Anti-hypercholesterolemic effect of *Zingiber montanum* extract [version 2; peer review: 1 approved]

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**Abstract**

**Background:** High cholesterol levels (hypercholesterolemia) has been recognized to cause various disease, most notably the cardiovascular disease. Unfortunately, most anti-hypercholesterolemic drugs deliver several side effects for patients, by which medicinal plants have begun to attract attention for treating hypercholesterolemia. Among others, *Zingiber montanum* (J.König) Link ex A.Dietr. has traditionally been taken for treating health problems caused by high cholesterol levels. Hence, this work aimed at investigating anti-hypercholesterolemic effects offered by the plant.

**Methods:** This study was conducted on 30 male Wistar rats. During experiments, the subjects were divided into 6 groups (n=5), i.e. no treatment (Group 1, control); high-fat diet (Group 2, control); high-fat diet with simvastatin (Group 3); high-fat diet with plant extracts (Group 4-6 with 100, 200, and 400 mg/kg BW, respectively). After 4 weeks of treatments, blood samples were collected from each group. Then, plasma concentrations of triglycerides, total cholesterol, high density lipoproteins (HDL), and low density lipoproteins (LDL) were measured.

**Results:** There were significant differences in total cholesterol (p=0.000), LDL (p=0.000) and triglycerides (p=0.001) for Groups 4-6 (high-fat diet treated with different plant extract doses) in comparison with Group 2 (high-fat diet, control). Meanwhile, there were no significant differences in HDL levels (p=0.830) between Group 2 (high-fat diet, control) and other groups. The results also showed significant differences in total cholesterol and LDL for subjects treated with plant extracts (Group 4, 100 mg/kg BW, p=0.000; Group 5, 200 mg/kg BW, p=0.000; Group 6, 400 mg/kg BW, p=0.000) compared to Group 2 (high-fat diet, control). Then, treatments with 400 mg/kg BW (Group 6) discovered significant reductions in total cholesterol, LDL, and triglycerides (p=0.030).

**Conclusion:** Therefore, *Z. montanum* has been discovered to deliver anti-hypercholesterolemic effects to experimental subjects, making it potential to act as a natural source of anti-hypercholesterolemic agents.

**Keywords**

anti-hypercholesterolemic, *Zingiber montanum*
Introduction

Hypercholesterolemia is a health condition characterized by a very high level of cholesterol in the blood\(^1\). If it is not well treated, hypercholesterolemia certainly increases coronary heart disease risk\(^2\). In current advances, various agents have been made available to treat hypercholesterolemia patients, including HMG CoA reductase inhibitors or statins (Simvastatin)\(^3\). In current advances, various agents have been made available to treat hypercholesterolemia patients, including HMG CoA reductase inhibitors or statins (Simvastatin)\(^3\). To avoid unintended side effects of artificially made anti-hypercholesterolemic agents, medicinal plants have begun to attract attention for treating hypercholesterolemia in Indonesia, where various locally growing plants have been used for traditional medicine. Among others, Zingiber montanum (J.König) Link ex A.Dietr., which belongs to the family Zingiberaceae, has been recognized to act as a traditional medicine in East Kalimantan, Indonesia, for treating health problems caused by high cholesterol levels\(^4\). This study, therefore, aimed at investigating anti-hypercholesterolemic effect of Z. montanum.

Methods

Plant material

The sampling of Z. montanum was conducted in the Kutai Kartanegara, East Kalimantan, Indonesia (0°24'18.4"S 117°4'24.7"E). The plant was carefully verified by Ir. Hj. Hastaniah, M.P. to ensure its authenticity. The voucher specimen (voucher no. 27b/UN17.4.3.08/LL/2018) was then deposited in the Laboratory of Dendrology and Forest Ecology, Faculty of Forestry, Mulawarman University, Samarinda, Indonesia.

Plant extraction

In the laboratory, the rhizomes of Z. montanum were sliced and dried at room temperature for 3 days. After that, they were crushed and transferred into a glass container. Crushed rhizomes were soaked in absolute ethanol (9401-03 Alcohol, Anhydrous, Reagent, J.T. Baker) for 5 days. The mixture was shaken occasionally with a shaker (3525 Incubator Orbital Shaker, Lab-Line, US). After 5 days, it was filtered (Whatman Filter Paper 11μm, Sigma-Aldrich) and evaporated by using a rotary evaporator (RV06-ML Rotary Evaporator, IKA, Germany). In the end, dried extracts were obtained and stored at 4°C in a dark bottle.

Experimental model

In this study, experiments were designed to follow Federer’s rule, with six groups of induction. For the experiments, 30 male Wistar rats (Rattus norvegicus, weighing 250–350g, aged 12–13 months) were obtained from Animal House of the Faculty of Medicine, Mulawarman University, Indonesia. They were randomly divided into 6 groups, i.e. Group 1 (no treatment, control), Group 2 (high fat diet, control), Group 3 (high fat diet with simvastatin), and Groups 4–6 (high fat diet with separate doses of Z. montanum extract; 100, 200, and 400 mg/kg, respectively). They were acclimatized for one week in a controlled room temperature (25°C) with a 12-hour light/dark cycle. Besides, they were provided with an access to food pellets, while filtered water was provided ad libitum to help them adapt to the new environment. During experiments, each test subject was separately housed in a wire cage (30x30x30 cm). In all treatments, high-fat diets were administered for all test subjects for 4 weeks, in which 10% chicken egg yolk and reused cooking oil were added to their standard pellet diets (JAPFA, Comfeed, Indonesia) with tap water ad libitum.

Biochemical analysis

After 4 weeks of treatment, blood samples were collected from each treatment group separately after an overnight fasting. All test subjects were anesthetized intraperitoneally with a ketamine injection (Hameln, Germany) at a 60 mg/kg BW dose before taking the blood samples. After the anesthetize, each test subjects was euthanized by applying cervical dislocation. Each blood sample was aspirated through the left ventricle of test subject’s heart. Practically, two millilitres of blood were aspirated by using a 3 ml disposable syringe to later be filled into a vaccutainer tube with an anticoagulant. Then, plasma concentrations of triglycerides, total cholesterol, high density lipoproteins (HDLs), and low density lipoproteins (LDLs) were measured in three repetitions for each sample by utilizing an automatic analyzer system (BiOLis 24i; Boeki, Tokyo, Japan).

Data analysis

In this work, statistical analyses were performed in SPSS software version 16.0. Data normality was examined by applying the Shapiro-Wilk normality test. Then, parameter data were analyzed by using ANOVA and post hoc with Tukey test. The analyses set \( p \)-value of \( \leq 0.05 \) as being significant.

Ethical considerations

All protocols taken in this study had been approved for Ethical Animal Care from the Medical and Health Research Ethics Commission, Faculty of Medicine, Mulawarman University with approval no. 81/KEPK-FK/V/2018. All possible efforts had been ensured to ameliorate any suffering of animals treated as test subjects in this research.

Results

Looking at results of the statistical analyses, significant differences were found between total cholesterol (\( p = 0.000 \)), LDL (\( p = 0.000 \)) and triglycerides (\( p = 0.001 \)) (Figure 1) levels.
achieved between Group 2 (high-fat diet, control) and Group 4–6 (treatments of Z. montanum extracts at different doses). Besides, there was no significant difference in HDL (p=0.830) levels between Group 2 and other groups. Meanwhile, post-hoc Tukey test revealed significant differences between total cholesterol (p=0.000) and LDL (p=0.000) levels of all Z. montanum treatments (Groups 4–6) with the high-fat diet control (Group 2). Then, results for Z. montanum treatment at 400 mg/kg BW doses (Group 6) particularly discovered significant reductions in total cholesterol, LDL and triglycerides (p=0.030) (Table 1).

Discussion

The Z. montanum (Supplementary File 1) has been widely taken as a medicinal plant in Asia. Pharmacological properties of Z. montanum include antimicrobial, antioxidant, insecticidal, anti-cancer, anticholinesterase, and anti-inflammatory. In the literature, previous researches on anti-hypercholesterolemic effects of other Zingiber species mainly focused on Z. officinale (a.k.a. ginger). In general, a restoration of changes in low-density lipoprotein and HMG CoA reductase by Z. officinale administration with a high-fat diet has been suggested as an explanation for the effect of ginger in hyperlipidemia treatments.

In fact, the rhizome extracts of Z. montanum showed the highest total curcuminoid content compared to other Zingiber species. Curcumin as antioxidants would hence be able to efficiently prevent LDL oxidations. The significant changes in LDL levels suggested Z. montanum to deliver an

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**Table 1.** Effect of Z. montanum and simvastatin in total cholesterol, triglycerides, high density lipoproteins (HDL), and low density lipoproteins (LDL) levels after 4 weeks of treatment in a high fat diet rat model.

<table>
<thead>
<tr>
<th>Group</th>
<th>Total Cholesterol (mg/ml)</th>
<th>HDL (mg/ml)</th>
<th>LDL (mg/ml)</th>
<th>Triglycerides (mg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFD control</td>
<td>241.0 ± 11.6</td>
<td>44.8 ± 6.7</td>
<td>163.8 ± 13.1</td>
<td>161.8 ± 30.6</td>
</tr>
<tr>
<td>HFD + SIM</td>
<td>128.2 ± 9.4*</td>
<td>38.2 ± 11.8</td>
<td>73.2 ± 4.7*</td>
<td>84.2 ± 24.6*</td>
</tr>
<tr>
<td>HFD + ZM-1</td>
<td>168.0 ± 25.4*</td>
<td>40.6 ± 11.2</td>
<td>103.1 ± 6.9</td>
<td>121.4 ± 28.4</td>
</tr>
<tr>
<td>HFD + ZM-2</td>
<td>144.2 ± 14.9*</td>
<td>39.2 ± 6.7</td>
<td>82.6 ± 3.4*</td>
<td>112.0 ± 25.0</td>
</tr>
<tr>
<td>HFD + ZM-3</td>
<td>135.2 ± 19.0*</td>
<td>37.2 ± 14.1</td>
<td>77.5 ± 7.7*</td>
<td>102.6 ± 37.1*</td>
</tr>
<tr>
<td>Normal control</td>
<td>101.4 ± 2.2*</td>
<td>36.8 ± 8.4</td>
<td>50.3 ± 3.3*</td>
<td>71.4 ± 19.7*</td>
</tr>
</tbody>
</table>

Note: HFD = high-fat diet, SIM = simvastatin; ZM-1 = Z. montanum 100 mg/kg; ZM-2 = Z. montanum 200 mg/kg; ZM-3 = Z. montanum 400 mg/kg

*Tukey post-hoc test significant p<0.05 compared to HFD control
effect on lipid metabolism\textsuperscript{16}. Curcumin with other chemical compounds from \textit{Z. montanum} was then suggested to offer anti-hypercholesterolemic effects.

**Conclusion**

Looking at all results in this study, \textit{Z. montanum} extract have been discovered to reduce lipid profile levels. The medicinal plant could therefore deliver anti-hypercholesterolemic effects to experimental subjects, making it potential to act as a natural source of the anti-hypercholesterolemic agents.

**Data availability**

F1000Research: Dataset 1. Effect of ethanol extract of \textit{Z. montanum} and simvastatin in total cholesterol, triglycerides, high density lipoproteins (HDL), and low density lipoproteins (LDL) levels after 4 weeks of treatment in a high fat diet rat model. \url{http://dx.doi.org/10.5256/f1000research.16417.d221668}\textsuperscript{17}

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The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

**Supplementary material**

Supplementary File 1: Picture of rhizome of \textit{Zingiber montanum} (J.Koenig) Link ex A.Dietr.

Click here to access the data

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**References**

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The authors have followed all suggestion given

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Natural Product Chemistry, Bioactivity study

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

1. The manuscript needs to be sent for proofreading. There are a lot of grammatical mistakes and poor sentence construction, and there is no connection between sentences in paragraphs.
2. In the manuscript, the voucher of herbarium specimen of the plant should be stated, and also where the herbarium specimen is deposited and who is identifying the plant (botanist).

3. Please mention the replication that was conducted in each experiment.

4. Discussion: rewrite the discussion to discuss more details about the results of the experiments and compare the previous research or facts from the article or book, to support the results.

5. Check on how to write the species name of plants for the first and subsequent usage, and be consistent.

Is the work clearly and accurately presented and does it cite the current literature? 
Yes

Is the study design appropriate and is the work technically sound? 
Yes

Are sufficient details of methods and analysis provided to allow replication by others? 
Yes

If applicable, is the statistical analysis and its interpretation appropriate? 
Yes

Are all the source data underlying the results available to ensure full reproducibility? 
Yes

Are the conclusions drawn adequately supported by the results? 
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Natural Product Chemistry, Bioactivity study

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 04 Aug 2019

Swandari Paramita, Mulawarman University, Samarinda, Indonesia

1. The manuscript has sent for proofreading.
2. The plant was authenticated by Ir. Hj. Hastaniah, M.P. and the voucher specimen (voucher number: 27b/UN17.4.3.08/LL/2018) was deposited to Laboratory of Dendrology and Forest Ecology, Faculty of Forestry, Mulawarman University, Samarinda, Indonesia.
3. There was one replication that was conducted in each experiment of every sample.
4. In the discussion has been rewriting to explain the results of the experiments and compare the previous research to support the results.
5. All the species name of the plants has been corrected as “Zingiber montanum” for the first, and “Z. montanum” for subsequent usage.
Competing Interests: No competing interests were disclosed.

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