PLANTS USED IN TRADITIONAL MEDICINE AGAINST MALARIA

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ABSTRACT

A survey of medicinal plants used for the treatment of malaria is presented from a variety of literature sources. The geographical area and parts used are given. The methods of testing antimalarial properties and a brief discussion highlighting mode of action of some of the active constituents showing promising antimalarial activity is included.

Key Words: Medicinal plants; Antimalaria, Bioassay.

INTRODUCTION

Malaria is one of the world's most devastating human infections, affecting over 200 million peope and causing more than 2 million deaths each year. Also, according to surveys conducted by the World Health Organisation (WHO), malaria is one of the diseases that cause enormous suffering, morbidity and mortality in the world especially in tropical developing countries[1,2,3]. The classic symptoms of malaria are fever with chills, sweats and headache. Nausea, vomiting, myalgia and abdominal or back pain may also be present. Persons with malaria frequently become dehydrated owing to increased insensible water loss and decreased fluid intake[4]. Although this mosquito-borne infection has been virtually eradicated from some developed countries, emigration and travel to endemic regions constitute a continuing health problem. Practical, effective and safe drugs, insecticides and vaccines are still needed to combat malaria. In the 1950s, attempts to eradicate this scourge from most parts of the world failed, primarily because of the development of resistance to insecticides and antimalarial drugs. Since 1960, transmission of malaria has risen in most tropical areas where the infection is endemic, chloroquine resistant and multidrug-resistant strains of P falciparum have spread, and the degree of resistance to drugs of this most prevalent and dangerous plasmodial species has increased[5-9].

MALARIA INFECTION

Human malaria is caused by four species of obligate intracellular protozoa of the genus Plasmodium, they reproduce asexually in man but sexually in female mosquitoes (genus Anopheles). Each species has distinguishing morphological features and the disease caused by each is also destructive. P. falciparum causes malignant tertian malaria, the most dangerous form of human malaria which poses the greatest risk to non immune individuals and children less than 5 years of age. P. vivax causes benign tertian malaria and produces milder clinical attacks than those of P. falciparum. P. vivax infection has a low mortality rate in untreated adults and is characterised by relapses that occur as long as 2 years after primary infection. P. ovale causes a rare malarial infection with a periodicity and relapses similar to those of P. vivax but it is milder and more readily cures. P. malariae causes quartan malaria an infection that is common in localized areas of the tropics. Clinical attacks may occur years after infection but are much rarer than after infection with P. vivax.

Although malaria can be transmitted by transfusion of infected blood, man is naturally infected by sporozoites infected by the bite of infected female Anopheles mosquitoes. The parasites rapidly leave the circulation and localize in hepatic parenchymal cells where they multiply and develop into tissue schizonts. The asymptomatic tissue (pre-erythrocytic or exoerythrocytic) state of infection lasts for 5 to 16 days, depending on the species of Plasmodium. The tissue schizonts then rupture, each releasing thousands of merozoites, these enter the circulation, invade erythrocytes and initiate the erythrocytic stage or cycle of infection. Once human plasmodia enter the erythrocytic cycle, they cannot invade other tissues, thus there is no tissue stage of infection for human malarias that are contacted by transfusion. In erythrocytes, most parasites, undergo asexual development from young ring forms to trophozoites and finally to mature schizonts. Schizont-containing erythrocytes rupture, each releasing 6 to 24 merozoites and it is this process that produces the febrile clinical attack. The released merozoites then invade more erythrocytes to continue the cycle, which proceeds until death of the host or modulation by drugs or acquired immunity. Some erythrocytic parasites differentiate into sexual forms known as gametocytes.

After blood is ingested by a female mosquito, ex-flagellation of the male gametocyte is followed by male gametogenesis and

fertilization of the female gametocyte in the gut of the insect. The resulting zygote, which develops in the gut wall as an oocyst, eventually gives rise to the infective sporozoite, which invades the salivary gland of the mosquito. The insect then can infect another human host by taking a blood meal.[5]

MEDICINAL PLANTS AS ANTIMALARIAL AGENTS

The search for novel compounds effective against Plasmodium strains resistant to widely used synthetic drugs has led to increased interest in new and existing information about malaria remedies from natural sources[10-12] Simultaneously and as importantly, the need for accessible, inexpensive and culturally relevant health care in most parts of the world are beginning to direct pharmacological research toward the safe and effective use of traditional remedies[1,13]. Plants form the major part of treatments used by traditional healers in many societies thus many plants have a reputation of being useful against malaria. Lists of such plants can be found in the literature and these have been collated in Table 1. The list presented here makes no claims to being exhaustive and there are many areas of the world where the plants used against malaria have not been recorded or transmitted in a form readily accessible to the scientific community. Majority of traditional healers or herb users normally refer to malaria as fever, thus plants used against fever are also included. The table however, gives an indication of those plant general whose members are used in different geographical locations and thus, lays a basis for the selection of plants for investigation of chemical constituents and biological activity.

The genuineness of the claims made for some of the plants have not been tested scientifically due to a number of reasons such as variety of species of malaria parasite and relative scarcity of information on the traditional method of using some of the plants which makes it difficult to know which extraction method to use for the preparation of the test solutions. In spite of these problems, work has been carried out in recent years on some plants with traditional uses against malaria parasite, both to investigate the reputed use and to elucidate the chemical basis and mode of action of any activity displayed. In this survey the results of scientific investigations are considered in the context of the traditional usage of the plants. It is hoped that this review will stimulate more studies aimed at providing a better understanding of the antimalarial properties of the medicinal plants.

Table 1: Plants Used to Treat Malaria

Species	References	Plant Parts Used[A]	Geographical Area
ACANTHACEAE			
Andrographis paniculata Nees	42	PL	Mauritus and Rodrigues
Peristrophe bicalyculata (Retz.) Nees	40	LK	Southern Nepalese
Ruellia tuberosa L.	42	LV	Mauritus and Rodrigues
Rungia parviflora (Retz.) Nees	40	LJ	Southern Nepalese
ADIANTHACEAE			
Acrostichum aureum L.	46	LV, RT	Eastern Nicaragua
AMARANTHACEA			
Achyranthes aspera L.	42	RT	Mauritius and Rodrigues
Amaranthus viridis L.	27	LV, PL	East Africa
Alternanthera tenella	32	LV	Tanzania
AMARYLLIDACEAE			
Crinum amabile L	16	BU	East Asia
ANACARDIACEAE			
Anacardium occidentale L.	46	LV, BK	Eastern Nicaragua
Mangifera indica L.	33	BK, LV	West Africa
Pseudospondias microcarpa Engl.	32	LV, BK	Tanzania
Spondias mombin L.	46	LV, BK	Eastern Nicaragua
Spondias purpurea L.	46	LV, BK	Eastern Nicaragua
ANNONACEAE			
Annona glabra L.	35, 46	LV, BK	Eastern Nicaragua & Kenya *Annona*
muricata L.	46	LV, BK	Eastern Nicaragua
Enantia chlorantha Oliver	34	BK	West Africa
Isolana companulata Engl. Diels	28	BK	West Africa
Monanthotaxis laurentii Verdc	27	LV	West Africa
Uvaria chamae Beauv	34	RT	West Africa
Uvaria dependens	39	BK	West Africa
Apocynaceae			
Alstonia boonei Wild	34	BK	Kenya
Alstonia scholaris R. Br.	35	LJ	Kenya

Species	References	Plant Parts Used^	Geographical Area
Alstonia congensis Engl.	33	BK, LV	West Africa
Aspidosperma oblongum A. DC	25	B K	Brazil
Carissa edulis Vahl.	34	LV, RT	West Africa
Catharanthus roseus L. G. Don	42	LV, ST	Mauritius and Rodrigues
Giessospermum sericium Benth	25	B K	Brazil
Picralima nitida Th. & H. Dur.	34	BK, FR, RT	West Africa
Pleiocarpa mutica Benth	31	RT	West Africa
ARACEAE			
Homalomena rubra	35	RT	Kenya
Montrichardia arborescens (L.) Sch.	47	FL	Martinique
Pothos ovatifolius	35	RT	Kenya
ARALIACEAE			
Schefflera odorata Merr-et-Rof	35	LV	Kenya
ARISTOLOCHIACEAE			
Aristolochia albida Duch.	33	RT, LV	East Africa
ASTERACEAE			
Artemisia absinthium L.	47	LV	Martinique
Artemisia annua L.	17	P L	China
Blumea pubigera Merr	35	LV	Kenya
Chromolaena odorata (L.) K. & Rob	47	RT	Martinique
Eupatorium triplinerve Vahl	47	LV	Martinique
Inula cappa DC	40	RT	Southern Nepalese
Neurolacria lobata (L.) R. Br.	46	LV	Eastern Nicaragua,
Pluchea carolinensis (Jacq.) G. Don	47	LV	Martinique
Pterocaulon alopecuroidum D. C.	47	LV	Martinique
BIGNONIACEAE			
Crescenta cujete L.	46	LV	East Nicaragua
BOMBACACEAE			
Adansonia digitata L.	33	BK, LV	West Africa
BORAGINACEAE			
Cordia curassavica (Jacq.) R & Sch.	46	LV	East Nicaragua
Cordia spinescens L.	46	LV	East Nicaragua
Symphytum officinale L.	47	LV	Martinique
CAPRIFOLIACEAE			
Sambucus canodensis L.	47	FL	Martinique
CARICACEAE			
Carica papaya L.	34, 35	FR, LV LX	West Africa Kenya
CELASTRACEAE			
Maytenus senegalensis Lamk	32	BK, RT	Tanzania
CECROPIACEAE			
Cecropia peltata L.	46	LV	East Nicaragua
CISTACEAE			
Cistus laurifolius L.	48	FL	WestAnatolia
COMBRETACEAE			
Combretum micranthum G. Don	42	BK, LV	Mauritius & Rodrigues
COMPOSITAE			
Ageratum conyzoides L.	34	LV	West Africa
Centaurea solstitialis L.	41, 48	FL	Mediterranean Area
Chrysanthemum indicum DC	35	LV	Kenya
Elephantopus mollis Kunth	28	LV	West Africa
Elephantopus scaber L.	33	LV, RT	West Africa
Neurolaena lobata (L.) R. Br.	50	PL	Panama
CONNARACEAE			
Cnestis ferruginea D.C.	34	LV, RT, F R	West Africa
CONVOLVULACEAE			
Cuscuta chinensis Lam.	42	PL	Mauritius & Rodrigues
Ipomoea pes-caprae (L.) R. Br.	46	LV	East Nicaragua
Merremia kentrocaulos Rendle	30	RT	East Africa

Species	References	Plant Parts Used[A]	Geographical Area
CUCURBITACEAE			
Momordica charantia Schum	46	LV, ST	East Nicaragua
Momordica foetida Schum	32	LV	West Africa
CYPERACEAE			
Kyllinga tibialis Ledeb	47	RT	Martinique
EUPHORBIACEAE			
Alchornea cordofolia Mull	34	LV	West Africa
Alchomea rugosa Mull. Aug	33	BK, RB	South Africa
Drypete natalensis	32	BK, LV	Tanzania
Jatropha curcas L.	46	LV	East Nicaragua
Jatropha hastata Jacq.	46	LV	East Nicaragua
Manihot esculenta Crantz.	46	LV, RT	East Nicaragua
Phyllanthus acidus (L.) Skeels	46	LV	East Nicaragua
Phyllanthus amarus S & Thn.	46	FL	Martinique
FABACEAE			
Andira mermis (Wright) HBK	46	BK	East Nicaragua
Canavalia maritima (Aubl.) Thou.	46	LV, RT	East Nicaragua
Cassia alata L.	46	LV, FL	East Nicaragua
Cassia occidentalis L.	46	LV, RT	East Nicaragua
Cassia tora L.	46	LV	East Nicaragua
Cassia undulata Benth	46	LV, RT	East Nicaragua
Desmodium adscendens (Sw) DC	46	LV, RT	East Nicaragua
Desmodium barbatum L.	46	LV, RT	East Nicaragua
Desmodium canum (Gmel) Sch. & Thell	46	LV, RT	East Nicaragua
Desmodium triflorum (L.) DC	46	LV, RT	East Nicaragua
Hymenaea courbaril L.	46	BK, ST	East Nicaragua
Mimosa pudica L.	46	LV, ST, PL	East Nicaragua
Pithecolobium dulce (Roxb.) Benth	46	BK	East Nicaragua
GENTIANACEAE			
Coutoubea spicata Aubl.	46	LV	East Nicaragua
Enicostema verticillatum (L.) Engl.	47	LV, PL	Martinique
GRAMINEAE			
Bambusa vulgaris Schrad	47	LV	Martinique
Cymbopogon citratus Stapf.	33, 47	LV	West Africa & Martinque
Saccharum officinarum L.	47	ST	Martinique
LABIATAE			
Coleus amboinicus Benth	47	LV	Martinique
Hoslundia opposita Vahl.	32	RB	Tanzania
Hyptis verticillata Jacq.	47	LV, RT	Martinique
Leonotis nepetifolia (L.) R. Br.	47	LV	Martinique
Ocimum basilicum L.	32, 47	PL, LV	Kenya, Martinique
Pogostemon heyneanus Benth	47	LV	Martinique
Teucrium chamaedrys L.	48	PL	Martinique
LAMIACEA E			
Ocimum micranthum Wilid.	46	LV	East Nicaragua
LAURACEAE			
Cinnamomum zeylanicum Blu.	47	BK	Martinique
LEGUMINOSAE			
Baphia nitida Loold	34	BK, WD	West Africa
Bauhinia rufescens Lam.	33	RT	West Africa
Cassia didymobotya Fres.	32	LV, RB	Tanzania
Cassia obtusifolia L.	32	LV	Tanzania
Doliocarpus dentatum Standl.	25	BK	Brazil
Entada phaseoloides Merrill	42	LV	Mauritius & Rodrigues
Peltogyme racemosum Ducke	25	BK	Brazil
Stryphnodenodron guyanense Benth	25	Bk	Brazil
Vicia ervilia Wilid	48	SD	West Anatolia
LILIACEAE			
Allium cepa L.	47	BU	Martinique
Allium schoenoprosum L.	47	BU	Martinique
Smilax barbata	35	RT	Kenya
LOGANIACEAE			
Anthocleista nobilis Don	33	BK, RT	East Africa
Fagraea racemosa Jack	35	LV	Kenya

Species	References	Plant Parts Used[A]	Geographical Area
LORANTHACEAE			
Struthanthus cassythoides Standl	46	LV, P L	East Nicaragua
MALVACEAE			
Gossypium barbadense L.	46, 47	LV	East Nicaragua & Martinique
Hibiscus bifurcatus Gav.	46	LV, FL	East Nicaragua
Hibiscus tiliaceus L.	46	BK, LV	East Nicaragua
Sida rhombifolia L.	46	LV	East Nicaragua
MELIACEAE			
Azadirachta indica Jussf.	32	RT, B K, LV	East and West Africa
Carapa paniculata Benth	25	B K	Brazil
Cedrela odorata L.	46	B K	East Nicaragua
Lansium domesticum Correa	35	BK, SD	Kenya
Swietenia macrophylla King	46	BK	East Nicaragua
MENISPERMACEAE			
Cissampelos mucronata Rich	32	LV	Tanzania
Cissampelos pareira L.	46	LV, RT	East Nicaragua
Cyclea barbata Miers	12	RT	East Asia
Stephia erecta Miers	36	ST	Thailand
MIMOSACEAE			
Acacia caffra (Thumb.) Wilid	43	LV	South Africa
MORACEAE			
Ficus species	33	PL	South Africa
MORINGACEAE			
Moringa pterygosperma Gaertn	37	RB, RT	India
MYRISTICACEAE			
Myristica fragrans Houtl.	46	SD	Martinique
Virola koschnyi Warb.	46	BK, LV, ST	East Nicaragua
MYRTACEAE			
Eugenia acapulcensis Stewd.	46	LV	East Nicargua
Pimenta racemosa Moore	46, 47	LV	East Nicargua & Martinique
Psidium guajava L.	46	BK, LV, FL	East Nicargua
Syzygium cordatum Hochst.	32	RB	Tanzania
ONAGRACEAE			
Ludwigia octovalvis Raven	46	FL	East Nicaragua
OXALIDACEAE			
Averrhoa bilimbi L.	46	FL, LV	East Nicaragua
PALMAE			
Cocos nucifera	47	FR	Martinique
PAPILIONACEAE			
Abrus precatorius Robts Linn.	32, 33, 34	LV, R B	Africa
Atylosia scarabaeoides Benth	42	PL	Mauritius & Rodrigues
Cajanus cajan Mill sp.	34	LV	West Africa
Clitoria ternatea L.	42	RT	Mauritius & Rodrigues
PASSIFLORACEAE			
Passiflora quadragulasis L.	46	LV	East Nicaragua
PIPERACEAE			
Piper arborescens	35	RT	Kenya
Piper auritum HBK	46	LV	East Nicaragua
Piper bettle	35	LV	Kenya
Piper hispidum Sw	46	LV	East Nicaragua
Piper jacquemontianum (Kunth) D.C.	46	LV	East Nicaragua
Piper peltatum L.	46	LV	East Nicaragua
Piper umbellatum (L.) Miquel	45	LV	Central Nepal
Pothomorphe peltata Miq.	25	BK	Brazil
PLANTAGINACEAE			
Plantago major L.	47	LV	Martinique
POACEAE			
Bambusa vulgaris Schradex Wendl.	46	RT	East Nicaragua
Eleusine indica (L.) Gaertn	46	RT	East Nicaragua
PORTULACEAE			
Portulaca gradiflora Hooker	47	LV	Martinique
ROSACEAE			
Parinari excelsa Sabine	32	LV, RB	Tanzania
RUBIACEAE			

Coffea arabica L.	46	SD	East Nicaragua
Cinchona pubescens Vahl	33,46	B K, ST	East Nicaragua & Africa
			Africa
Corynanthe pachiceras Schum	33	BK	East Africa
Crossopteryx febrifuga Benth –	33	BK	West Africa
Gardenia vogelli Hook	32	RB	Tanzania
Mitragyna africana Korth	33	BK	West Africa
Morinda lucida Benth	33,34	LV	West Africa
Mussaenda afzelli Don	33	BK	East Africa
Nauclea diderichii	33,34	RT, LV	West Africa
Psychotria elata (Sw) Hammel	46	LV, ST, RT	East Nicaragua
Psychotria ipecacuanha Stokes	46	RT	East Nicaragua
Psychotria kirkii Hiern	32	RT	Tanzania
Psychotria poeppigiana Muell. Arg.	46	RT	East Nicaragua
RUTACEAE			
Aegle marmelos Correa	40	RT	S. Nepalese
Citrus aurantiifolia Swingle	46	LV, F L, RT	East Nicaragua
Citrus aurantium L.	46	F L, LV, RT	East Nicaragua
Citrus paradisi Macfad.	46	FL	East Nicaragua
Citrus sinensis (L.) Osbeck	46	FL, LV	East Nicaragua,
Toddalia asatica (L.) Lam	42	PL	Mauritania, Rodrigues
Zanthoxylum chalybium	32,34	LV, RT, ST	Tanzania
Zanthoxylum zanthoxyloides Lam.	33	BK, RT	West Africa
Vepris lanceolata Don	34	LV, RT	Tanzania
SAPINDACEAE			
Melicoccus biiugatus Jacq.	47	LV, FR	Martinique
SAPOTACEAE			
Chrysophyllum cainito L.	46	LV, FL	East Nicaragua
Doanais fragrans (Lam.) Pers.	42	PL	Mauritius & Rodrigues
Pachystela brevipes Engl.	49	BK	Tanzania
Scoparia dulcis L.	46	LV, RT, P L	East Nicaragua
Striga senegalensis Benth	34	LV, B K	West Africa
SIMARUBACEAE			
Eurycoma longifolia Jack	22	RT	Indonesia
Harrisonia abyssinica Oliv.	49	RT	Tanzania
Simaba guianensis Planch	25	B K	Brazil
Simaba multiflora Planch	25	B K	Brazil
Quassia africana Baill	46	ST	East Nicaragua
Quassia amara L.	46	BK	East Nicaragua
Quassia simarouba L. f.	46	BK	East Nicaragua
SOLANACEAE			
Capsicum frutescens L.	46	FL, LV	East Nicaragua
Physalis angulata L.	46	LV, PL	East Nicaragua
Solanum americanum Mill.	47	LV	Martinique
Solanum torvum Sw	46	LV, RT	East Nicaragua
STERCULIACEAE			
Dombeya burgessiae Gerr. Ex. Harv.	49	LV	Tanzania
Theobroma cacao L.	47	LV, SD	Martinique
THYMELAEACEAE			
Dias cotinifolia L.	43	LV	South Africa
TURNERACEAE			
Turnera ulmifolia L.	46	LV	East Nicaragua,
UMBELLIFERAE			
Eryngium foetidum L.	47	PL	Martinique
Steganotaenia araliacea Hochst	49	RT	Tanzania
URTICACEAE			
Lecanthus reduncularis Wedd.	51	P L	Nepal
Pilea microphylla (L.) Liebm	47	PL	Martinique
VERBENACEAE			
Callicarpa macrophylla Vahl.	51	FR	Nepal
Citharexylum spinosum L.	47	LV	Martinique
Clerodendrum indicum (L.) Kuntze	40	PL	S. Nepalese
Lantana camara L.	42	LV	Mauritius & Rodrigues
Lippia alba N.E. Br	47	LV	Martinique
Lippia nodiflora (L.) Riche	40	PL	S. Nepalese
Premna arborea Garw	35	LV	Kenya
Stachytarpheta cayenensis Vahl.	46	LV	East Nicaragua
Stachytarpheta jamaicensis Vahl.	46	LV	East Nicaragua
Stachytarpheta indica (L.) Vahl.	42	LV	Mauritius & Rodigues
Tamonea spicata Aubl.	46	LV	East Nicaragua

Species	References	Plant Parts Used*	Geographical Area
Vitex buchananii Baker en Gurke	49	RT	Tanzania
VITACEAE			
Ampelocissus africana Merr	49	LV	Tanzania
ZINGIBERACEAE			
Costus afer Ker-Gawl	49	LV	Tanzania
Curcuma longa L.	33	P L	West Africa
Hedychium cylindricum	35	FL	Kenya
Zingiber officiale Roscoe	47	RT	Martinique

Plant Parts Used

BK	=	Stem bark	LX	=	Latex
BU	=	Bulb	RB	=	Root bark
FL	=	Flowers	RT	=	Roots or rhizome
FR	=	Fruit	SD	=	Seeds
PL	=	Herb (all above ground parts)	ST	=	Stem
LJ	=	Leaf juice	WD	=	Wood
LV	=	Leaves			

TEST TO DETERMINE ANTIMALARIAL ACTIVITY IN MEDICINAL PLANTS

The testing of plant extracts for antimalarial activity explains the problem facing many researchers who are trying to validate the traditional use of plants in treatment of malaria. Tests should reproduce conditions and effects of antimalarials but also be as economic as possible suitable for a high throughput of samples and be socially acceptable.

IN VIVO ANIMAL TESTING

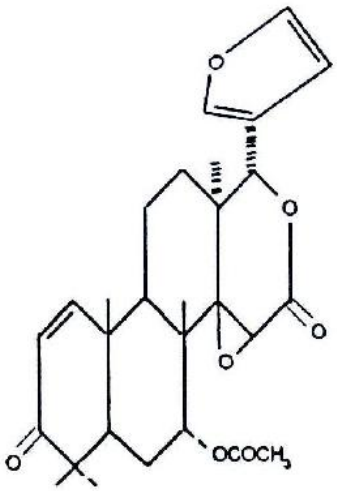
The schizontocidal activity on early infection is assessed by administering the extract as simple daily dose on days 1, 2 and 3 to different groups of infected mice. Parrallel test is run with chloroquine as the standard. The degree of parasitaemia is determined on day 4 and percentage suppression of parasitaemia could be assessed in relation to control. Various dilutions of the extract are used to produce dose-related suppression of parasitaemia. For the prophylactic study, a parallel test is run with pyrimethamine[14].

This method was used by many workers including Kirby and Co. in 1993. Suppressive tests were firstly carried out on two groups of mice of known weight. One group was used as test and the other as control. On the first day each mouse was infected intravenously with parasitised red blood cells. The newly infected mice were then randomized into groups of three and treated orally with the extract daily for 4 days. On the last day, tail blood smears were prepared from each mouse and parasitaemia was determined microscopically. The doses of the extract used were gradedly increased[15].

IN VITRO TESTING

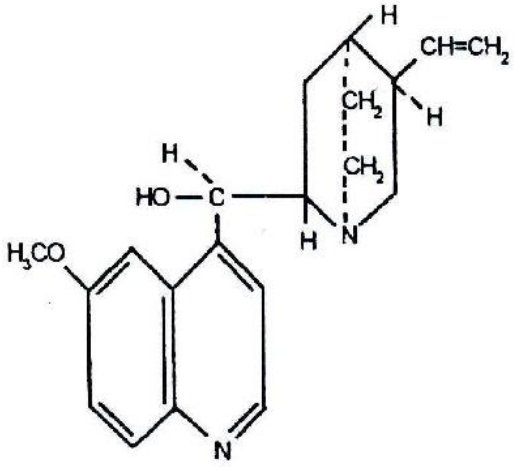
Vigorously growing cultures of P. falciparum with a predominance of young ring forms are usually used in the determination of drug sensitivity. The extracts are tested at least twice, in duplicate, at 12 concentrations in four-fold dilutions. Chloroquine or pyrimethamine is tested concomitantly each occasion as a control depending on whether it is schizonticidal or prophylactic activity. From dose-response curves the IC_{50} values (concentrations at which inhibition of parasite growth represents 50%) are derived for each extract or drug. Data from different experiments are accumulated and the mean IC_{50} value for each drug or extract is calculated[15].

The antimalarial activity of the test compounds could be assessed also with an in vitro radio-isotope-incorporation method. A suspension of P. falciparum infected red blood cells is added to wells of a standard 96-well tissue culture plate containing 25m l of drug or extract to be tested. Each test compound is assayed in duplicate over a concentration range of 10,000 - 14ng/ml. In addition, the known antimalarial drugs quinine, chloroquine, mefloquine and artemisinin are tested in each experiment over a range of 250-0.3ng/ml. Microtiter plates are incubated for 24 hours at 37°C in a sealed chamber under an atmosphere of 5% CO_2 . 5% O_2 and 90% N_2 . After this incubation period, 0.5mi of [^{3}H(G)] hypoxanthine is added to each well (25ml of 2OmCi/ml) and the microtiter plate is returned to the sealed chamber at 37°C for an additional 18 hour incubation. The assay is terminated by harvesting the contents of each microtiter plate onto a glass fibre filter using semi-automatic cell harvester. Filters are dried and the radioactivity from individual wells are excised from the filter and placed in 4-ml vials with toluene-based scintillation cocktail. Radioactivity is



Gedunnin

Cinchona bark consists of various speqies, races and hybrids of Cinchona (Family Rubiaceae), large trees indigenous to Colombia, Ecuador, Peru and Bolivia. The BP and EP recognise *C. Succirubra* and its varieties and hybrids containing not less than 6.5 per cent of total alkaloids, 30 - 60 per cent of which consists of quinine-type alkaloids. Quinine is used for treatment of malaria. Other alkaloids like quinidine are employed for the prophylaxis of cardiac arrhythmias and for the treatment of atrial fibrillation[23].



Quinine

Quinine's antimalarial action is believed to be by the intercalation of the quinoline moiety into the DNA of the Plasmodium parasite, thereby reducing the effectiveness of DNA to act as a template. Intercalating agents such as quinine are rigid planar polycyclic molecules that insert between the adjacent stacked base pairs of the double helix of DNA. This results in DNA that has increased length and because of a greater electrostatic interaction between the intercalated molecule and the two DNA strands, there is an inhibition of the strand separation that is required for replication and transcription of the genetic code[24].

DISCUSSION AND CONCLUSION

From the tables, it is clear that a wide variety of plants are claimed to have antimalarial properties, however, the degree of effectiveness of the plants remain uncertain until detailed physiological studies have been carried out. The wide range of plant families involved indicated that a variety of chemical structural types is associated with the active principles.

Considering the numbers of deaths caused by malaria and increase in resistance to the synthetic drugs, the development of thermostable, non-resistant, potent and cheap remedies suitable for malaria treatment cannot be over-emphasised. Although scientific investigations into plants traditionally used to treat malaria are showing results which indicate that plants can provide the source for individual compounds or standardised extracts which could be useful in many places where malaria is endemic. Evaluation of the efficacy and effectiveness of traditional remedies not only with laboratory testing but more "clinical investigations" results from the in-vivo situation are required and could be obtained from follow-up studies of patients who are treated with traditional remedies for malaria by traditional healers.

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