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EVALUATION OF THE ANTIPLASMODIAL ACTIVITY OF *TALINUM TRIANGULARE* (TALINACEAE), A WEST AFRICAN FOOD PLANT

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ABSTRACT

Malaria remains a major public health problem in Côte d'Ivoire due to its morbidity, mortality and significant socio-economic consequences. The emergence and spread of strains resistant to current antimalarial drugs requires the diligent search for new active molecules; and medicinal plants represent a preferred alternative. The general objective of this work was to evaluate *ex vivo*, the antiplasmodial activity of aqueous and hydroethanolic extracts of *Talinum triangulare* leaves, a plant of the Talinaceae family on *Plasmodium falciparum* by chemo-sensitivity tests. Chemio-sensitivity tests were performed on clinical isolates of *P. falciparum* isolated from patients with simple malaria. The HRP2 colorimetric method (ELISA test) was used to determine the *ex vivo* sensitivity of *P. falciparum* to *Talinum triangulare* extracts. The results showed that all extracts have very good antimalarial activity with $IC_{50s} < 5$ µg/mL. However, the hydroethanolic extract showed better activity than the aqueous extract with a median IC_{50} of 2.63 µg/mL. The Amodiaquine (reference molecule) used was sensitive on two clinical isolates and resistant on the other three. Phytochemical triage revealed the presence of secondary metabolites such as alkaloïds, sterols and polyterpenes. These results make *Talinum triangulare* a promising resource in the search for antimalarial molecules.

KEYWORDS: *P. falciparum*, *Talinum triangulare*, antiplasmodium, *ex vivo*, chemo-sensitivity.

INTRODUCTION

Malaria is an endemo-epidemic parasitosis in intertropical areas. It is characterized by the presence in the body of a unicellular (protozoan) parasite of the genus *Plasmodium*, transmitted to humans by the bite of the female of a hematophagous mosquito of the genus *Anopheles*.[30] It is one of the most frequent parasitic infectious diseases in the world.[32] The number of malaria cases worldwide was estimated at 219 million and the number of deaths associated with 435,000.[23] Malaria remains a high mortality factor in Africa, especially among children under five (5) years of age. He kills a child every two minutes.[2] *Plasmodium falciparum*, which causes 99% of malaria cases, is the most prevalent parasite in Sub-Saharan Africa.[2] Côte d'Ivoire in particular is facing this scourge, especially since it is ranked among the fourteen (14) African countries most affected by *Plasmodium falciparum* malaria.[9] It is the leading cause of morbidity and mortality among children under 5 years of age, 33% of the reasons for consultation in health centres, 40% of the causes of school and work absenteeism, and 50% of loss of agricultural income. Ivorian populations spend about 25% of their income on the prevention and treatment of this disease.[24] Several actions are being taken by the international community to combat this parasite. However, the most reliable curative treatments based on artemisinin and quinine derivatives are confronted with resistance phenomena. Many strains of *Plasmodium falciparum*, accounting for 99% of deaths, are increasingly resistant to standard drugs based on quinine, chloroquine, mefloquine or sulfadoxinepyrimethamine.[22] In addition, resistance to artemisinin-based combination therapies (ACTs) has been reported in five countries in the Mekong Basin.[23] According to the World Health Organization (WHO), more than 80% of african populations use traditional medicine and pharmacopoeia to address health

problems.[19] Medicinal plants therefore appear to be an important source to explore. A promising alternative would then be to anticipate the proliferation of resistant parasites by discovering new bioactive molecules against malaria from medicinal plants since quinine and artemisinin, two reference antimalarial molecules, have been isolated from medicinal plants. It is in this context that this study, which has the general objective of evaluating the antiplasmodial activity of *Talinum triangulare* leaf extracts on *Plasmodium falciparum*, is carried out.

MATERIAL AND METHODS

MATERIAL

Plant material

The plant material consisted of leaves of *Talinum triangulare*, belonging to the Talinaceae family and widely known as wild spinach. In Côte d'Ivoire, this plant is used either for food needs or for the treatment of malaria.

Reference antimalarial molecule

The reference antimalarial drug molecule used in this study was Amodiaquine. It was provided by the Malaria Research and Control Centre (MRCC) of the National Institute of Public Health (NIPH) in Abidjan.

Biological material

The biological material used was clinical isolates of *P. falciparum* from patients with simple malaria and human blood from the O Rhesus positive group.

METHODS

Preparation of the aqueous extract

Talinum triangulare leaves were harvested on 21 December 2018 in the Department of Daloa, more precisely in Koffikro, a camp located 12 km from Daloa (Côte d'Ivoire). They were washed, dried in a dark place and then sprayed with a mechanical shredder (Retsch, M6951).

One hundred (100) grams of the vegetable powder obtained was cold macerated in one (1) litre of distilled water using a blender. After three (3) minutes of homogenization, the homogenate obtained was collected in a square of white and clean cloth and then pressed by hand. The collected solution was filtered twice (2) on hydrophilic cotton and once (1) on 3 mm Whatman filter paper. The filtrate obtained was dried in an oven at a temperature of 60°C for 24 hours to obtain a powder of total aqueous extract (AE).

Preparation of the hydroethanolic extract

His preparation followed the same preparation process as before; the only difference being that instead of water, an ethanol-water mixture (70/30 : v/v) was used. This preparation allowed the hydroethanolic extract (EE) to be obtained after drying in an oven at 60°C for 48 hours. The two extracts (AE, EE) were stored separately in hermetically sealed jars at laboratory temperature.

Yield of the crude extract

The yield of the crude extract is defined as the ratio between the mass of the dry extract obtained and the mass of the treated plant material.[16] This yield is calculated according to the formula:

$$R(\%) = (Me / Mv) \times 100$$

***R(%)**: Extraction efficiency in %.*
***Me**: Mass of the extract after evaporation of the solvent*
***Mv**: Mass of the fine powder used for extraction*

Evaluation of antiplasmodial activity

Plasmodium falciparum strains were adapted to culture using the method of.[31]

Preparation of reagents and culture medium

The culture medium was RPMI 1640 (Roswell Park Memorial Institute). It is a nutrient medium used as a base medium for the cultivation of *Plasmodium falciparum*. It was used to prepare the washing medium and the complete medium.

To prepare the washing medium, 1 g of bicarbonate was dissolved in 500 mL RPMI 1640 and homogenized. The assembly was then sterilized with a stericup and 500 µL of Gentamicin was added. As for the complete medium, the same process was used with the only difference that 2.5 g albumax was added before sterilization with stericup.

Collection and delivery of parasitized blood

Samples were collected at the Anonkoua-Kouté Urban and Community Health Unit (UCHU) located on the outskirts of Abobo commune (Abidjan, Côte d'Ivoire). Patients who came to this centre for consultation were referred to the laboratory for the biological diagnosis of malaria by RDT (rapid diagnostic test) following a clinical examination. The positive status of the RDT made it possible to ask for their consent to have the patient's blood as a sample for the study. After obtaining the patients written consent, blood was collected by laboratory technicians at the elbow fold by venipuncture and then collected in previously identified EDTA tubes. These blood samples were sent to the Swiss Centre for Scientific Research (SCSR) using a cooler containing cold accumulators.

Ex vivo culture test

Ex vivo sensitivity tests are based on the culture of *Plasmodium falciparum* isolates in the presence of a series of concentrations of the compounds to be tested. The extracts were added in duplicate in the wells of the culture plates at different concentrations.

Treatment of parasitized red blood cells (RBC)

In the laboratory, a thick drop and a thin smear were taken to determine parasite density and *P. falciparum* mono-infection. This density was to be between 0.1 - 0.3% and is obtained by counting the number of parasitized red blood cells on the total number of red blood cells (parasitized red blood cells + healthy red

blood cells). Thus, *Plasmodium falciparum* isolates meeting these criteria were washed three times with the RPMI wash to remove serum and white blood cells. When the resulting red blood cell had a parasitaemia greater than 0.3%, dilution with healthy red blood cells (O+) was performed.

Preparation of the drugs tested

Ten (10) mg of extract were dissolved in 10 mL distilled water (for aqueous extract) or in 1mL DMSO plus 9 mL water (for hydro-ethanolic extract) to obtain a stock solution with a concentration of 1 mg/mL for each extract. These two extract solutions obtained were filtered on 0.45 µm millipore filters and the filtrate was used to prepare the 200 µg/mL stock solution by dilution to 1/5th. The latter in turn underwent a series of dilution of reason ½ to obtain the appropriate concentration ranges for the test from 100 µg/mL to 1.56 µg/mL.

The Amodiaquine stock solution (S_1) was prepared from Amodiaquine powder. Thus, 31.2 mg of Amodiaquine powder was dissolved in 1 mL of DMSO and then 4 mL of distilled water was added to obtain 5 mL of an S_1 solution at 6.24 mg/mL corresponding to a molar concentration of $13.43.10^{-3}$ mol/L (with $MW_{Amodiaquine}$ = 464.8 g/mol). This solution obtained was filtered through a 0.22 µm millipore filter. Fifteen (15) µL of this solution were then sampled and mixed with 1.985 mL of culture RPMI to obtain 2 mL of a S_2 solution with a concentration of 100.725 µM. From the S_2 solution, a dilution series was performed to obtain a concentration range from 1600 nM to 25 nM in the wells of the culture plate for the test.

Preparation of the inoculum

For a 96-well plate, a volume of 12 mL of inoculum was prepared. This inoculum was obtained from the red blood cells (0.6 mL) of parasitized blood and the cultured RPMI medium (11.4 mL). The hematocrit level was 5%.

Loading of plates and cultivation

It was made according to the plate plan described in Table 1. Thus, 100 µL of each drug concentration was duplicated in the wells except for the control wells, which received only the cultured RPMI. Finally, a 100 µL distribution of the inoculum was added to the contents of all wells of the plate to obtain a final volume of 200 µL per well. The plates were placed in a candle chamber and then placed in the incubator for 72 hours at 37°C. After the 72 hours of incubation, the plates were removed from the oven and placed in the freezer at -20°C for reading.

Table 1: 96-well plate plan for the chemosensitivity test.

	Isolate 1						Isolate 2					
A	AE;C1	AE;C1	EE;C1	EE;C1	AQ;C1	AQ;C1	AE;C1	AE;C1	EE;C1	EE;C1	AQ;C1	AQ;C1
B	AE;C2	AE;C2	EE;C2	EE;C2	AQ;C2	AQ;C2	AE;C2	AE;C2	EE;C2	EE;C2	AQ;C2	AQ;C2
C	AE;C3	AE;C3	EE;C3	EE;C3	AQ;C3	AQ;C3	AE;C3	AE;C3	EE;C3	EE;C3	AQ;C3	AQ;C3
D	AE;C4	AE;C4	EE;C4	EE;C4	AQ;C4	AQ;C4	AE;C4	AE;C4	EE;C4	EE;C4	AQ;C4	AQ;C4
E	AE;C5	AE C5	EE;C5	EE;C5	AQ;C5	AQ;C5	AE;C5	AE;C5	EE;C5	EE;C5	AQ;C5	AQ;C5
F	AE;C6	AE;C6	EE;C6	EE;C6	AQ;C6	AQ;C6	AE;C6	AE;C6	EE;C6	EE;C6	AQ;C6	AQ;C6
G	AE;C7	AE C7	EE;C7	EE;C7	AQ;C7	AQ;C7	AE;C7	AE;C7	EE;C7	EE;C7	AQ;C7	AQ;C7
H	T	T	T	T	T	T	T	T	T	T	T	T

***T**: Drug-free growth control; **AE**: Aqueous extract; **EE:** Ethanolic extract; **AQ**: Amodiaquine and **C**: Concentration of the drug in the different wells.*

Reading and measurement of antimalarial activity

ELISA test

The HRP2 colorimetric method was chosen for the determination of the *ex vivo* sensitivity of *P. falciparum* to our plant extracts. To do this, the acquisition of the Malaria Ag CELISA kit marketed by the Cellabs laboratory was necessary.

Principle of the test

The principle of the sandwich ELISA technique was applied. The microwells are covered with a monoclonal antibody to capture anti-*P. falciparum*. A second peroxidase-conjugated anti-*P. falciparum* monoclonal antibody, provided in the kit, is then prepared. The inoculum collected from the culture is introduced into the microwells, and if parasite-specific HRP2 (antigen) is present, it binds to the wall of the microwells. A washing step removes any remaining blood components. A monoclonal detection antibody conjugated to Horseradish peroxidase is then added. The latter binds to the antigen (HRP2) captured on the surface of the microwell. The microwells are washed, and an enzyme substrate solution is added to the wells and incubated. The appearance of staining after incubation indicates the presence of *P. falciparum* HRP2 in the tested inoculum. The intensity of staining, which is a function of the amount of plasmodial antigen, is measured with a spectrophotometer in the visible (450 nm).

Determination of the IC_{50}

The measurement of antimalarial drug activity is expressed as a 50% Inhibitory Concentration (IC_{50}) of parasitic growth. The IC_{50}s and corresponding correlation coefficients were determined graphically using ICESTIMATOR software version 1.2.[18,29]

Classification of antiplasmodium activities

According[5], the antiplasmodial activity of extracts and pure compounds is classified according to IC_{50} as follows:

❖ For crude extracts (µg/mL)
- IC_{50} > 50 µg/mL, the extract is inactive;
- IC_{50} between 15 and 50 µg/mL, the extract is moderate;
- IC_{50} between 5 and 15 µg/mL, the extract is active;
- IC_{50} < 5 µg/mL, the extract is very active

❖ For pure compounds (µM)
- IC_{50} > 50 µM, inactive compound;
- IC_{50} between 11 and 50 µM, the compound is not very active,
- IC_{50} between 2 and 11 µM, the compound is active;
- IC_{50} < 1 µM, the compound is very active (can be considered as a lead compound).

Characterization of chemical compounds

Phytochemical sorting consists in carrying out a qualitative chemical analysis based on colouring or precipitation reactions more or less specific to each class of active ingredients. The phytochemical groups sought in the extracts include: sterols, polyterpenes, alkaloids, tannins, polyphenols, flavonoids, quinones and saponins. Sterols and polyterpenes were detected by the Liebermann reaction[4], polyphenols by the ferric chloride reaction[7], flavonoids by the cyanidin reaction[8], catechic tannins by the Stiasny reagent and gall tannins by sodium acetate and ferric chloride 2%[27], quinonic substances by Borntraëger recation[4], alkaloids by Burchard reaction[21] and saponins by foam index.[12]

RESULTS

Extraction efficiency

The extraction yield varied according to the secondary metabolite content of each extract, the nature and polarity of the solvent used for extraction. Table 2 records the yield of the various extracts obtained.

Table 2: Efficiency of the various extractions.

	AE	EE
Mass of the fine powder used for extraction (g)	100	100
Mass of the extract after evaporation of the solvent (g)	22.64	12.25
Extraction efficiency (%)	22.64	12.25

Chemosensitivity test

The antiplasmodial activity of the plant extracts was expressed as a 50% inhibitory concentration (IC_{50}) of parasitic growth. Crude extracts of *Talinum triangulare* and Amodiaquine had variable activities on the clinical strains of *P. falciparum* used. The IC_{50}s range from 1.42 µg/mL to 9.99 µg/mL for aqueous extracts and from 1.43 µg/mL to 8.65 µg/mL for hydroethanolic extract. As for Amodiaquine, it allowed IC_{50}s ranging from 57.08 nM to 108.12 nM to be obtained. All the results are reported in the following table.

Table 3: IC_{50} values of the different extracts (µg/ml) and amodiaquine (nM) on clinical isolates.

Plant	Isolates	Extracts IC_{50} (µg/ml and nM)		
		Aqueous	EthOH	AMQ
Leaves of *Talinum triangulare*	Isolate 3	2.96	2.21	59.39
	Isolate 7	1.42	1.43	126.38
	Isolate 14	2.68	1.65	57.08
	Isolate 16	9.99	2.78	85.58
	Isolate 18	7.28	8.65	108.12
	IC_{50} MINI	1.42	1.43	57.08
	IC_{50} MAXI	9.99	8.65	126.38
	IC_{50} MED	2.96	2.21	85.58

***AMQ** : Amodiaquine, **MINI** : Minimum, **MAXI** : Maximum, **MED** : Median, et **EthOH** : hydro-éthanolic extract, **IC_{50}** : Inhibitory Concentration 50*

Figure 1 below is an example of an inhibition curve for the determination of the IC_{50}, which is the activity of the hydro-ethanolic extract of *T. triangulare* on the growth of the clinical isolate 7 of *P. falciparum*.

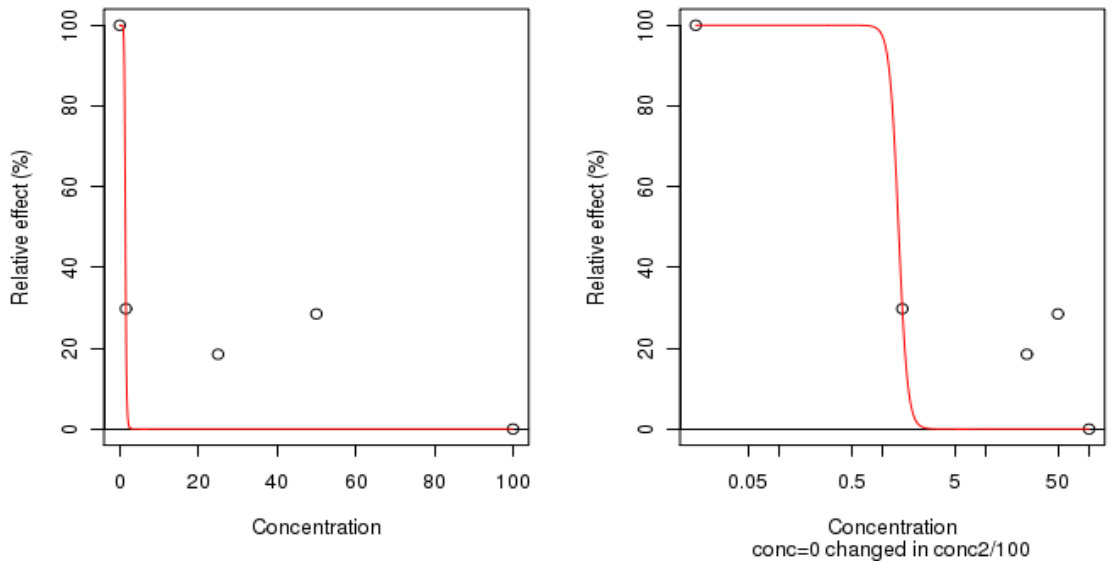

Figure 1: Inhibition curve for the determination of the IC_{50} of the hydroethanolic extract of *T.triangulare* on the growth of *Plasmodium falciparum*.

Overall, the curves obtained show a gradually decreasing pace, with more or less steep slopes depending on the drug.

Phytochemical sorting

Phytochemical screening performed on aqueous and hydroethanolic *Talinum triangulare* extracts revealed the presence of various secondary metabolites. All identified chemical compounds are listed in Table 4.

Table 4: Summary table of the results of the different chemical tests.

Compounds / Extracts	Sterols Polyter	Polyph	Flavon	Tanins		Substances Quin	Alcaloïdes		Sapsd
				Gal	Cat		D	B	
EthOH	++	_	_	_	_	+	++	++	_
Aqueous	+	_	_	_	_	_	++	++	_

*+: Presence, -: Absence, ++ : intense presence, **EthOH** : Hydro-ethanolic, **D** : DRAGENDORFF, **B** : BOUCHARDAT, **Gal** : Gallique, **Cat** : Catechiques, **Sapsd** : Saponosides, **Quin** : Quinonique, **Polyter** : Polyterpenes, **Polyph** : Polyphenol, **Flavon** : Flavonoide.*

DISCUSSION

Extraction and yield

The yield of the aqueous extract: EA (22.64%) is higher than that of the hydroethanolic extract: EE (12.25%). This would mean that the hydroethanolic extract has been rid of macromolecules less soluble in the ethanol-water mixture, to contain only the bioactive and soluble molecules in this mixture. In addition, the work of[28] carried out in India on *Talinum triangulare* yielded a yield of 23.42% for extraction by aqueous maceration of the leaves of the same plant and 10.08% for extraction in alcohol. The result obtained by this author with the aqueous extract on this plant (23.42%) is sensitive to ours (22.64%). However, the results of the work of[28] have resulted in a lower yield (10.08%) during the hydroethanolic extraction of the plant than ours (12.25%). This could be explained by the difference in the plant's harvesting locations and soil composition. The calculation of yields makes it possible to quantitatively assess the bioactive compounds that can be derived from each species. These yields also make it possible to consider the quantity of organs to be harvested if necessary for a similar study, which would make the use of medicinal plants more rational and therefore sustainable for the target species.[33] The choice of plant organs used is justified by the fact that leaves and bark are the ideal site for biosynthesis and even for the storage of secondary metabolites responsible for the plant's biological properties.[6] From these results, it appears that the yields of the extracts are a function of the polarities of the solvents.

Chemosensitivity test

During this study, aqueous and hyroethanolic extracts of *Talinum triangulare* were tested on five (5) clinical isolates of *P. falciparum*. The results of this work revealed from the classification table proposed by[5] that *Talinum triangulare* leaf extracts are generally very active on the five clinical isolates of *P. falciparum* studied with different effects. They generally indicate an IC_{50} of less than 5 µg/mL (2.96 µg/mL for aqueous extract and 2.21 µg/mL for hydroethanolic extract).

The aqueous extract is active on isolates 16 and 18 with respective IC_{50}s of 9.99 µg/mL and 7.28 µg/mL. And on the other three isolates (isolate 3; isolate 7 and isolate 14), he showed very good antiplasmodial activity giving IC_{50}s below 5 µg/mL (with 1.42 µg/mL for isolate 7; 2.68 µg/mL for isolate 14 and 2.96 µg/mL for isolate 3). This good and even very good activity of the aqueous extract justifies the study carried out and confirms the traditional use of this plant. These IC_{50}s are lower than those obtained by[1] (IC50 = 12.66 µg/mL), when testing the aqueous extract of *Hoslundia opposita* leaves on clinical isolates of *P. falciparum* in the evaluation of the chemosensitivity of this extract by the maturity test. In view of these results, it can be said that the aqueous extract of *Talinum triangulare* is three times more active on *Plasmodium falciparum* than that of *Hoslundia opposita.* This difference in activity could be explained by the presence of compounds more active on *P. falciparum* in *Talinum triangulare* than in *Hoslundia opposita*. However, the work of[20] with *Alchornea cordifolia* showed results that were significantly similar to those of our study (3.36 µg/mL). Other studies on the antiplasmodial activity of *Azadirachta indica* and *Artemisia annua* have yielded 6.24 µg/mL and 6.25 µg/mL respectively.[25,13] These results show that *Talinum triangulare* can be a definite hope in the search for antimalarial drugs.

The hydroethanolic extract is active on isolate 18 because its IC_{50} (8.65 µg/mL) is between 5 µg/mL and 15 µg/mL. However, on the other isolates (isolates 3; 7; 14 and 16), it is very active with respective IC_{50}s of 2.21 µg/mL, 1.43 µg/mL, 1.65 µg/mL and 2.78 µg/mL. This result shows that isolate 7 is more sensitive to hydroethanolic extract than isolate 14; which is more sensitive to it than isolate 3; whereas the latter is more sensitive than isolate 16. These results indicate that isolate 18 is less sensitive to this drug than others. The mean IC_{50} values obtained on these five isolates studied (2.63 µg/mL) are lower than those of[17] during the action of *Hoslundia opposita* hydroethanolic extract on *P. falciparum* (11.68 µg/mL). These results therefore show that the hydro-ethanolic extract of *Talinum triangulare* is about four times more active than *Hoslundia opposita* on *P. falciparum*.

In general, the median IC_{50} of the hydroethanolic extract (2.21 µg/mL) is lower than that of the aqueous extract (2.96 µg/mL) on *P. falciparum*. In addition, for the same isolate, it is also noted that the hydroethanolic extract has smaller IC_{50}s than the aqueous extract. However, at the isolate 18 level, the hydroethanolic extract has a higher IC_{50} than the aqueous extract. It can be deduced that hydroethanolic extract concentrates more active ingredients than aqueous extract.

This work is in line with that of[17], who showed that hydroethanolic extract has a better activity than aqueous extract. This observation could be explained by the difference in the content of active compounds. The Amodiaquine test (reference molecule) on the 5 isolates yielded IC_{50}s greater than 60 nM on 3 clinical isolates (7; 16 and 18). Thus, it is possible to say that these isolates are Amodiaquino-resistant. However, for the other two isolates, 3 and 14, the IC_{50}s are less than 60 nM. Therefore, for these isolates, it can be inferred that they are Amodiaquino-susceptible.[3]

The latter results are in agreement with those of[15] and[11], as these authors have shown that the strains of *P. falciparum* used were Amodiaquino-susceptible. The results of the isolates (7; 16 and 18) do not agree with those of[15] and.[11]

Phytochemical study

The results of phytochemical triage revealed that the aqueous extract of *Talinum triangulare* leaves is characterized by the presence of sterols and polyterpenes and an intense presence of alkaloids; while the hydroethanolic extract is characterized by the presence of quinonic substances, and by an intense presence of sterols and polyterpenes and alkaloids. However, in these two extracts, there is an absence of polyphenols, flavonoids, tannins and saponosides. The work of[34,35] showed that the antiplasmodial activity of *Funtumia elastica* and *Zanthoxylum gilletii* were due to alkaloids such as holarrhesin and dihydronitidine respectively.

According to[14], sterols and polyterpenes have antimicrobial activity.[10] and[28] found that the presence of secondary metabolites such as alkaloids and quinonic substances in *Talinum triangulare* may be responsible for the antimicrobial activity of this plant. Thus, the curative properties of this plant are due to the presence of various secondary metabolites.[26,28]

CONCLUSION

In Côte d'Ivoire, malaria is the main reason for consultation and hospitalization in health centres. Many teams around the world are working to find alternative tools, strategies and remedies to eliminate this parasitic disease. This quest is also supported by the emergence of *Plasmodium falciparum*'s resistance to conventional antimalarial drugs. In addition, access to treatment for the poor is a problem given the high cost of drugs. For these populations, the use of medicinal plants is a very interesting alternative. This study evaluated the antiplasmodial activity of *Talinum triangulare*, a food plant of the Talinaceae family. To this end, the various

aqueous and hydro-ethanolic extracts of *Talinum triangulare* leaves were tested on the ex vivo sensitivity of various *Plasmodium falciparum* isolates. Both extracts revealed very good antiplasmodial activity on parasite growth. This activity can be explained by the presence of many secondary metabolites such as alkaloids, polyterpenes and sterols. This justifies the traditional use of this plant in the treatment of malaria. However, the hydroethanolic extract showed better activity on all isolates used with a median IC50 of 2.21 µg/mL. This better activity could be explained by the presence of quinonic substances (alkaloids), and the intense presence of sterols and polyterpenes. Thus this extract can be a promising source for the development of phytomedicines against malaria.

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