In-vitro antileptospiral activity of Canarium odontophyllum Miq. (Dabai) leaves extract

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ABSTRACT

Aims: To evaluate the anti-leptospiral activity of Canarium odontophyllum leaves against Leptospira interrogans serovar Bataviae and Leptospira borgpetersenii serovar Javanica.

Methodology and results: The extracts (hexane, acetone, methanol and aqueous) used in this study were tested at concentration ranging from 0.049 mg/mL to 25 mg/mL using broth microdilution method. Percentage inhibition (%) was obtained through OD reading at 400 nm. Only methanol extract was incubated with Leptospira to observe population changes under dark field microscope prior to subjected for DNA damaging studies through gel electrophoresis of genomic DNA. Methanol extract showed the highest percentage inhibition of 66% against L. interrogans serovar Bataviae and 74% against L. borgpetersenii serovar Javanica. The IC₅₀ value of methanol extract was 4.60 mg/mL and 2.25 mg/mL against serovar Bataviae and serovar Javanica, respectively. Both Leptospira culture which was treated with IC₅₀ value of methanol extract showed drastic decrease in population compared to untreated Leptospira for both serovar. There was no DNA damage towards serovar Bataviae. However, serovar Javanica exhibited DNA damage as observed from the presence of DNA fragmentation on the gel electrophoresis.

Conclusion, significance and impact of study: These findings confirmed that methanol leaves extract from of Canarium odontophyllum has a potential to control leptospirosis.

Keywords: anti-leptosomal, Leptospira interrogans, Leptospira borgpetersenii, Canarium odontophyllum

INTRODUCTION

Leptospirosis is a re-emerging zoonotic disease where the first case recorded in Malaysia was in 1925. This disease occurs due to the bacterial infection by pathogenic Leptospira species which is carried by animals and transmitted to humans through various mechanisms (Lim et al., 2011).

Genus Leptospira is divided into two species which is pathogenic and non-pathogenic or saprophytic. Pathogenic Leptospira such as Leptospira interrogans (L. interrogans) is the cause of Leptospirosis disease while saprophytic Leptospira such as Leptospira biflexa (L. biflexa) are the living organisms that are free in water and soil and not infecting animal and human. Leptospira sp. is a spiral Gram-negative bacterium and has internal flagella (Johnson, 1996). Leptospira sp. has a diameter of 0.1 μm and a length about 6 to 20 μm. The cells have pointed ends which either one or both of the ends will bend into a distinctive hook. Movement of Leptospira sp. produced by two flagella that rotate over the membranes and these bacteria are mostly carried by small rodents and mammals which infect humans through urine containing Leptospira bacteria either directly or indirectly (Levett, 2001).

According to the latest statistics released by the Ministry of Health Malaysia, there were 31,771 cases of leptospirosis reported in 2011 to 2016 which lead to 396 deaths. According to the Ministry of Health Malaysia through MyHealth portal, the signs and symptoms of this illness begin with fever, chill, body ache and headache in about 75% to 100% of the patient. 25% to 35% of them are coughing and about 7% to 40% of the patients may have muscle aches, spleen or liver enlargement, swelling of the gland, sore throat, muscle spasm and rashes. Canarium odontophyllum Miq, or known as dabai by local people in Sarawak who come from the Burseraceae family are trees that can be found in tropical rainforests in Sarawak, Malaysia (Ding and Diana, 2013). The dabai tree grows vertically to a height of 30 to 50 meters and has a large pinnate leaf size. Phytochemical studies on dabai leaves showed that it contains flavonoids, tannins,
saponins, terpenoid and phenolic compounds in aqueous, acetone and methanol extracts (Basri and Nor, 2014). Acetone extract of Canarium odontophyllum has been proven to act as an anti-bacterial agent whereas methanol extract of this leaf also has a potential an anti-MRSA agent (Basri and Nor, 2014; Basri et al., 2014c). The aqueous extract has been shown to reduce sugar level in diabetic rat (Saari et al., 2017). Apart from its leaf, study on stem bark and fruit of Canarium odontophyllum tree has also been conducted and have been proven as anti-oxidant (Shakirin et al., 2010), anti-cancer agent (Basri et al., 2014a), anti-atherosclerotic (Shakirin et al., 2012), anti-microbial and anti-yeast (Basri et al., 2014b). However, studies on Canarium odontophyllum leave against Leptospira bacteria have not been conducted yet. Thus, with various pharmacological activities that have been reported on leaf extract from C. odontophyllum, its potential against Leptospira sp. is necessary to be carried out.

MATERIALS AND METHODS

Chemicals

Leptospira sp. Ellinghausen-McCullough-Johnson-Harris (EMJH) enrichment media Difco™ (Becton, Dickinson and Co.,USA), Leptospira EMJH media Difco™ (Becton, Dickinson and Co.,USA), Tris Borat EDTA (Next Gene Scientific Sdn Bhd Malaysia), Agarose (Next Gene Scientific Sdn Bhd Malaysia), DNA dye GelRed™ (Biotium, California), Gel Loading Dye Blue (Thermo Scientific Sdn Bhd Malaysia), DNA dye GelRed™ (EMJH) enrichment media Difco™ (Becton, Dickinson and Co., USA). About 2.3 g of EMJH mannheim, Germany). About 2.3 g of EMJH Leptospira spp. DifcoTM enriched media was dissolved with 900 mL distilled water in a 1 L Scotch bottle at pH 7.5, autoclaved for 15 min, left at room temperature overnight and filtered through a 0.2 µm filter unit. About 100 mL EMJH Leptospira spp. DifcoTM enriched media was added to the 900 mL basic media prepared earlier. Next 5 mL of the media was aliquoted into each of the 10 mL culture tubes and 5-fluorouracil (200 µg/mL) was also added to it. These culture tubes were then kept in 4 °C until used.

Polymerase chain reaction (PCR)

The PCR was conducted to make sure the Leptospira used was a pathogenic Leptospira by using primer LipL32. This assay was done using 50 µL reaction mixture that consisted of 25 µL Econo Taq® Green Master Mix, 20 µL of sterile distilled water 1 µL of each and forward primer and 3 µL of template DNA of each serovar. Base pair of LipL32 forward was 5'- GTC GAC ATG AAA CTT TCG ATT TTG -3' and base pair of LipL32 reverse primer was 5'- CTG CAG TTA ATT GGC CTC GTC AGA AGC -3'. The mixture was mixed using micro centrifuge and performed in the Thermocycler with the following conditions: initial denaturation at 94 °C for 5 min, followed by 30 cycles of denaturation at 94 °C for 1 min, annealing at 55 °C for 45 sec, extension at 72 °C for 30 sec and a final extension at 72 °C for 6 min. The PCR product were checked for amplification by electrophoresis using 1.5% agarose gel and visualized by gel documentation system and photographed. (Cheema et al., 2007)

Percentage inhibition (% test)

Percentage inhibition test was conducted to test various concentrations ranging from 0.049 mg/mL to 25 mg/mL of Canarium odontophyllum leaves extracts in inhibiting the activity of Leptospira sp. using broth microdilution technique with 96-well plate (Murray and Hosenthal, 2004). One hundred microliter Leptospira in EMJH media was poured in all well (one plate for one serovar). Each row is designated for various concentrations with same solvent of the extract (methanol, acetone, aqueous, and hexane). In each row, 50 µL of various concentrations of leaf extract at 0.049 mg/mL, 0.098 mg/mL, 0.195 mg/mL, 0.391 mg/mL, 0.781 mg/mL, 1.563 mg/mL, 3.125 mg/mL, 6.25 mg/mL, 12.5 mg/mL and 25 mg/mL was added horizontally and incubated for three days at 30 °C in the dark condition. After incubation time, the plate was read by spectrophotometer at the wavelength of 400nm (Stoddard et al., 2014) in triplicate and the average OD of test was calculated. The percentage of inhibition of Leptospira growth by Canarium odontophyllum extract was calculated through the following formula (Wang et al., 2010):

\[
\text{Inhibition Percentage} = \frac{OD (\text{control}) - OD (\text{test})}{OD (\text{control})} \times 100
\]

Where, OD (control) = OD400 reading average for control sample
OD (test) = Average OD400 reading for test sample
Note: Percentage of inhibition is 0 or no inhibition if the result is negative.
Dark Field Microscopy

Before Leptospira treated with IC<sub>50</sub> of the most effective extract, the culture was observed under dark field microscope (Murray and Hospenthal, 2004). Then, the culture was incubated with IC<sub>50</sub> of the most effective extract for each serovar and incubated for three days at 30 °C in the dark condition. After the incubation time, drop of sample was placed in the slide and observed under dark field microscope again to check the population changes by comparing with the untreated culture. This procedure was done to compare whether there were any changes before and after the treatment of the extract with Leptospira culture.

Genomic DNA damage

IC<sub>50</sub> of the most effective Canarium odontophyllum leaves extract was added in the Leptospira culture in EMJH media and incubated for three days at 30 °C in the dark condition. After incubation time, genomic DNA was isolated according to manufacturer instruction (HiYield ™ Genomic DNA (Bacteria) Mini Kit). For control, genomic DNA was isolated from Leptospira culture without extract. Genomic DNA sample (2 μL) mixed with 4 μL of dye was loaded on a 1% agarose gel with 3 μL ethidium bromide. The sample was run for 1 h at 50 mV. Gel was observed under UV light and photographs were taken using gel documentation system. This test was done to observe whether the extract could cause fragmentation and degradation of Leptospira genomic DNA (Ahsan et al., 2012).

RESULTS

Polymerase chain reaction (PCR)

Both Leptospira used in this study which were L.interrogans serovar Bataviae and L.borgpetersenni serovar Javanica were confirmed pathogenic with the presence of band at756bp obtained with LipL32 based primers as shown in Figure 1.

![Figure 1: PCR amplification of LipL32 gene](image)

Lane 1: 100bp DNA ladder
Lane 2: PCR product of L. interrogans serovar Bataviae
Lane 3: PCR product L. borgpetersenni serovar Javanica

<table>
<thead>
<tr>
<th>Extract concentration of Canarium odontophyllum (mg/mL)</th>
<th>Methanol</th>
<th>Acetone</th>
<th>Aqueous</th>
<th>Hexane</th>
</tr>
</thead>
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<tr>
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<td>0</td>
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<td>0.098</td>
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<td>0.195</td>
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<td>0.391</td>
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<td>25</td>
<td>66</td>
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Table 1: Percentage inhibition of L. interrogans serovar Bataviae

<table>
<thead>
<tr>
<th>Extract concentration of Canarium odontophyllum (mg/mL)</th>
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<th>Acetone</th>
<th>Aqueous</th>
<th>Hexane</th>
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<td>2</td>
<td>0</td>
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<tr>
<td>0.195</td>
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<td>7</td>
<td>11</td>
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<td>25</td>
<td>74</td>
<td>58</td>
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<td>30</td>
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Table 2: Percentage inhibition of L. borgpetersenni serovar Javanica

IC<sub>50</sub> value of methanol extract for each serovar

From the result above, the graph was plotted and the concentration of the most effective extract which was...
methanol extract that inhibits 50% of the population for each Leptospira serovar was identified. Thus, table below showed the IC$_{50}$ value of methanol extract for each serovar.

<table>
<thead>
<tr>
<th>Leptospira sp.</th>
<th>IC$_{50}$ value (mg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. interrogans serovar Bataviae</td>
<td>4.60</td>
</tr>
<tr>
<td>L. borgpetersenii serovar Javanica</td>
<td>2.25</td>
</tr>
</tbody>
</table>

**Leptospira population changes under dark field microscope**

Reduction of Leptospira population in the culture after incubation time with the IC$_{50}$ value of methanol extract for each serovar was proven through the observation under dark field microscope as shown in Figure 2: L. interrogans serovar Bataviae and Figure 3: L. borgpetersenii serovar Javanica. From the observation, the untreated culture has more cells compared to the treated culture which indicated that the extract was able to lower the number of Leptospira cells.

**Genomic DNA damage**

Genomic DNA degradation was observed in L. borgpetersenii serovar Javanica (Figure 5) but not in L. interrogans serovar Bataviae (Figure 4) by IC$_{50}$ value of *Canarium odontophyllum* methanol leaves extract because the DNA fragmentation only happen on the gel which contain genomic DNA of L. borgpetersenii serovar Javanica. Thus, proves that this IC$_{50}$ value of extract could only react and damage the DNA of L. borgpetersenii serovar Javanica but not L. interrogans serovar Bataviae.

**DISCUSSION**

*Leptospira* sp. is the cause of Leptospirosis. *L. interrogans* serovar Bataviae and *L. borgpetersenii* serovar Javanica
were chosen in this study because both these serovar were the most dominant serovar present in rat in Kuala Lumpur (Benacer et al., 2013) and Peninsular Malaysia (Benacer et al., 2016). Thus, these serovar were chosen to be significant to show infection in Malaysia.

As we know, Leptospira is divided into two which is pathogenic and non-pathogenic (saprophytic) so to differentiate this two, we have to do polymerase chain reaction (PCR). The primer that was used to detect pathogenic Leptospira is LipL32 because LipL32 is one of outer membrane protein that is only present in pathogenic Leptospira whether in-vivo or in-vitro (Htaka and Levett, 2015). Based on PCR product results, the presence of band at 756bp when using LipL32 (Cheema et al., 2007) proved that both Leptospira cultures were found to be pathogenic.

*Canarium odontophyllum* or known as dabai are very popular among the people in Sarawak and the fruit is often used as food. However, its leaves have not been used until the study of dabai leave extract turned out to be an anti-bacterial agent especially towards *Staphylococcus aureus* (Basri and Nor, 2014), an anti-MRSA agent (Basri et al., 2014c), blood glucose reducing agent (Saari et al., 2017), vasorelaxant effect (Basri et al., 2018) and anti-cancer activity to colorectal cancer (Basri et al., 2015). Scientists were interested to use the leaves because they can be easily obtained from its large tree which produce many leaves regardless of season unlike its seasonal grown fruit (MARDI, 2014).

From percentage inhibition result, different solvent of extract gives a different percentage of inhibition which is methanol extract gives a highest percentage of inhibition while hexane gives a low percentage of inhibition. This is because different solvents have the different ability to extract active ingredients from plants. The use of methanol as a solvent can dissolve various active compounds either polar or non-polar (Basri et al., 2014b). This was proved by the presence of many phytochemical constituent study of *Canarium odontophyllum* methanol leaves extract by Basri and Nor (2014) such as flavonoids, saponins, tannins, terpenoid and phenolic compounds. However, phytochemical studies for hexane extracts of *Canarium odontophyllum* leaves have not been carried out yet. According to previous studies using crude extracts of *Canarium odontophyllum* leaves, methanol extract was also the most effective extract as an antibacterial agent (Basri and Nor, 2014) but this study is not conducted against *Leptospira* sp.

IC50 value was different for each serovar because every *Leptospira* serovar has different lipopolysaccharide expression on its surface (Adler et al., 2010). Furthermore, *L. interrogans* is a more virulent species of *L. borgpetersenii* (Lehmann et al., 2014) so it is possible that it requires higher extract concentration to inhibit 50% of its population. Bulach et al. (2006) in his study stated that external surface proteins that contributed to Leptospira's efficacy such as LigA, LigB and LigC were present in *L. interrogans* but for *L. borgpetersenii* only had LigB which made them less virulent but still able to infect and become pathogenic to humans.

Observation under a dark field microscope is very important to support the percentage of inhibition result and IC50 and also one of the most important methods to detect the presence of *Leptospira* in the culture. The population of treated *Leptospira* cultures had less cell compared untreated culture. Even though dark field microscope results are only able to see population changes in terms of qualitative but according to study done by Terpstra (2003) emphasized that although observation of *Leptospira* under dark-field microscopy are conventional techniques with qualitative calculation, it is the most useful technique for showing and determining the population of *Leptospira*. This technique can be improved by using a counting chamber but the motile nature of *Leptospira* can make the calculation inaccurate.

There are many plant extracts that have shown to cause cell death involving bacterial DNA fragmentation. For example, the ethanol extract of *Syzygium cumini* leave has caused fragmentation of genomic DNA of *Vibrio cholerae* (Ahsan et al., 2012). Methanol and aqueous extracts from *Eclipta alba* and *Phyllanthus amarus* also resulted in fragmentation of the genome DNA of *Leptospira* sp. (Chandan et al., 2012). This is probably because the extracts activated the intracellular signals and trigger the endonuclease to carry out bacterial DNA damage. However, further investigation is needed to explain the exact mechanism of this extract as an anti-leptospiral agent.

**CONCLUSION**

The methanol extract from *Canarium odontophyllum* leaves exhibited an anti-leptospiral effect especially towards *L. borgpetersenii* serovar Javanica and could be used to control infection caused by leptospirosis.

**ACKNOWLEDGEMENTS**

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**REFERENCES**


