Anti-malarial activity of the leaf latex of *Aloe weloensis* (Aloaceae) against plasmodium parasites

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Research Article

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Abstract

Background: Lack of available vaccines and emerging resistance on the anti-malarial drug have provided the necessity to find noble plant–based anti-malarial drugs. The leaf latex *Aloe weloensis* has been used in folk medicine against malarial and other human ailments in Ethiopia. Hence, the present study aimed to investigate the anti-malarial activity of the leaf latex of *A. weloensis* against Plasmodium parasites to validate its traditional claim.

Methods: The leaf latex of *A. weloensis* was evaluated *in vitro* anti-malarial activity against 3D7 strain of *Plasmodium falciparum*. The prophylactic and curative models were employed to determine *in vivo* anti-malarial activity of the latex against *P. berghei* infected mice, and antioxidant activity of the leaf latex of *A. weloensis* was assessed in DPPH assay.

Results: The leaf latex of *Aloe weloensis* endowed with free radical inhibition activity (IC_{50} = 10.25 µg/ml). The latex of *A. weloensis* leaf was demonstrated inhibitory activity against 3D7 strain of *P. falciparum* (IC_{50} = 9.14 µg/ml). The prophylactic and curative effect of the latex was found to be dose-dependent. Parasitemia reduction was significant (200 mg/kg, $p<0.01$, 400 and ,600 mg/kg, $p<0.001$) in prophylactic test compared to the control. Parasitemia level of the mice treated with 200, 400, and 600 mg/kg doses of the latex significantly ($p<0.001$) reduced with suppression of 36%, 58%, and 74% respectively in the curative test. The leaf latex significantly ($p<0.01$) improved mean survival times, packed cell volume , rectal temperature, and bodyweight of *P. berghei* infected mice.

Conclusion: The result was confirmed the anti-malarial activity of the leaf latex of *Aloe weloensis* at various doses which corroborates the traditional uses of the plant.

Introduction

Plants and plant extracts possess a wide margin of safety and show potential effectiveness in treating various diseases [1,2]. Medicinal plants are the major resource for the treatment of malaria infections in Africa since health care facilities are limited [3]. Currently, the available anti-malarial drugs like quinine, halofantrine, mefloquine, chloroquine and more recently arthimisinin are plant origin [4-6].

Lack of available vaccines and -the emerging resistance to anti-malarial drugs have provided the necessity to find noble plant-based anti-malarial drugs [7-9]. Developing noble anti-malarial agents is imperative to overcome the challenges posed by the development of anti-malarial drug resistance. Nature has gifted various plants with a potential effect against plasmodium parasites [10-12].

Aloe species have been used as topical and oral therapeutic agents due to their health, beauty, medicinal, and skincare properties. They have been demonstrated antibacterial, antitumor, anti-inflammatory, anti-arthritic, anti-rheumatoid, anticancer, and antidiabetic activities [13]. The latex of *Aloe weloensis* leaf showed antibacterial effect against gram-negative and gram-positive strains [14]. The plant's leaf latex has been used in folk medicine against malarial and other human ailments in Ethiopia [15]. The leaf latex

Aloe weloensis showed a significant anti-malarial effect in 'Peter's (4-day suppressive) test and safe at 2000 mg/kg [16]. The leaf latex of this plant contains flavonoids, glycosides, anthraquinones, saponins, terpenoids, and tannins that showed prominent anti-malarial activities in various plant extracts through a various mechanisms of action [12,17-19]. This study was aimed to investigate the anti-malarial activity of the leaf latex of *A. weloensis* against Plasmodium parasites.

Methods

Collection and preparation of leaf latex of *Aloe weloensis*

The leaf latex of *A. weloensis* was collected from North East Ethiopia (Gubalafto) and identified by the botanist in May 2020. The plant's leaf was cut near to the stem and inclined towards the collecting plate to gain the latex. The latex was dried under shade at room temperature with optimal ventilation. The dried latex was kept in a clean vial and stored in a desiccator until used for the experiment.

Experimental animals and parasite

Healthy Swiss albino mice of either sex weighing 20-35 gram and aged 2-3 months were used in the study. The mice were obtained from Wollo University and kept in the Pharmacy Department's animal house in 12 h light-dark cycle and permitted free to diet and water *ad libitum* [18]. Animals were acclimatized to the laboratory conditions for one week before the initiation of the experiment. *Plasmodium berghei* Anka strain was obtained from Ethiopian Public Health Institute. The parasite was maintained by serial blood passage from infected mice to uninfected ones on a seven-day basis. This study was carried out based on the guide for the care and use of laboratory animals [17,20,21].

Acute oral toxicity study

Acute oral toxicity study was carried out based on the Organisation for Economic Co-operation and Development (OECD) guidelines 425 [22]. One female Swiss albino mouse was fasted for 4 h and the fasting body weight of the animal was measured. Then, the leaf latex was administered to the mouse at a dose of 5000 mg/kg. The mouse was then kept under strict observation of physical and behavioral changes for one day, with special attention during the first four h. Following the result from the first mouse, another four mice were fasted for 4 h and then, the latex was administered to each mouse at the dose of 5000 mg/kg and were observed in the same manner. The observation was continued for fourteen days for any signs of overt toxicity.

In vitro antioxidant activity of the leaf latex *Aloe weloensis*

Antioxidant activity of the latex of *Aloe weloensis* leaf was evaluated using DPPH free radical scavenging assay [23]. A 3ml of 0.1mM (DPPH in methanol) was mixed in 1 ml methanolic solution of different concentrations (12.5-400 µg/ml) of the latex and incubated in the dark for thirty minutes at room temperature. Ascorbic acid was used as a standard antioxidant. After 30 minutes, the absorbance of the

mixture and the control at 517nm was read by using a UV spectrophotometer. The test was conducted in triplicate, and the percent of scavenging of inhibition was calculated as follow

% free radical scavenging= Absorbance of Control – Absorbance of Sample x 100

Absorbance of Control

Where absorbance of control was the absorbance without sample, absorbance samples was the absorbance of sample seed extract or ascorbic acid.

In vitro anti-malarial evaluation of the leaf latex of *Aloe weloensis*

Chloroquine sensitive *P. falciparum* (3D7 strain) was used *in vitro* blood-stage culture to determine the anti-malarial efficacy of *Aloe weloensis*. *Plasmodium falciparum* culture was maintained in the method described in previous studies with some modification [19,24]**.***Plasmodium falciparum* (suspension of 3D7) synchronized in 5% sorbitol to ring stage was seeded (200 µl/well with 2% ring stages and O^{Rh+} red blood cells at 2% hematocrit) in 96-well tissue culture plates. Then, the latex of *A. weloensis* leaves in different concentrations (10 - 320 µg/ml) was added to these wells. Chloroquine at the same concentration was used as the standard control, and dimethyl sulfoxide without the tested samples were used as the negative control. The parasites were cultured for 30h in the desiccators and then incubated at 37°C for 72h in 2% O_2, 5% CO_2, and 93% N_2 [18,19]. The infected red blood cells (RBCs) were transferred into a freshly prepared complete medium to propagate the culture. After 72 h incubation, the cultures were preserved at - 20 °C, and the parasites were harvested. The thin blood smears were prepared and fixed with 100%methanol and stained with 10% Giemsa for 30munite to evaluate the growth stage of the parasites. The parasitemia was examined under the microscope, and IC50 was determined by plotting the latex concentration on the percentage of growth inhibition. Percentage growth inhibition of the parasites was determined by using the following formula [18,24].

$$\%\ \text{of growth inhibition} = \frac{(\text{Mean parasitemia of the control} - \text{Mean parasitemia of the sample}) * 100}{Mean\ parasitemia\ of\ control}$$

Parasite inoculation

Plasmodium berghei Anka strain was used for induction of malaria in experimental mice. The parasites were maintained by intraperitoneal serial passage of blood, and parasitemia level (30-37%) of *P. berghei* infected donor mice were determined [25,26]. Donor mouse was anaesthetized by pentobarbitone at 150 mg/kg i.p. and infected blood was collected by cardiac puncture into heparinized vacutainer tube containing trisodium citrate (0.5%). The blood was then diluted in normal saline (0.9%) and RBC count of normal mice so that the final suspension would contain about 1×10^7 parasitized red blood cells (PRBCs) in 0.2ml suspension [17,18]. Each mouse used in the study was infected intraperitoneally with 0.2ml containing 1×10^7 *P. berghei* parasitized RBCs.

Dosing and grouping of the animals

The mice were divided into five groups randomly (n=6). Group I (negative control) was treated with 10 mg/kg 2% Tween-80 in distilled water (TW80); Group II, III and IV were treated with 200 ,400 and 600 mg/kg doses of the leaf latex, respectively. Group V was treated with the standard drug, chloroquine (25 mg/kg) [17,20].

Anti-malarial activity of the leaf latex of *A. weloensis* in curative test ('Rane's test)

On the first day (day 0), the mice were injected intraperitonially with standard inoculum of 1x 10^7 *P. berghei* infected erythrocytes. After seventy-two hours, mice were randomly assigned into five groups (n=6). Group I was treated with vehicle; group II, III, and IV were treated three doses of the latex of *A. weloensis* respectively. Group V was treated with chloroquine daily for five days. Thin blood films were prepared from each mouse's tail blood daily for five days to determine the levels of parasitemia and mean survival time for each group [17,18,28].

Anti-malarial activity of the leaf latex of *A. weloensis* in prophylactic test

Mice were randomly assigned into five groups (n=6) and treated with a single dose according to their respective grouping. Then, after 24 h (day 0), each mouse was injected intraperitoneally with 0.2ml infected blood containing 1×10^7 *P. berghei* parasitized RBCs. After 72 h (day 3 post-infection) blood samples were collected from the tip tail of each mouse, and slides were prepared. Then, % inhibition, parasitemia level, and survival time were determined [17].

Peripheral blood smears preparation

Thin smears of blood were made from each mouse's tail on the fifth day (D 5). The smears were applied on microscopic slides, and the blood was drawn evenly across a second slide to make thin blood films and allowed to dry at room temperature. Then, they were fixed with 100 % methanol and stained with 10 % Giemsa stain (PH = 7.2) for 15 minutes.

Parasitemia determination

Each stained slide for each mouse was examined under a microscope. The parasitemia level was determined by counting the number of parasitized erythrocytes in random fields of the microscope. Percent parasitemia and percent suppression were calculated by using the following formula..

$$\% \text{ Parasitemia} = \frac{(\text{number of parasitized RBC})}{(\text{total number of RBC})} \times 100$$

$$\% \text{ Suppression} = \frac{(\text{mean parasitemia of negative control-mean parasitemia of treated group})}{(\text{mean parasitemia of negative control})} \times 100$$

Determination of mean survival time

Mean survival time (MST) is another parameter that is commonly used to evaluate the efficacy of anti-malarial plant materials. Mortality was monitored every day, and the number of the days from the time of infection up to death was recorded for each mouse in the treatment and control groups throughout the follow-up period, and the MST was calculated for each group by using the following formula.

$$MST = \frac{\text{Sum of survival time of all mice in a group (days)}}{\text{Total number of mice in that group}}$$

Packed Cell Volume Measurement

The packed cell volume (PCV) was measured to predict the effectiveness of the test latex in preventing hemolysis resulting from increasing parasitemia associated with malaria. Blood was collected from each mouse's tail in heparinized microhematocrit capillary tubes by filling three-quarters of its volume. The tubes were sealed by sealant and placed in a microhematocrit centrifuge with the sealed ends outwards.

The blood was then centrifuged at 12,000 rpm for 15 min. The tubes were then taken out of the centrifuge, and PCV were determined using a standard Micro-Hematocrit Reader. The PCV of each mouse was then measured before infection and on day four after infection using the formula (17, 20, 25).

$$PCV = \frac{\text{(Volume of erythrocytes in a given volume of blood)}}{\text{(Total blood volume)}}$$

Determination of body weight and temperature changes

The body weights of the mice were determined to observe whether the leaf latex was prevented weight loss for 'Peter's test. The body weight of each mouse was measured before infection (day 0) and on day 4 using a sensitive digital weighing balance. Rectal temperature was also measured by a digital thermometer before infection, and four hours after infection, and then daily.

Statistical analysis

The results of the study were expressed as the mean ± standard error of the mean. Statistical analysis of the data was carried out with a one-way analysis of variance followed by Tukey post hoc multiple comparison test. Significant differences were set at $p<0.05$.

Results

Acute toxicity

In the acute toxicity study, no sign of toxicity or mortality was observed in mice after oral administration of the leaf latex at 5000 mg/kg doses, signifying that the LD_{50} was greater than 5000 mg/kg.

Antioxidant activity of the leaf latex of *Aloe weloensis*

Antioxidant capacity of the latex was assayed using DPPH free radical. Qualitative detection showed that the color of the test solution changed from violet to a slightly yellow color. The finding of the study showed that antioxidant activity ($p<0.001$) of the latex was concentration-dependent with IC_{50} value of 10.25 µg/ml (Table 1).

Table 1: Percentage of free radical scavenging activity of the leaf latex of *Aloe weloensis*

Concentration (µg/ml)	% of inhibition	
	Ascorbic acid	Leaf latex
12.5	26.03±0.16	9.21±0.37
25	37.82±0.23	21.67±0.71
50	54.56±0.52	33.14±0.53
100	70.21±0.32	47.01±0.41
200	79.38±0.45	68.01±0.31
400	95.13±0.34	83.54±0.27
IC50 (µg/ml)	2.97	10.25

The result expressed as mean ± standard error of the mean. n=3.

The effect of the leaf latex of *A. weloensis* on *P. falciparum* growth in culture

After 72hr incubation, the latex of *Aloe weloensis* was potentially inhibiting the growth of *Plasmodium falciparum* (3D7 strain). The finding showed that the latex was active against *P. falciparum* parasites, and growth inhibition was concentration-dependent (Figure 1). The IC50 of the latex and chloroquine were found to be 9.14 and 0.12 µg/ml, respectively.

The effect of the leaf latex of *Aloe weloensis* in curative test

The finding showed that parasitemia reduction was significant($p<0.001$) at 200, 400 and 600 mg/kg doses of the latex with suppression of 36%, 58%, and 74%, respectively (Table 2). The result showed that all doses of the latex endowed curative effect as compared to the control. Curative effect of 200 mg/kg dose was significantly ($p< 0.01$) lower than chloroquine ($p<0.001$). All doses of the latex significantly ($p<0.01$) improved the mean survival time of the mice compared to the vehicle control. The survival time of the mice treated with the lowest dose (200 mg/kg) was significantly ($p<0.01$) lower than chloroquine.

Table 2: Parasitemia level, % Suppression and survival time of infected mice treated by the leaf latex of *A. weloensis* leaf in curative test

Groups	% Parasitemia	% Suppression	Survival times (days)
10 ml/kg NC	76.85±0.61	00.00	8.12%±0.41
25 mg/kg CQ	00.00±0.00	100.00^{a3b3c2d2}	30.00±0.00^{a3b2}
200 mg/kg LL	40.37±0.71^{a3e2}	36.17^{a3e3}	12.72±0.45^{a2e2}
400 mg/kg LL	30.25±0.45^{a3e2}	57.69^{a3e2}	20.14±0.62^{a2}
600 mg/kg LL	23.65±0.57^{a3e1}	73.51^{a3e2}	24.87±0.73^{a2}

Data are expressed as means ± standard error of the mean; n = 6; [a] compared to vehicle; [b] to 200 mg/kg; [c] to 400 mg/kg; [d]to 600 mg/kg; [e] to 25 mg/kg CQ; [1] $P<0.05$; [2] $P<0.01$; [3] $P<0.001$ with respect to vehicle control. CQ, chloroquine; LL, Leaf latex; NC, negative control.

The effect of *A. weloensis* leaf latex on PCV, rectal temperature, and body weight

In this study, the leaf latex at 400 and 600 mg/kg doses significantly (p< 0.01) prevented packed cell volume and reduced rectal temperature of *P. berghei* infected mice compared to the vehicle control. In addition, 25 mg/kg chloroquine was significantly (p<0.001) prevented PCV and rectal temperature (Table 3). Prevention of bodyweight reduction was significant at the middle and upper doses of the treatment group (p< 0.05 at 200 and p<0.01 at 400 and 600 mg/kg) compared to the control in the curative test.

Table 3: Packed cell volume, rectal temperature and body weight of infected mice treated by the leaf latex of *A. weloensis*in the curative test

Groups	PCV		Temperature		Bodyweight	
	Day 0	Day 4	Day 0	Day 4	Day 0	Day 4
10 ml/kg NC	49.60±1.36	40.60±1.81	37.12±0.16	29.64±0.36	28.80±0.37	24.760±0.23
25 mg/kg CQ	48.12±0.10	53.20±0.37^{a3b1}	35.60±0.73	37.42±0.12^{a3}	27.60±0.51	32.60±0.73^{a3}
200mg/kg LL	48.00±0.71	42.00±0.95^{c1}	36.58±0.13	32.38±0.31^{c1}	27.00±0.71	27.24±0.37^{a1}
400mg/kg LL	48.80±0.73	46.80±0.63^{a2}	36.54±0.18	34.36±0.31^{a2}	26.80±0.37	29.60±1.52^{a2}
600mg/kg LL	49.00±0.56	47.10±1.08^{a2}	36.54±0.18	36.02±0.07^{a2}	28.60±0.51	31.80±0.68^{a2}

Data are expressed as means ± standard error of the mean; n = 6; [a] compared to vehicle; [b] to 200 mg/kg; [c] to 25 mg/kg CQ; [1] $P<0.05$; [2] $P<0.01$; [3] $P<0.001$ with respect to vehicle control.

Day 0: weight, temperature and packed cell volume pre-treatment on day zero; Day 4: post-treatment on day five; CQ, chloroquine; LL, Leaf latex; NC, negative control; PCV, packed cell volume.

The effect of the leaf latex of *Aloe weloensis* in prophylactic test

The finding showed that the leaf latex at the doses of 200 mg/kg ($p<0.05$),400, and 600 mg/kg ($p<0.01$) significantly reduced parasitemia level in the prophylactic test compared to the vehicle control. Parasitemia reduction was dose-dependent, and percentage of suppression was increased with increasing the doses of the leaf latex of *A. weloensis*. At the same time, all doses of *A. weloensis* leaf latex significantly ($p<0.01$) increased the mean survival time of the mice. The survival time of the mice treated with the latex at 200 mg/kg dose was significantly ($p< 0.01$) lower than the standard drug. (Table 4).

Table 4: Parasitemia level, % Suppression and survival time of infected mice treated by the leaf latex of *A. weloensis* leaf in prophylactic test.

Group	% Parasitemia	% Suppression	Survival times (days)
10 ml/kg NC	65.31±0.17	-	5.72±0.42
25 mg/kg CQ	00.0 ± 00^{a3b2}	100	30.45 ± 0.18^{a3b2}
200 mg/kg LL	27.42 ± 0.23^{a1c1d1e2}	37.87	8.21 ± 0.15^{a1d1e2}
400 mg/kg LL	16.52 ± 0.18^{a2b1}	46.29	14.10 ± 0.31^{a2}
600 mg/kg LL	12.12 ± 0.41^{a2b1}	56.68	17.50 ± 0.22^{a3b1}

Data are expressed as means ± standard error of the mean; n = 6; [a] compared to vehicle; [b] to 200 mg/kg; [c] to 400 mg/kg; [d]to 600 mg/kg; [e] to 25 mg/kg CQ; [1] $P<0.05$; [2] $P<0.01$; [3] $P<0.001$ with respect to vehicle control. CQ, chloroquine; LL, Leaf latex; NC, negative control.

Discussion

Anti-malarial activity of the leaf latex *Aloe weloensis* was evaluated against plasmodium parasites. The *in vitro* test was evaluated on chloroquine-sensitive 3D7 strain of the parasite while the *in vivo* tests were evaluated on *P. berghei* infected mice since *berghei* produce disease similar to human Plasmodium infection and sensitivity to standard drug chloroquine [4,17,27].

In this study, the leaf latex showed potent anti-malarial activity against 3D7 strain of *P. falciparum*. Parasite inhibition was found to be concentration-dependent, with IC_{50} values of the leaf latex and

chloroquine were 9.14 and 0.02 µg/mL, respectively. According to a literature review by Satish et at [19] the leaf latex of *A. weloensis* was active (IC_{50} = 5–50 µg/ml) against 3D7 strain of *P. falciparum*. The parasite growth inhibition calls for further investigation in the curative and prophylactic model against *P. berghei* infected mice since *in vivo* models allow the possible bioactivation and the likelihood of the immune system to eradicate the infection, unlike *in vitro* study [4,6,26].

Plant extracts are considered active when reduction or percentage suppression in parasitemia is ≥30% or significant prolonging the survival time of treated mice compared to the vehicle control [28-30]. Thus, the leaf latex of *A. weloensis* was found to be active against *P. berghei* infected mice.

Curative test was employed in the current study to assess the effect of the leaf latex in late plasmodium infection. The finding showed that curative effect of the latex was significant ($p< 0.001$) at all doses compared to vehicle with % suppression of 36% (200 mg/kg), 58% (400 mg/kg) and 74% (600 mg/kg). This confirmed that the leaf latex of *A. weloensis* endowed efficacy in the late stages of plasmodium infection. The relatively less chemo suppression activity (36%) at 200 mg/kg dose of the leaf latex possibly due to less accumulative efficacy to bring high chemo suppression. The latex at the dose of 400 mg/kg (58%) and 600 mg/kg (74%) showed greater parasite suppression, implying the dose-dependent curative effect of the latex.

Phytoconstituents present in the latex may block parasite growth and replication. Alkaloids endowed anti-malarial effect by blocking detoxification of heme and protein synthesis in *P. falciparum* [31,32*]*. Quinine is an alkaloidal anti-malarial drug isolated from Cinchona bark. It is useful in treating multidrug-resistant malaria and serving as the lead compound for the derivative of chloroquine [33]. Phytosteroids and flavonoids showed an outstanding activity against plasmodium parasites by boosting host immunity [34].

In this study, all doses of the latex significantly ($p<0.01$) improved mean survival time of the mice as compared to the vehicle control in curative test. This finding might indicate that the latex suppressed *P. berghei* and reduced the parasite's overall pathologic effect on the mice. The longest mean survival time of the mice was strongly associated with the maximum parasitemia inhibition. According to the previous study by Basir *et al*., the leaf latex of *A. weloensis* was active as the latex prolonged mean survival time beyond 12 days [35].

In addition, packed cell volume and rectal temperature of mice were used to predict the effectiveness of the test compounds. Contrary to humans, mice's body temperature was decreased while increasing parasitemia due to a decrease in the metabolism of infected mice [6,35]. In this study, the doses of the latex at 400 and 600 mg/kg showed a significant ($p<0.01$) protective effect in rectal temperature of *P. berghei* infected mice. This could probably be due to the preventive effects of the latex in some pathological processes that cause a reduction in internal body temperature, augment the immune system and metabolic rate of infected mice.

Packed cell volume reduction is one feature of *P. berghei* infected mice and was determined to evaluate the effectiveness of *Aloe weloensis*. In both human and mice, escalating parasitemia causes the destruction of infected RBCs, clearance of uninfected RBCs, and erythropoietic suppression and dyserythropoiesis [36]. Packed cell volume was monitored before infection and on day four after infections, for groups to predict the effectiveness of the study plant. The study results showed that medium and high doses of the latex significantly ($p<0.01$) prevented PCV reduction compared to vehicle control. This effect is in line with the pack cell volume protection effect of the *Aloe megalacantha* [37]. However, the low dose was devoid of significant prevention effect of red blood cells hemolysis., This might be due to high parasitemia level and the low concentration of bioactive molecules at the lower dose relative to the other doses. The prevention of packed cell volume reduction might be due to the destructive antiplasmodial effect of the leaf latex against the parasitized RBCs and the causative parasite, thereby sustaining the availability of the new RBCs produced in the bone marrow [38,39].

The body weight loss in the experimental animals is due to the appetite-suppressing effects of the parasite [35]. Significant body weight loss was measured in the negative control group than the groups treated with three doses of the latex and chloroquine. Hence, the present finding showed that the latex of *A. weloensis* was found to prevent *P. berghei* induced weight loss in mice.

In this study, the finding showed that percentage suppression of parasitemia significantly changed by all latex doses compared to the vehicle control in the prophylactic test. Parasitemia suppression was increased with increasing doses of the leaf latex ($p<0.05$ at 200 mg/kg, $p<0.01$ at 400 and 600 mg/kg). In the prophylactic model, all doses of the latex significantly ($p<0.01$) improved the mean survival time of the mice relative to the control. The survival time of the mice treated with 200 mg/kg dose of the latex significantly ($p<0.01$) lower than chloroquine. The finding of the study showed that the leaf latex of *A. weloensis* able to prevent chloroquine-sensitive plasmodium parasite.

In summary, The present study showed that the leaf latex of *Aloe weloensis* endowed with prominent anti-malarial activity against the 3D7 strain of *P. falciparum* and *P. berghei*. The medium and high doses of the latex showed a greater prophylactic and curative effect.

Conclusion

The finding of the study confirmed the anti-malarial and antioxidant effect of *Aloe weloensis* leaf latex at various tested doses which corroborate its use in the folk medicine. Therefre, further study is required to identify, characterize, and isolate the bioactive compound (s) that possess anti-malarial activity.

Abbreviations

OECD; Organization for Economic Cooperation and Development

Declarations

Availability of data and materials

All the datasets used/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval

Ethical approval was obtained from the ethical review committee of College of Medicine and Health Sciences, Wollo University. The study was conducted according to OECD Guidelines and the Guide for the Care and Use of Laboratory Animals.

Competing interests

None.

Authors' contributions

Gedefaw Getnet Amare, Amsalu Degu and Zemene Demelash Kifle were involved in the design of the study, the actual experiment, aanlaysis of the data and write of the mansuscript All authors have read the submission version of the manuscript.

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Figures

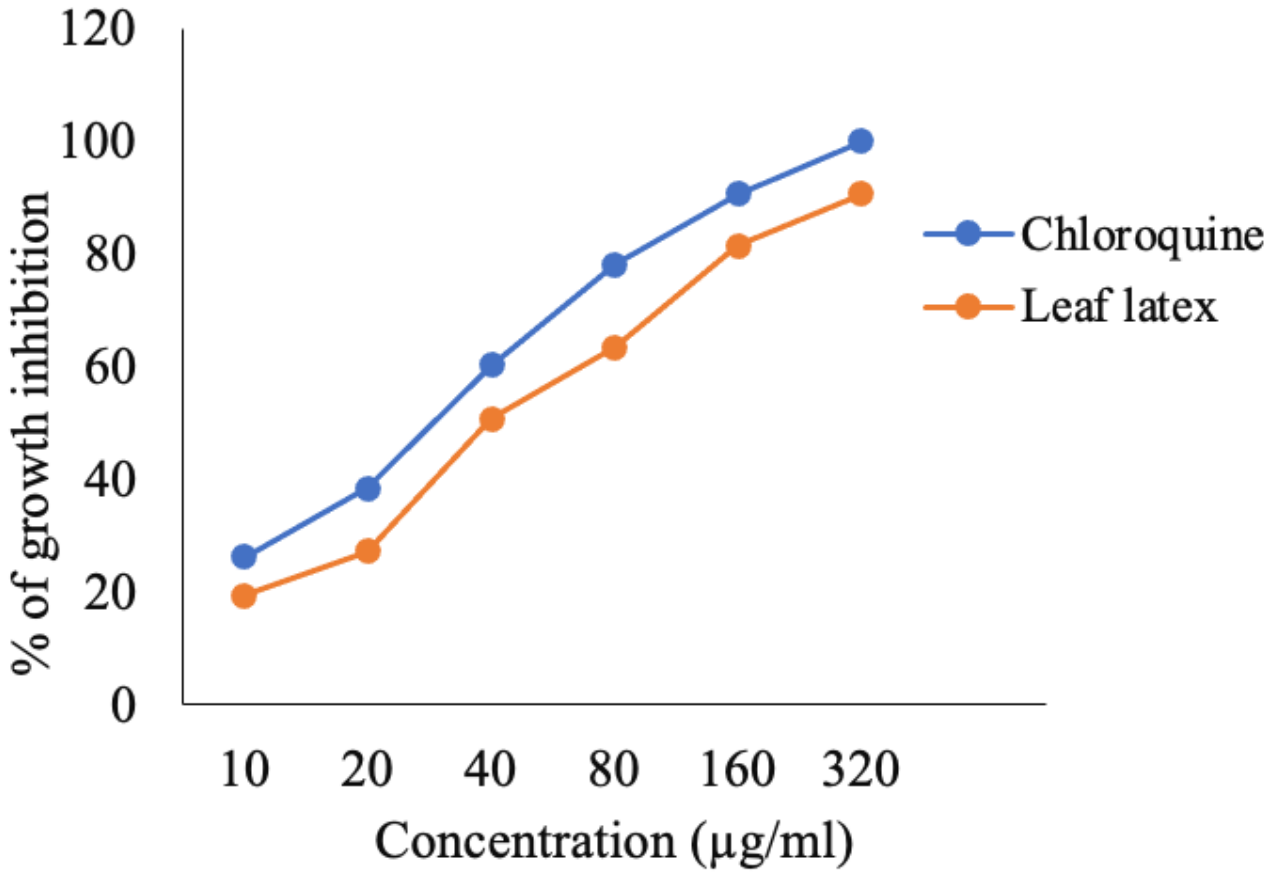

Figure 1

P. falciparum growth inhibition effect of the leaf latex of A. weloensis