.13 x 10 ⁻³ | |
| A | 0.1 | 3.13 x 10 ⁻³ | 0.05 | 6.25 x 10 ⁻³ | 0.1 | |
| T | 2.5 x 10 ⁻³ | 2.5 x 10 ⁻³ | 2 x 10 ⁻² | 2.5 x 10 ⁻² | 3.1 x 10 ⁻⁴ | |

^aMIC: Minimum inhibitory concentration

^bMBC: Minimum bactericidal concentration

Data were obtained from three independent experiments

Ec: *Escherichia coli*; Cf: *Citrobacter freundii*; Sa: *Staphylococcus aureus*; Se: *Staphylococcus epidermidis*; Bs: *Bacillus subtilis*; Bc: *Bacillus cereus*; HE: Hexane extract; EAE: Ethyl acetate extract; EE: Ethanol extract; WE: Water extract; S: Streptomycin; A: Ampicillin; T: Tetracycline; n.a: not active.

Table 4
EC₅₀ value of *Synedrella nodiflora* (L.) Gaertn. extracts

| Sample | EC ₅₀ (mg/mL) | |
|--------|---------------------------------------|----------------------------------|
| | <i>Staphylococcus aureus</i> (Gram +) | <i>Escherichia coli</i> (Gram -) |
| HE | 1.98 | 1.60 |
| EAE | 8.13 | 1.59 |
| EE | 1.84 | 1.47 |
| WE | 1.86 | 3.03 |
| S | 1.15×10^{-3} | 3.13×10^{-3} |
| A | 2.25×10^{-3} | 9.52×10^{-2} |
| T | 0.34×10^{-3} | 1.35×10^{-3} |

EC₅₀ is the concentration of sample (plant extracts or antibiotics) that kills 50% of the population of microorganism. Data were obtained from two independent experiments.

HE: Hexane extract; EAE: Ethyl acetate extract; EE: Ethanol extract; WE: Water extract; S: Streptomycin; A: Ampicillin; T: Tetracycline

The largest inhibition zones were obtained with the ethanol extract (Table 2). MIC and MBC values for all the extracts tested were in the range 0.38 mg/mL – 6 mg/mL (Table 3). The ethanol extract abrogated the survival of 5 of the 6 bacterial strain tested and was mostly active against *Bacillus* species. *Staphylococcus aureus* (Gram-positive) and *Escherichia coli* (Gram-negative) were used for death kinetic assay. In this assay, the ethanol extract gave the lowest EC₅₀ value 1.84 mg/mL against *Staphylococcus aureus* and 1.47 mg/mL against *Escherichia coli*, respectively (Table 4).

3.3. Phytochemical screening

Table 5
Phytochemical screening of *Synedrella nodiflora* (L.) Gaertn. extracts

| Sample | Alkaloid | Flavonoid | Phenol | Tannin | Steroid | Triterpenoid | Saponin |
|--------|----------|-----------|--------|--------|---------|--------------|---------|
| HE | - | + | - | + | - | + | - |
| EAE | - | + | + | + | - | - | - |
| EE | - | + | +++ | - | - | - | - |
| WE | - | + | ++ | - | - | - | - |

HE: Hexane extract; EAE: Ethyl acetate extract; EE: Ethanol extract; WE: Water extract; S: Streptomycin; A: Ampicillin; T: Tetracycline
 -: Negative (absent); +: Positive (Slightly present); ++: Positive (Moderately present); +++: Positive (Considerably present)

Phytochemical screening of *Synedrella nodiflora* (L.) Gaertn. extracts revealed the presence of phenolic compounds (tannins and flavonoids) and triterpenoids (Table 5). The total phenolic contents assay showed that the ethanol extract had the highest phenolic contents with the value of 521 mg/g gallic acid equivalent (Table 6). The standard curve of gallic acid obtained was $y = 0.0011x + 0.0018$ ($R^2 = 0.9996$), with x as the concentration of gallic acid (mg/mL). The flavonoid contents was measured by the aluminium chloride spectrometry method, using quercetin as a standard ($y = 0.0207x - 0.0202$; $R^2 = 0.9993$, with x as the concentration of quercetin in mg/mL). Most flavonoids were found in the ethanol extract (Table 6).

Table 6
Total phenolic (TPC) and total flavonoid content (TFC) of *Synedrella nodiflora* (L.) Gaertn. extracts

| Sample | TPC | TFC |
|---------------|---------------------------------|-------------------------------|
| | [Gallic acid Equivalent (mg/g)] | [Quercetin Equivalent (mg/g)] |
| Hexane | 69 ± 0.00 ^a | 0.98 ± 0.00 ^a |
| Ethyl acetate | 272 ± 0.01 ^a | 1.62 ± 0.00 ^a |
| Ethanol | 521 ± 0.01 ^a | 2.18 ± 0.00 ^a |
| Water | 486 ± 0.00 ^a | 0.98 ± 0.00 ^b |

Data were obtained from three independent experiments, each performed in triplicates (n=9) and represented as mean ± SD.

^a Values with the same superscript letter are significantly different ($P < 0.05$) according to Tukey multiple comparison test.

4. Discussion

In recent years, much attention has been devoted to natural antioxidants and their association with health benefits (Arnous, et al., 2001). Antioxidants are one of the primary defence mechanisms employed to combat the damaging effects of free radicals (Bunger, et al., 2006). In this study, the antioxidant properties of *Synedrella nodiflora* (L.) Gaertn. extracts were determined using the FRAP and β -carotene bleaching assays. The ethanol extracts displayed significant antioxidant activities. According to the “polar paradox” lipid oxidation occurs at the water/oil interface, where lipophilic antioxidants are located, the more hydrophilic of the sample would have shown a lower antioxidant activity. However, in our study, using β -carotene bleaching assays the crude ethanol extract exhibited higher antioxidant activity than the ethyl acetate and hexane extracts. This might be due to the value of total phenolic and total flavonoid contents in the ethanol extract which is higher than the hexane and ethyl acetate extracts.

Infectious diseases represent a serious health problem worldwide today, mostly due to the resistance of antibiotics. In this study, two doses (1 mg and 3 mg) of *Synedrella nodiflora* (L.) Gaertn. extracts were used in the pour-plate disc diffusion assay. Increasing doses showed increasing antibacterial activity. The ethanol extract was the most active and exhibited inhibition zone diameters superior to 7 mm. According to Gislene et al. (2000), any chemicals that have antibacterial activity with zones of inhibition of 7 mm and above can be considered as potential antimicrobial candidates. Most extracts of *Synedrella nodiflora* (L.) Gaertn. were active against *Staphylococcus aureus* and *Bacillus cereus* were inactive against *Citrobacter freundii*.

According to Fabry, et al (1998), crude extracts are considered as potentially useful therapeutically if they have MIC values < 8 mg/mL. The MIC and MBC values of *Synedrella nodiflora* (L.) Gaertn. ethanol extract were equal and in the range 0.75 mg/mL – 6 mg/mL. In the death kinetic assay, the ethanol extract had the lowest EC_{50} against *Escherichia coli* and *Staphylococcus aureus*. Overall, our results indicate that the crude extracts were more effective against Gram-positive bacteria than Gram-negative bacteria (Greenberg, et al., 2008). Among them, the ethanol extract negated the growth of all the bacteria tested.

To explore the correlation between secondary metabolites and the biological activities, phytochemical testing of the extracts were conducted. Phenolic compounds (tannins and flavonoids) and triterpenoids were detected. The high concentration of phenolic compounds in the ethanol extract explains the antioxidant and antibacterial activities recorded.

Several reports emphasize on the fact that there is a positive relationship between total phenols and antioxidant activity (Robards, et al., 1999; Oktay, et al., 2003; Ferreira, et al., 2007). In agreement to previous reports, our study revealed

the existence of a positive correlation between the total phenolic contents and FRAP value ($y = -0.0364x + 18.755$, $r^2 = 0.8383$) and total phenolic contents and β -carotene bleaching value ($y = -0.3446x + 164.46$, $r^2 = 0.7867$).

Flavonoids have strong antioxidant activities due to their ability to scavenge free radical and terminate radical chain reactions (Bors, et al., 1990). This ability allows them to interfere with the pathophysiology of inflammation (Conner & Grisham, 1996). Flavonoids have been reported to possess antibacterial properties (Havsteen, 2002). Their mode of action is based on the inhibition of the macromolecular (DNA, RNA and protein) or lipid synthesis in the bacteria (Mori, et al., 1987). Flavonoids are most efficient against Gram-positive bacteria than Gram-negative bacteria because of the lipid content of Gram-negative cell wall is greater than Gram-positive bacteria (Klancnik, et al., 2009; Cushnie & Lamb, 2005). The present study suggests that the ethanol extract of *Synedrella nodiflora* (L.) Gaertn. has antioxidant and antibacterial properties on account of phenolic compounds, of which flavonoids. The present results substantiate the antiseptic and anti-inflammatory traditional uses of the plant.

5. Conclusion

Extracts of *Synedrella nodiflora* (L.) Gaertn. displayed promising antimicrobial and antioxidant activities. Total phenolic and flavonoid contents showed a positive correlation with the antioxidant activities exhibited. The present study demonstrates that the ethanol extract of *Synedrella nodiflora* (L.) Gaertn. has antioxidant and antibacterial properties on account of phenolic compounds, of which flavonoids.

References

- Abad, M.J., Bermejo, P., Carretero, E., Martinez-acitores, C., Noguero, B., Villar, A. 1996. Antiinflammatory activity of some medicinal plant extracts from Venezuela. *Journal of Ethnopharmacology*. 55: 63-68.
- Arnous, A., Makris, D.P., Kefalas, P. 2001. Effect of principal polyphenolic components in relation to antioxidant characteristics of aged red wines. *Journal of Agriculture & Food Chemistry*. 49:5736 – 5742.
- Benzie, I.F.F., & Strain, J.J. 1996. The ferric reducing ability of plasma (FRAP) as a measure of “antioxidant power”: The FRAP Assay. *Analytical Biochemistry*. 239: 70-76.
- Block, G., Patterson, B.H., Subar, A.F. 1992. Fruit, vegetables and cancer prevention: a review of the epidemiological evidence. *Nutrition and Cancer*. 18: 1-29.

- Bors, W., Heller, W., Michel, C., & Saran, M. 1990. Flavonoids as antioxidants: determination of radical scavenging efficiencies. *Methods of Enzymology*. 186: 67-103.
- Bunger, J., Ackermann, J., Jentzsch, A., Mehling, A., Pfitzner, I., Reiffen, K.A., Schroeder, K.R., Wollenweber, U. 2005. 'An interlaboratory comparison of methods used to assess antioxidant potentials'. *International Journal of Cosmetic Science*, 28, pp. 135 – 146.
- Burkill, H.M. 1985. *The useful plants of West Tropical Africa*, Vol. 1. Ithaka Harbours Incorporation. UK.
- Conner, E.M. & Grisham, M.B. 1996. Inflammation, free radicals, and antioxidants. *Nutrition*. 12: 274 -277.
- Cowan, M.M. 1999. Plants products as antimicrobial agents. *Clinical Microbiology Reviews*. 12(4): 564-582.
- Cushnie, T.P.T., & Lamb, A.J. 2005. Review: antimicrobial activity of flavonoids. *International Journals of Antimicrobial Agents*. 26: 343-356.
- Fabry, W., Okemo, P.O., Ansorg, R. 1998. Antibacterial activity of East African medicinal plants. *Journal of Ethnopharmacology*. 60: 79-84.
- Ferreira, I.C.F.R., Baptista, P., Vilas-Boas, M., & Barros, L. Free-radical scavenging capacity and reducing power of wild edible mushroom from northeast Portugal. *Food Chemistry*. 2007: 100, 1511-1516.
- Forestieri, A.M., Monforte, M.T., Ragusa, S., Trovato, A., Iauk, L. 1996. Antiinflammatory, analgesic and antipyretic activity in rodents of plant extracts used in African medicine. *Phytotherapy Research*. 10: 100-106.
- Froehlicher, T., Hennebelle, T., Martin-Nizard, F., Cleenewerck, P., Hilbert, J., Trotin, F. & Grec, S. 2009. Pheolic profiles and antioxidative effect of hawthorn cell suspensions, fresh fruits and medicinal dried parts. *Food Chemistry*. 115: 897-903.
- Gislene, G.F., Locatelli, J., Preitis, P.C. & Silva, G.L. 2000. Antibacterial activity of plant extracts and phytochemicals on antibiotic resistant bacteria. *Brazilian Journal of Microbiology*. 31(4): 20-33.
- Greenberg, M., Dodds, M. & Tian, M. 2008. Naturally occurring phenolic antibacterial compounds show effectiveness against oral bacteria by a quantitative structure – Activity relationship study. *Journal of Agriculture & Food Chemistry*. 56: 11151 – 11156.
- Grundman, M. 1997. Vitamin E and alzheimer disease: the basis for additional clinical trials. *American Journal of Clinical Nutrition*. 71S: 660S-666S.
- Havsteen, B.H. 2002. The Biochemistry and medical significance of the flavonoids. *Pharmacology and Therapeutics*. 96: 67 – 202.
- Holm, L. 1997. *Worls weeds: nature histories & distribution*. Wiley Interscience. Pp. 340-344.

- Idu, M & Onyibe, H.I. 2007. Medicinal plants of Edo state Nigeria. *Journal of Medicinal Plant Research*. 2: 32-41.
- Klancnik, A., Guzej, B., Hadolin-Kolar, M., Abramovic, H. & Smole Mozina, S. 2009. *In vitro* antimicrobial and antioxidant activity of commercial rosemary extract formulations. *Journal of Food Protection*. 72: 1744 – 1752.
- Mayachiew, P & Devahastin, S. (2008). Antimicrobial and antioxidant activities of Indian gooseberry and galangal extracts. *LWT*, 41, 1153-1159.
- Miller, H.E. 1971. A simplified method for the evaluation of antioxidants. *Journal of American Oil Chemistry Society*, 48, 91-97.
- Mori, A., Nishino, C., Enoki, N. & Tawara, S. 1987. Antibacterial activity and mode of action of plant flavonoids against *Proteus vulgaris* and *Staphylococcus aureus*. *Phytochemistry*. 26: 2231 – 2234.
- Noga, E.J., Engel, D.P., Aroll, T.W., McKenna, S., & Davidian, M. 1994. Low serum antibacterial activity coincides with increased prevalence of shell disease in blue crabs *Callinectes sapidus*. *Disease of Aquatic Organism*. 19: 121-128.
- Odebiyi, A & Sofowora, A.E. 1978. Phytochemical screening of Nigeria medicinal plants part III. *Lyoydia*. 41: 234-243.
- Odom, M.D., Richard B., William D. James, Timothy G. Berger. 2000. *Andrews' diseases of the skin: clinical dermatology*. W.B. Saunders Company. pp. 1135
- Oktay, M., Gulchin, O.I., Kufrevioglu, O. 2003. Determination of *in vitro* antioxidant activity of Fennel (*Foeniculum vulgare*) seed extracts. *Lebensm Wiss Technology*. 36: 263-271.
- Ozturk, S. & Ercisli, S. 2006. Antibacterial activity and chemical constitutions of *Ziziphora clinopodioides*. *Journal of Ethnopharmacology* 106: 372-376.
- Prashanth, D. Asha, M.K. & Amit, A. 2001. Antibacterial activity of *Punica granatum*. *Fitoterapia*. 72: 171-173.
- Rathi, J.M., & Gopalakrishnan, S. 2006. Insecticidal activity of aerial parts of *Synedrella nodiflora* Gaertn. (Compositae) on *Spodoptera litura* (Fab.). *Central European Agriculture*. 7(2): 289-296.
- Rios, J.L. & Recio, M.C. 2005. Medicinal plants and antimicrobial activity. *Journal of Ethnopharmacology*. 100: 80-84.
- Robards, K., Plenzer, P.D., Tucker, G, Swatsitang, P., & Glover, W. 1999. Phenolic compounds and their role in oxidative processes in fruits. *Food Chemistry*. 66: 401-436.
- Sanchez-Moreno, C., Larrauri, J.A., & Saura-Calixto, F. (1999). Free radical scavenging capacity and inhibition of lipid oxidation of wine, grape juices and related polyphenolic constituent. *Food Research International*, 32, 407-412.

- Slavin, J., Jacobs, D., Marquart, L. 1997. Whole-grain consumption and chronic disease: preventive mechanism. *Nutrition and Cancer*. 27: 12-21.
- Slinkard, K., and Singleton, V.L. 1977. Total phenol analysis: automation and comparison with manual methods. *American Journal of Enology and Viticulture*. 28, 49-55.
- Temple, N.J. 2000. Antioxidants and disease: more questions than answers. *Nutrition Research*. 20: 449-459.
- Trease, G.E. & Evans, W.C. 1989. *A text book of pharmacognosy*, 13th Bailliere Tinnall, Ltd. London. pp. 101-104.
- Willcox, J.K., Ash, S., Catignani, G. 2004. Antioxidant and prevention of chronic disease. *Critical Reviews in Food Science and Nutrition* 44: 275-295.
- Woode, E., Amoateng, P., Ansah, C & Duwiejua, M. 2010. Anti-nociceptive effects of an ethanolic extract of the whole plant of *Synedrella nodiflora* (L.) Gaertn in mice: Involvement of adenosinergic mechanism. *Science alert* an open access publisher.

Antibacterial and Antioxidant Activities of *Synedrella nodiflora* (L.) Gaertn. (Asteraceae)

ORIGINALITY REPORT

%**20**

SIMILARITY INDEX

%**15**

INTERNET SOURCES

%**16**

PUBLICATIONS

%**14**

STUDENT PAPERS

PRIMARY SOURCES

1

Lanny Hartanti, Stefania Maureen Kasih Yonas, Josianne Jacqlyn Mustamu, Sumi Wijaya, Henry Kurnia Setiawan, Lisa Soegianto. "Influence of extraction methods of bay leaves (*Syzygium polyanthum*) on antioxidant and HMG-CoA Reductase inhibitory activity", *Heliyon*, 2019

Publication

%**1**

2

www.ncbi.nlm.nih.gov

Internet Source

%**1**

3

grad.uprm.edu

Internet Source

%**1**

4

Mata, A.T.. "Antioxidant and antiacetylcholinesterase activities of five plants used as Portuguese food spices", *Food Chemistry*, 2007

Publication

%**1**

5

sajbs.com

Internet Source

%**1**

bmccomplementalternmed.biomedcentral.com

6

Internet Source

%1

7

Souza-Moreira, Tatiana M., Raquel R. D. Moreira, Luis V. S. Sacramento, and Rosemeire C. L. R. Pietro. "Histochemical, phytochemical and biological screening of *Plinia cauliflora* (DC.) Kausel, Myrtaceae, leaves", *Revista Brasileira de Farmacognosia*, 2010.

Publication

%1

8

Submitted to Birla Institute of Technology

Student Paper

%1

9

Hakimoglu, F.. "The effect of ethanol extract of *Hypericum lysimachioides* on lipid profile in hypercholesterolemic rabbits and its in vitro antioxidant activity", *Atherosclerosis*, 200705

Publication

%1

10

www.wjpsonline.org

Internet Source

%1

11

academicjournals.org

Internet Source

%1

12

Francisca Rodrigues, Ana Palmeira-de-Oliveira, José das Neves, Bruno Sarmento, Maria Helena Amaral, Maria Beatriz Oliveira. "Medicago spp. extracts as promising ingredients for skin care products", *Industrial Crops and Products*, 2013

Publication

<%1

13

academic.oup.com

Internet Source

<% 1

14

baadalsg.inflibnet.ac.in

Internet Source

<% 1

15

hdl.handle.net

Internet Source

<% 1

16

core.ac.uk

Internet Source

<% 1

17

Jimoh, F. O., A. A. Adedapo, A. A. Aliero, and A. J. Afolayan. "Polyphenolic Contents and Biological Activities of *Rumex ecklonianus*.", *Pharmaceutical Biology*, 2008.

Publication

<% 1

18

www.macrothink.org

Internet Source

<% 1

19

Kanatt, S.R.. "Antioxidant potential of mint (*Mentha spicata* L.) in radiation-processed lamb meat", *Food Chemistry*, 2007

Publication

<% 1

20

www.georgikon.hu

Internet Source

<% 1

21

Turkoglu, A.. "Antioxidant and antimicrobial activities of *Laetiporus sulphureus* (Bull.) Murrill", *Food Chemistry*, 2007

Publication

<% 1

22

azdoc.site

Internet Source

<% 1

23

Victor Kuete, Frédéric Nana, Bathélémy Ngameni, Armelle Tsafack Mbaveng, Félix Keumedjio, Bonaventure Tchaleu Ngadjui. "Antimicrobial activity of the crude extract, fractions and compounds from stem bark of Ficus ovata (Moraceae)", Journal of Ethnopharmacology, 2009

Publication

<% 1

24

btdt.biblioteca.ufpb.br

Internet Source

<% 1

25

Submitted to Massey University

Student Paper

<% 1

26

Anja Klančnik. "Investigation of some factors affecting the antibacterial activity of rosemary extracts in food models by a food microdilution method : Factors affecting MIC of plant extract", International Journal of Food Science & Technology, 02/2011

Publication

<% 1

27

www.worldcocoaoundation.org

Internet Source

<% 1

28

Ozturk, S.. "Antibacterial activity and chemical constitutions of Ziziphora clinopodioides", Food Control, 200705

<% 1

29

www.nature.com

Internet Source

<% 1

30

Iness Bettaieb Rebey, Soumaya Bourgou, Imen Ben Slimen Debez, Iness Jabri Karoui et al. "Effects of Extraction Solvents and Provenances on Phenolic Contents and Antioxidant Activities of Cumin (*Cuminum cyminum* L.) Seeds", Food and Bioprocess Technology, 2011

Publication

<% 1

31

Alyson Bexfield, A. Elizabeth Bond, Emily C. Roberts, Edward Dudley et al. "The antibacterial activity against MRSA strains and other bacteria of a <500Da fraction from maggot excretions/secretions of *Lucilia sericata* (Diptera: Calliphoridae)", Microbes and Infection, 2008

Publication

<% 1

32

sutir.sut.ac.th:8080

Internet Source

<% 1

33

Karima Dhaouadi, Faten Raboudi, Carmen Estevan, Enrique Barraón, Eugenio Vilanova, Mohamed Hamdaoui, Sami Fattouch. "Cell Viability Effects and Antioxidant and Antimicrobial Activities of Tunisian Date Syrup (Rub El Tamer) Polyphenolic Extracts", Journal of Agricultural and Food Chemistry, 2011

<% 1

34

P Hyland. "Nonagenarians from the Swedish NONA Immune Study have increased plasma antioxidant capacity and similar levels of DNA damage in peripheral blood mononuclear cells compared to younger control subjects", *Experimental Gerontology*, 2002

Publication

<% 1

35

Submitted to Universiti Malaysia Sabah

Student Paper

<% 1

36

www.hgh-frag-176-191.com

Internet Source

<% 1

37

Submitted to Coventry University

Student Paper

<% 1

38

Adewale Adetutu, Winston A. Morgan, Olivia Corcoran. "Antibacterial, antioxidant and fibroblast growth stimulation activity of crude extracts of *Bridelia ferruginea* leaf, a wound-healing plant of Nigeria", *Journal of Ethnopharmacology*, 2011

Publication

<% 1

39

www.acgpubs.org

Internet Source

<% 1

40

Submitted to University of Malaya

Student Paper

<% 1

| | | |
|----|--|------|
| 41 | Neha Tiwari, Nidhi Srivastava, Vinay Sharma. "Comparative analysis of total phenolic content and antioxidant activity of in vivo and in vitro grown plant parts of Carica papaya L.", Indian Journal of Plant Physiology, 2014 Publication | <% 1 |
| 42 | www.deepdyve.com Internet Source | <% 1 |
| 43 | world-food.net Internet Source | <% 1 |
| 44 | Mukhrizah Othman, Sivaneswary Genapathy, Pit Sze Liew, Qin Ting Ch'ng et al. "Search for antibacterial agents from Malaysian rainforest and tropical plants", Natural Product Research, 2011 Publication | <% 1 |
| 45 | Maisuthisakul, P.. "Assessment of phenolic content and free radical-scavenging capacity of some Thai indigenous plants", Food Chemistry, 2007 Publication | <% 1 |
| 46 | Submitted to Bloomsbury Colleges Student Paper | <% 1 |
| 47 | Submitted to University of Westminster Student Paper | <% 1 |

EXCLUDE QUOTES ON

EXCLUDE
BIBLIOGRAPHY ON

EXCLUDE MATCHES < 10
WORDS