Antimalaria Activities of Several Active Compounds from Medicinal Plants

Maulana Yusuf Alkandahri1,2,*, Nia Yuniarshi3, Afit Berbudi1, Anas Subarnas1

1Department of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Padjadjaran University, Jatinangor; Faculty of Pharmacy, Buana Perjuangan Karawang University, Karawang, West Java, INDONESIA.
2Faculty of Pharmacy, Buana Perjuangan Karawang University, Karawang, West Java, INDONESIA.
3Department of Biomedical Sciences, Parasitology Division, Faculty of Medicine, Padjadjaran University, Jatinangor, West Java, INDONESIA.

Correspondence
Maulana Yusuf Alkandahri
Department of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Padjadjaran University, Jatinangor; Faculty of Pharmacy, Buana Perjuangan Karawang University, Karawang, West Java, INDONESIA.
Phone no: +6282167757738
E-mail: alkandahri@gmail.com

ABSTRACT

The growth and spread of resistance to all first-line antimalarial drugs used in the treatment of malaria today has caused many problems in eradicating malaria in various countries in the world. Researchers have begun to look for candidates for new antimalarial drug compounds derived from natural products that have been scientifically proven to have antimalarial activity. This is done to replace antimalarial drugs that are currently experiencing resistance. Some active compounds that have been successfully isolated from various plants, including curcumin, kaempferol, piperine, andrographolide, α-mangostin, catechin, luteolin and betulinic acid, have been scientifically tested to have antimalarial activity with different mechanisms of action.

Key words: Malaria, Antimalarial, Curcumin, Kaempferol, Piperine, Andrographolide, α-Mangostin, Catechin, Luteolin, Betulinic acid.

INTRODUCTION

Malaria is still a health problem in the world, with 229 million cases of malaria worldwide and more than 400,000 people suffering from malaria dying each year.1 The high number of malaria cases is caused by the emergence of various obstacles in eradicating malaria, including the resistance of malaria parasites to available antimalarial drugs, increased Anopheles mosquito immunity to chemicals, and the discovery of side effects from these antimalarial drugs.2 The growing and widespread resistance to all the first-line antimalarial drugs used in the treatment and prevention of malaria has now caused many problems in the malaria prevention programme.3 Research to obtain new antimalarial drugs, both synthetic drugs and those derived from natural materials, is continuing, one of which is through the exploration of active compounds from natural materials, especially medicinal plants that have traditionally been used by the community to treat malaria in various endemic areas across the world. The aim is to find new antimalarial compounds that have mild side effects with low toxicity, so that they do not harm the patient.4 This review article will discuss the active compounds and antimalarial activity of several medicinal plant isolates.

CURCUMIN

Curcumin (1,7-bis (4’hydroxy-3-methoxyphenyl) 1,6-heptadiene, 3,5-dion) is a phytochemical component found mainly in Curcuma longa and Curcuma zanthorrhiza. Curcumin is often used as a medicine and traditional ingredient to treat various diseases in several countries.5 Curcumin has several pharmacological activities such as anti-inflammatory,6-10 antioxidant,7 anticancer,8 antiocoagulant,9 hepatoprotective10 and antibacterial.12 In addition, curcumin has been shown to have antimalarial activity against Plasmodium species.13-14 The antimalarial activity of curcumin is caused by its ability to inhibit histone acetyltransferase from P. falciparum, causing parasitic cell damage.14 Other studies also report that curcumin can interact with sarco/endoplasmic reticulum Ca2+ ATPase (SERCA) in P. falciparum which causes the inhibition of a Ca2+ ion transporter called PfATP6.15 Meanwhile, from in vitro antimalarial activity testing, IC50 values obtained from curcumin were 5 μM, whereas at concentrations of 50 μM, curcumin was able to reduce the viability of P. falciparum, which caused a decrease in parasitic cell proliferation. Other results also reported that at concentrations of 5 μg/ml and 50 μg/ml, curcumin was able to inhibit 79.6% and 100% growth of P. falciparum.16 In addition, in antimalarial testing in vivo with a dose of 100 mg/kg, curcumin was able to inhibit the growth of parasites >80%.15 Wakeine-Grinberg et al. reported that the administration of curcumin at a dose of 50 mg/kg, twice daily for 6 days after infection in C57Bl/6 mice infected with P. berghei ANKA, can prevent cerebral malaria (CM) and delay death by up to 10 days.17 In addition, it has been shown in vitro that curcumin reduces the production of proinflammatory cytokines IL6, TNF and IL12p40 in PBMC primed with trophozoites/schizonts stages of P. falciparum and downregulated the expression of VCAM1, ICAM1 and E-selectin in TNF-activated human endothelial cells.18 In addition, other studies report that curcumin can inhibit thrombin-activated platelet adhesion to brain microvascular endothelial cells in vitro which is thought to accumulate in brain microvasculature in murine and pediatric CM patients.19

KAEMPFEROL

Kaempferol (3,4’ 5, 5,7-tetrahydroxyflavone) is a natural flavonol, a flavonoid derivative, found in various plants and plant-derived foods such as kale, beans, tea, spinach and broccoli.12-23 Kaempferol has been reported to have high antioxidant properties, which are able to inhibit oxidative stress resulting from the formation of reactive oxygen species (ROS).
that occur during malaria infections. ROS and oxidative stress are also produced by monocytes and neutrophils which are activated during malarial infection, which cause haemoglobin to degrade; thus there is a correlation between antioxidant activity and antimalarial activity of kaempferol. In addition, the antimalarial activity of kaempferol is also caused by its ability to inhibit glycogen synthase kinase-3β (GSK3β) from malaria parasites. GSK3β is reported to play an important role in the host response to malaria parasitic infections. By inhibiting GSK3β in mammals, it can also significantly inhibit the activity of recombinant P. falciparum (PfGSK3β) protein. Somsak et al., reported that at a dose of 20 mg/kg, kaempferol was able to inhibit P. berghei by 52.89%, 40.80%, and 36.63% for each chemosuppressive, chemoprophylactic, and curative trial. Meanwhile, Barliana et al., reported that kaempferol was able to inhibit the growth of P. falciparum which is resistant to chloroquine in vitro after 24 hours of therapy with IC50 106 μM. In addition, kaempferol at a dose of 2,000 mg/kg daily for 30 days does not produce signs of toxicity in the form of hepatotoxic, nephrotoxic, haematotoxic, or death in test animals.

PIPERINE

Piperine (1-[5-(1,3-benzodioxol-5-yl)-1-oxo-2,4-pentadienyl] piperidine) is the main amide compound isolated from the Piper chaba Hunt fruit, Piper nigrum L. (black pepper) and Piper longum L. (long pepper). Piperine has been shown to have several pharmacological activities such as antioxidants, anticancer, antidepressive, hepatoprotective, anti-asthmatic, antipyretic, anti-inflammatory, analgesic, and anticonvulsant. In addition, piperine was also reported to have antimalarial activity in vitro against P. falciparum 3D7 strains (chloroquine-sensitive) and K1 (chloroquine-resistant) with IC50 against 3D7 and K1 P.falciparum respectively at 111.5 μM and 59 μM. The antimalarial activity of piperine is due to its ability to inhibit the modulation of expression of all P. falciparum resistance genes, including the P. falciparum multidrug resistance protein 1 gene (pfmrp1), the pfmrp1 protein coding gene that is a member of the ABC transporter superfamily located on chromosome 1, where this protein has been reported to be involved in the export of folate from malaria parasites into red blood cells. P. falciparum multidrug resistance gene 1 (pfmdr1) is a homologous P-glycoprotein coding gene located in the parasite digestive vacuole membrane, which is thought to play a role in modulation of antimalarial drug resistance and P. falciparum chloroquine resistance transporter (pfCRT), a protein-coding gene that is localised to the parasitic digestive vacuole membrane and contains 10 domains that line the membrane in the erythrocytic stage. Piperine might be a promising candidate for the development of new antimalarial drugs, due to its antimalarial potential and low risk of resistance in modulating the P. falciparum resistance gene that causes the development of resistance.

ANDROGRAPHOLIDE

Andrographolide (3-[2-[Decahydro-6-hydroxy-5-(hydroxymethyl)-5,8a-dimethyl-2-methylene-1-napthalenyl]ethylidene]dihydro-4-hydroxy-2(3H)-furanone) is a lactone diterpene compound isolated from the Andrographis paniculata (Burm. F) Nees plant, commonly known as the “king of bitters”. Andrographolide has been reported to have several pharmacological activities such as anti-inflammatory, antitumor, anti-diabetic, and hepatoprotective. In addition, andrographolide has been shown to have antimalarial activity in vitro and in vivo. The antimalarial activity of andrographolide is due to its ability to inhibit nuclear kappa B (NF-κB) transcription factors induced when erythrocytes are infected with P. falciparum by blocking the binding of NF-κB oligonucleotides to nuclear proteins where this pathway is an inflammatory pathway in the human cerebral.
Meanwhile, Risdawati reported that the antimalarial andrographolide activity was caused by this compound being able to disrupt the parasitic antioxidant defence system as evidenced by the reduction in GSH concentration and the activity of the thioredoxin reductase (TrxR) enzyme. 50 Kusumawardhani, et al., reported that the antimalarial activity of standardised A. paniculata leaf extracts (andrographolide levels; 10.82 ± 0.37%) against P. berghei in vivo obtained ED50 of 12.2223 mg of standardised A. paniculata/KgBW leaf extract, equivalent to 1,320 mg of andrographolide compounds. 51 Meanwhile, Sachdeva reported that andrographolide at a dose of 0.1 mg/ml was able to inhibit the growth of malaria parasites in vitro by 53.9%.52 In addition, Mishra et al., reported that andrographolide showed high malaria parasitic inhibitory activity in rat models in vivo when given with curcumin or artsunate via the intraperitoneal route, and without showing any symptoms of toxicity after administration of the therapy.53

### α-MANGOSTIN

α-mangostin (1,3,6-trihidroksi-7-metoksii-2,8-bis (3metil-2-butenil)-9H-xanten-9-on) is the main xanthone compound found in the hull of the Garcinia mangostana L fruit.53-54 This compound has been reported to have pharmacological activities including anti-inflammatory, anti-tumor, cardioprotective, anti-diabetic, antibacterial, antifungal, anti-parasitic, antioxidant and anti-obesity agents.53 In addition, α-mangostin is also reported to have antimalarial activity.53 Antimalarial activity is suspected of α-mangostin which is a hydroxyxanthones derivative due to its ability to form complexes that are soluble with heme compounds so that it inhibits the formation of parasitic hemozoin, a process in which the malaria parasite protects itself against the effects of heme toxins released after digesting haemoglobin.55-56 The effect was caused by this compound having an alkyl group located in positions 3 and 6 which interacts with nitrogen atoms contained in

---

**Table 1. Active compounds and working mechanisms as antimalaria.**

<table>
<thead>
<tr>
<th>Active Compounds</th>
<th>Chemical Structures</th>
<th>Types of Malaria Parasites</th>
<th>Study Design</th>
<th>Mechanism of Action</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curcumin</td>
<td><img src="image" alt="Curcumin Structure" /></td>
<td>1. P. falciparum strain 3D7 and D10. 2. P. falciparum strain DD2 and 7G8. 3. P. berghei strain ANKA.</td>
<td>In vitro and in vivo</td>
<td>Interacts with sarco/ endoplasmic reticulum Ca2+ATPase (SERCA) in P. falciparum which causes inhibition of Ca2+ ion transporter.</td>
<td>15</td>
</tr>
<tr>
<td>Kaempferol</td>
<td><img src="image" alt="Kaempferol Structure" /></td>
<td>1. P. falciparum strain 3D7. 2. P. berghei strain ANKA.</td>
<td>In vitro and in vivo</td>
<td>Inhibits oxidative stress resulting from the formation of reactive oxygen species (ROS).</td>
<td>23</td>
</tr>
<tr>
<td>Piperine</td>
<td><img src="image" alt="Piperine Structure" /></td>
<td>1. P. falciparum strain 3D7. 2. P. falciparum strain K1.</td>
<td>In vitro</td>
<td>Inhibits the modulation of expression of all P. falciparum resistance genes.</td>
<td>32</td>
</tr>
<tr>
<td>Andrographolide</td>
<td><img src="image" alt="Andrographolide Structure" /></td>
<td>1. P. falciparum strain 3D7. 2. P. berghei strain ANKA.</td>
<td>In vitro and in vivo</td>
<td>Reduction in GSH concentration and the activity of the thioredoxin reductase (TrxR) enzyme.</td>
<td>50</td>
</tr>
<tr>
<td>α-Mangostin</td>
<td><img src="image" alt="α-Mangostin Structure" /></td>
<td>1. P. falciparum strain K1. 2. P. falciparum strain FCR3. 3. P. falciparum strain 3D7. 3. P. berghei strain ANKA.</td>
<td>In vitro and in vivo</td>
<td>Inhibits haemoglobin degradation process that occurs in the food vacuole of P. falciparum.</td>
<td>53, 58, 59</td>
</tr>
<tr>
<td>Catechin</td>
<td><img src="image" alt="Catechin Structure" /></td>
<td>1. P. falciparum strain DD2. 2. P. falciparum strain 3D7.</td>
<td>In vitro</td>
<td>Induces oxidative stress to P. falciparum.</td>
<td>62, 63</td>
</tr>
<tr>
<td>Luteolin</td>
<td><img src="image" alt="Luteolin Structure" /></td>
<td>1. P. falciparum strain 3D7. 2. P. falciparum strain 7G8.</td>
<td>In vitro</td>
<td>Inhibits FabG, FabZ and Fabl enzymes which involve in parasite fatty acid biosynthesis.</td>
<td>69</td>
</tr>
<tr>
<td>Betulinic acid</td>
<td><img src="image" alt="Betulinic Acid Structure" /></td>
<td>1. P. falciparum strain K1. 2. P. falciparum strain T9-96. 3. P. falciparum strain 3D7.</td>
<td>In vitro</td>
<td>Ability to bind the PfATP6 protein and sarco/ endoplasmic reticulum Ca2+ATPase (SERCA) in mammals.</td>
<td>75-77</td>
</tr>
</tbody>
</table>

---

endothelium.57-58 Meanwhile, Risdawati reported that the antimalarial andrographolide activity was caused by this compound being able to disrupt the parasitic antioxidant defence system as evidenced by the reduction in GSH concentration and the activity of the thioredoxin reductase (TrxR) enzyme.59 Kusumawardhani, et al., reported that the antimalarial activity of standardised A. paniculata leaf extracts (andrographolide levels; 10.82 ± 0.37%) against P. berghei in vivo obtained ED50 of 12.2223 mg of standardised A. paniculata/KgBW leaf extract, equivalent to 1,320 mg of andrographolide compounds.51
heme propionate compounds thus forming ionic bonds which cause an increase in antiplasmodial activity.\(^{36-37}\) This is in accordance with the research of Kuncoro, et al., which reported that with a-mangostin able to inhibit the development of trophozoite stages into schizogony stages in *P. falciparum*, where at the trophozoite stage an increase in haemoglobin uptake, with inhibition of haemoglobin uptake, would result in inhibition haemoglobin degradation process that occurs in the food vacuole of *P. falciparum*.\(^{38}\) Mahabusarakam et al., reported that active a-mangostin inhibits the growth of *P. falciparum* strain K1 (chloroquine and pyrimethamine-resistant) in vitro with IC\(_{50}\) of 17 μM.\(^{39}\) This is in accordance with the results of research by Upegui et al., who reported that active betulinic acid inhibits the growth of *P. falciparum* strain 3D7 (chloroquine-sensitive) in vitro with IC\(_{50}\) of 0.734 μM, 62-63 \(\pm\) 0.1 μM compared to 36.10 ± 4.9 μM. \(^{59}\) In addition, Upegui et al., also reported that at doses of 100 mg/kg/day twice daily for 7 days, a-mangostin and d-mangostin were able to reduce the growth of *P. berghei* respectively by 80.7% and 79.9%.\(^{39}\) These findings can provide a basis for further research on a-mangostin as a potential compound to be developed into antimalarial drugs.\(^{39}\)

**CATECHIN**

Catechin (2R,3S)-2-(3,4-dihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol is the main bioactive compound found in green tea (*Camellia sinensis*).\(^{60}\) Catechin is reported to have several pharmacological activities including antioxidant, anti-microbial, anti-inflammatory, anti-viral, anti-cancer and anti-allergic properties.\(^{61}\) In addition, this compound is also reported to have antimalarial activity against *P. falciparum*.\(^{62-63}\) The antimalarial activity of catechin is due to its ability to induce oxidative stress to *P. falciparum*.\(^{62}\) Goyal et al., reported that Plasmodium is very susceptible to oxidative stress, where an increase in oxidative stress will cause a redox imbalance.\(^{64}\) Meanwhile, the redox system plays an important role in the survival of Plasmodium in the host cell, by disturbing the redox balance will affect the survival of Plasmodium during the intraerythrocytic stage.\(^{65}\) Budiman et al., reported that active catechin inhibited the growth of *P. falciparum* with IC\(_{50}\) of 0.734 μM,\(^{59}\) this is in accordance with the research of Abdulah et al., who reported that catechin could inhibit the growth of *P. falciparum* strain DD2 (chloroquine-resistant) with IC\(_{50}\) 198 μM after 24 hours of treatment.\(^{66}\) Although this is a preliminary study, the results of this study can provide information for further research on catechin as a potential compound as an antimalarial drug.\(^{63}\)

**LUTEOLIN**

Luteolin (3',4',5,7-tetrahydroxyflavone) is a common flavonoid that exists in many types of plants, including herbs, vegetables and medicinal plants.\(^{67}\) Luteolin is reported to have several pharmacological activities including anti-inflammatory, antioxidant, anti-diabetic, antimicrobial, and anticancer.\(^{68}\) In addition, luteolin was also reported to have antimalarial activity against *P. falciparum* strain 3D7 (chloroquine-sensitive) and *P. falciparum* strain 7/96 (chloroquine-sensitive) in vitro with IC\(_{50}\) of 12.40 ± 1.0 μM compared to δ-mangostin with IC\(_{50}\) is 121.2 ± 1.0 μM, but δ-mangostin is more active in inhibiting the growth of *P. falciparum* strain 3D7 (chloroquine-sensitive) in vitro with IC\(_{50}\) of 36.10 ± 4.9 μM.\(^{39}\) In addition, Upegui et al., also reported that at doses of 100 mg/kg/day twice daily for 7 days, a-mangostin and d-mangostin were able to reduce the growth of *P. berghei* respectively by 80.7% and 79.9%.\(^{39}\) These findings can provide a basis for further research on a-mangostin as a potential compound to be developed into antimalarial drugs.\(^{39}\)

**BETULINIC ACID**

Betulinic acid ((3β)-3-Hydroxy-lup-20(29)-en-28-oic acid) is a naturally occurring pentacyclic triterpenoid found in the skin of several plant species, especially white birch (*Betula pubescens*).\(^{70}\) Betulinic acid has been shown to have several pharmacological activities such as anti-inflammatory, anti-dyslipidemia, anti-inflammatory, antiviral, anticancer, parasiticidal and anti-infectious.\(^{71}\) In addition, this compound was also reported to have antimalarial activity against *P. falciparum* strain K1 (chloroquine-resistant) and *P. falciparum* strain T9-96 (chloroquine-sensitive) with IC\(_{50}\) of 19.6 mg/ml and 25.9 mg/ml, respectively.\(^{39}\) This is in accordance with the results of research by Silva et al., who reported that active betulinic acid inhibits the growth of *P. falciparum* strain 3D7 (chloroquine-sensitive) with IC\(_{50}\) of 18 ± 0.17 μM.\(^{59}\) Antimalarial activity of betulinic acid is thought to be caused by its ability to bind the PIATP6 protein and sarco/endoplasmic reticulum Ca\(^{2+}\)ATPase (SERCA) in mammals so that it interferes with selectivity between parasites and hosts.\(^{39}\) The development of betulinic acid as an antimalarial for the future is very necessary, given that the antimalarial mechanism of this compound is similar to the drug artemisinin by inhibiting the sarco/endoplasmic reticulum Ca\(^{2+}\)ATPase (SERCA) ortholog PfATP6 in *P. falciparum, where PIATP6 is the only SERCA type Ca\(^{2+}\)ATPase sequence in the parasitic genome.\(^{72-73}\)

**CONCLUSION**

All of these isolates have been scientifically proven to have antimalarial activity, where each compound has a different mechanism of action in inhibiting the growth of malaria parasites. However, further research must be done to see the effectiveness of these compounds as antimalariais, so that they can be used in the latest malaria treatment, which has now shown resistance to first-line malaria treatment.

**ACKNOWLEDGMENT**

This article was funded by the Ministry of Research, Technology and Higher Education of the Republic of Indonesia through Doctoral Dissertation Research No. B/112/E3/RA.00/2021.

**CONFLICTS OF INTEREST**

The authors declare that there is no conflict of interest regarding the publication of this article.

**ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERCA:</td>
<td>sarco/endoplasmic reticulum Ca(^{2+})ATPase;</td>
</tr>
<tr>
<td>CM:</td>
<td>cerebral malaria;</td>
</tr>
<tr>
<td>IL-6:</td>
<td>interleukin-6;</td>
</tr>
<tr>
<td>TNF:</td>
<td>tumor necrosis factor;</td>
</tr>
<tr>
<td>PBMC:</td>
<td>peripheral blood mononuclear cell;</td>
</tr>
<tr>
<td>VCAM-1:</td>
<td>vascular cell adhesion molecule 1;</td>
</tr>
<tr>
<td>ICAM-1:</td>
<td>intercellular adhesion molecule 1;</td>
</tr>
<tr>
<td>ROS:</td>
<td>reactive oxygen species;</td>
</tr>
<tr>
<td>ERK:</td>
<td>extracellular signal-regulated kinase-3β;</td>
</tr>
<tr>
<td>JNK:</td>
<td>nuclear factor-kappaB;</td>
</tr>
<tr>
<td>GSH:</td>
<td>glutathione;</td>
</tr>
<tr>
<td>TrxR:</td>
<td>thioredoxin reductase enzyme;</td>
</tr>
<tr>
<td>SOD:</td>
<td>superoxide dismutase;</td>
</tr>
<tr>
<td>NF-kB:</td>
<td>nuclear factor-kappaB;</td>
</tr>
<tr>
<td>Hb:</td>
<td>haemoglobin;</td>
</tr>
<tr>
<td>FP IX:</td>
<td>factor IX;</td>
</tr>
<tr>
<td>PBMC:</td>
<td>peripheral blood mononuclear cell;</td>
</tr>
<tr>
<td>NF-kB:</td>
<td>nuclear factor-kappaB;</td>
</tr>
<tr>
<td>GSH:</td>
<td>glutathione;</td>
</tr>
<tr>
<td>TrxR:</td>
<td>thioredoxin reductase enzyme;</td>
</tr>
<tr>
<td>SOD:</td>
<td>superoxide dismutase;</td>
</tr>
<tr>
<td>NF-kB:</td>
<td>nuclear factor-kappaB;</td>
</tr>
</tbody>
</table>
transacylase; **FabH**: β-ketoacyl-ACP synthase III; **FabG**: β-ketoacyl-ACP reductase; **FabA or FabZ**: β-hydroxyacyl-ACP dehydratase; **FabI**: enoyl-ACP reductase; **FabB and/or FabF**: β-ketoacyl-ACP synthase I and II; **CUR**: curcumin; **KAEMP**: kaempferol; **PIR**: piperine; **ADG**: andrographolide; **α-MG**: α-mangostin; **CAT**: catechin; **LUT**: luteolin; **BA**: betulinic acid.


83. Alkandahri MY, et al.: Antimalaria Activities of Several Active Compounds from Medicinal Plants


ABOUT AUTHORS

Maulana Yusuf Alkandahri: A Doctoral student at the Department of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Padjadjaran University, Indonesia. He is also a lecturer at the Faculty of Pharmacy, Buana Perjuangan Karawang University, Indonesia.

Nia Yuniarsih: A lecturer at the Faculty of Pharmacy, Buana Perjuangan Karawang University, Indonesia.

Afiat Berbudi: A lecturer at the Department of Biomedical Sciences, Parasitology Division, Faculty of Medicine, Padjadjaran University, Indonesia.

Anas Subarnas: A Professor at the Department of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Padjadjaran University, Indonesia.

Cite this article: Alkandahri MY, Yuniarsih N, Berbudi A, Subarnas A. Antimalaria Activities of Several Active Compounds from Medicinal Plants. Pharmacogn J. 2022;14(1): 245-252.