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## **Ethnopharmacological survey of plants used in the traditional treatment of pain conditions in Mali**

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# Ethnopharmacological survey of plants used in the traditional treatment of pain conditions in Mali

## Abstract

Pain is among the major concerns of healthcare authorities across the world. It is complicated to diagnose, manage and treat. Current western treatments are successful to some extent in relieving pain; they provide minimum improvements in terms of physical and emotional functioning and are often accompanied by side effects. Finding new solutions in pain management has thus become a priority. Natural products have always been a huge source of new active principles; traditional medicine is thus a key to innovation. In Mali, traditional remedies are more popular than pharmaceutical drugs but this knowledge, verbally transferred from generation to generation is at risk as younger generations are not taking over. Thus, this study was designed to identify plants that are used traditionally in the South of Mali for the treatment of painful conditions. Data was collected by means of semi-structured face-to-face interviews with traditional healers (N=108) in the regions of Bamako, Sikasso and Dioila. Two quantitative ethnopharmacological indexes were calculated: Relative Frequency of Citation (RFC) and Fidelity Level (FL) when  $RFC > 0.10$ . A total of 66 plant species distributed across 29 families were recorded during this two-month survey. Stomach aches and external pains were the most cited pain conditions followed by body pains and pain due to diseases such as diabetes and sickle cell disease. *Cassia sieberiana* DC. (RFC = 0,22), *Zanthoxylum zanthoxyloides* (Lam.) Zepren. & Timler (0,13), *Pericopsis laxiflora* (Benth.) Meeuwen (0,11), *Flueggea virosa* (Roxb. ex Willd) Royle (0,08) and *Sarcocephalus latifolius* (Sm.) E.A.Bruce (0,08) were the most cited plants. This ethnopharmacological survey provides preliminary data for the discovery of new analgesic molecules.

**Keywords:** Medicinal plants, Ethnopharmacological research, Pain, Mali

## 1. Introduction

Pain represents a major public health issue worldwide (Phillips, 2006). An important challenge in analgesia is to provide more effective and safer treatments with fewer side effects. Indeed, more than 1.5 billion people worldwide suffer from chronic pain (Global Industry Analysts Inc., 2011) while almost 5% of the global population suffer from neuropathic pain (Global Industry Analysts Inc., 2011). Chronic pain can lead to depression and/or job loss (Breivik et al., 2006) as well as increasing direct and indirect health-care costs. Developing new solutions in pain management has become a priority. During the last decade, pain mechanisms have been better elucidated (Basbaum et al., 2009); however, progress in pain therapy is stagnating. Strategies used by drug developers consist mainly of reformulations of current drugs (Global Industry Analysts Inc., 2011), but there is a pressing need for new active molecules with fewer side effects.

Natural products represent a very large source of new bioactive principles, illustrated by the fact that more than 50% of clinically-approved drugs are in fact of natural origin (Newman and Cragg, 2007).

Moreover, the effectiveness of medicinal plants used by traditional healers has been proved by scientific studies (Al-Sayed and El-Naga, 2015; Gismondi et al., 2013; Scott et al., 2004). Literature data shows that several plant extracts, commonly used for the treatment of

painful and inflammatory conditions, demonstrate anti-nociceptive and anti-inflammatory activities (Melo et al., 2013; Silva, C.R. et al., 2013; Silva, M.A. et al., 2013).

Many countries rely on traditional medicine. In Mali, 75% of the population regularly consult traditional healers (WHO, 2015) for small health problems, such as headache or back pain, or even more important conditions such as diabetes, malaria or fractures. In Mali, traditional healers are organized in associations, which belong to the Malian Federation of Tradipraticians and Herbalists (FeMaTH). They are taught by their parents how to recognise diseases and treat people using local plants. This knowledge is based on empirical observations but has many times proved its accuracy (Gurib-Fakim, 2008).

The current survey has gathered data in relation to traditional remedies used to treat pain conditions such as stomach aches, muscle aches and back pains, but also pain due to sickle cell disease or diabetes as well as traumatic pains. In Mali and in neighbouring countries within the same climate zones, such as Burkina Faso, to the best of the authors' knowledge, no ethnopharmacological survey concerning pain has ever been published before. Many studies have aimed at identifying traditional medicine (Inngjerdingen et al., 2004; Nadembega et al., 2011; Tapsoba and Deschamps, 2006), but none were found to focus on pain. The present survey constitutes an original approach to identifying potential analgesic plants. This might be due to the fact that pain is often considered as a symptom rather than a disease. Thus care should be taken, during interviews, to ensure that the remedies described do not cure the disease that is responsible for pain but rather diminish the pain itself.

This survey will pave the way for the scientific community to investigate novel analgesic strategies, and for the local community to develop improved traditional medicine along the same lines as Malarial<sup>®</sup>, which is a plant-based drug used against malaria, developed by the Department of Traditional Medicine (DMT) in Bamako and sold in drugstores in Mali.

## 2. Materials and methods

### 2.1. Study areas and climate

This ethnopharmacological survey was conducted in the South of Mali, in four different cities and their surroundings (Figure 1): Bamako (Médine market, Médine market Kouloudjou, Hamdallaye market, Djikoroni Para market, Kalabancoura, Niamakoro), Siby (Kati Cercle, 50 km south-west of Bamako), Dioïla and its surroundings (Seremanbougou, Banko and Massigui in Dioïla), Sikasso and its surroundings (Ziasso and Finkolo in Sikasso Cercle).

The south of Mali belongs to the Sahelo-Sudanian and Sudano-Guinean climate zones (Arbonnier, 2009) with a bimodal seasonality: the rainy season from June to October and the dry season from November to May.

Bamako is a melting pot where many ethnic groups live. In Bamako, but also in Siby and in Dioïla Cercle, ethnic groups are mainly Bambara and Malinké but some are Pheul, Songhoï, Somono, Senoufo, Mianka, Dogon or Bozo, while in Sikasso, they are mostly Sénoufou.

**Figure 1.** Study area (red dots indicate interviews areas)

In Mali, traditional healers pass down their knowledge from parent to child. In Bamako, they earn a living by healing people with plants, which they collect outside the city. In the rural

areas, they are usually farmers by profession and traditional healers as a secondary activity. Medicinal plants are collected from the outlying areas, also known as “the bush”.

## 2.2. Interviews and data collection

This study was carried out between January and June 2014. In Mali, traditional healers are organized into associations and were approached by the presidents of these associations with the help of the Department of Traditional Medicine (DMT) in Bamako and of the Malian Federation of Tradipraticians and Herbalists (FeMaTH). The presidents of these associations introduced the traditional healers who are highly esteemed within their community. Traditional healers were selected in order to avoid family relationship and to have as many women as possible, since they are very few in the profession. A large panel of official traditional healers between 30 and 89 years old were interviewed. Data collection was performed in French or in Bambara. During these interviews, 27 women and 81 men were questioned individually. Data related to pain conditions such as stomach ache, headache, back pain, ulcer, rheumatism, menstrual pain, nerve pain (including sciatica or pain due to nerve damage), pain due to various diseases such as malaria, diabetes, sickle cell disease and external pain referring to pains due to a shock, an accident or any pain that can be treated topically were collected using a semi-structured questionnaire. Information about local names, plant parts used, ailments, methods of preparation and administration were collected. During the field surveys, whenever a plant species was mentioned the traditional healer was encouraged to show the plant, if possible, in which case the plant was photographed. Plant species were then identified by their local names and their photographs with the help of plant taxonomists from the DMT, Bamako. The plant list (The Plant List, 2015) and an African Pharmacopeia book (Ekl-Natey and Balet, 2012) were used to validate the scientific names of the plants.

Prior to the interviews, the project was presented to the head of the FeMaTH, who approved it and enabled the authors to contact the different associations of traditional healers. Before starting the interview, each healer was given information about the project, goals, methods, funding sources, expected output and possible impacts of their participation. Since most of the traditional healers had no formal education (79%) and therefore could neither read nor write, prior informed consent was obtained orally from each of the participants. Subjects were informed that they could refuse to answer any questions or stop participating at any time. Moreover, after the survey, the traditional healers were informed of the results.

## 2.3. Quantitative indices

Relative frequency of citation (RFC) shows the importance of use of each species (Table 1) and is calculated as follows:  $RFC = FC / N$ ; where FC is the number of traditional healers mentioning the use of the species, and N is the total number of traditional healers participating in the survey (Priyamka Sreekeesoon and Fawzi Mahomoodally, 2014).

The fidelity level (FL) of a given plant for a given use was calculated to rank the recorded plant species based on their claimed relative effectiveness (Table 1) as follows:  $FL = (N_p / N_T) \times 100$ ; where  $N_p$  is the number of traditional healers who mentioned the use of a particular species for a particular purpose and  $N_T$  is the number of traditional healers who mentioned the plant for any use (Togola et al., 2008). Species whose RCF was below 0.1 were not included in the FL calculations.

### 3. Results

#### 3.1. Demographic characteristics of the traditional healers

The survey was conducted with 108 respondents (25% women and 75% men) belonging to local associations of traditional healers. The mean age was  $60 \pm 13$  years old. The youngest was 30 years old and the oldest 89. The number of traditional healers increases with age (Figure 2), underlining the risk that knowledge could disappear and the need for the younger healers to take over.

**Figure 2.** Sex and age of 108 traditional healers interviewed during the survey.

Most of the respondents had no formal education (79%) and learned traditional medicine from their parents or grand-parents (78%). Ethnic groups were mainly: Bambara (37%), Malinké (17%), Pheul (13%) and Sénoufo (19%).

#### 3.2. Pain conditions

Pain conditions were classified according to a direct translation of the information given by the traditional healers, including stomach ache, headache, back pain, ulcer, rheumatism, menstrual pain, nerve pain (including sciatica or pain due to nerve damage), pain due to various diseases such as malaria, diabetes, sickle cell disease, and external pain referring to pains due to a shock, an accident or any pain that can be treated topically. Each time a traditional healer presented a plant for a specific pain condition, detailed information, such as the symptoms usually experienced by patients before and after the treatment, were requested. This enabled the validation of the targeted pain condition and treatment.

The most common pain conditions were stomach ache and external pain, which account for 35.8%.

**Figure 3.** Most common pain conditions (n = 108)

#### 3.2. Plants, their preparation and administration

A total of 112 recipes were reported to relieve painful conditions (Table 1). Traditional preparations were mainly decoctions (55%) and in crushed form (34%). Infusions, macerations and direct juice or sap were rarely used. Preparations were taken orally (66%) and/or externally including bathing (53%). Traditional healers usually encourage patients to drink the decoction and to bathe in it. A total of 66 plants were described, belonging to 60 genera and 29 plant families. The largest number of plants mentioned belonged to families of Leguminosae (26%), Combretaceae (8%) and Rubiaceae (8%). Species that ranked highest according to their RCF were *Cassia sieberiana* DC. (0.22), *Zanthoxylum zanthoxyloides* (Lam.) Zepren. & Timler (0.13), *Pericopsis laxiflora* (Benth.) Meeuwen (0.11), *Flueggea virosa* (Roxb. ex Willd) Royle (0.08) and *Sarcocephalus latifolius* (Sm.) E.A.Bruce (0.08), which attained a maximum FL Score of 100% for stomach ache.

**Table 1.** Alphabetical list of medicinal plants (scientific names) used to relieve pain conditions in the South of Mali. Col. Nb. = collection number referring to the general herbarium collection of the Department of Traditional Medicine in Bamako, leaves<sup>#</sup>, root<sup>†</sup>, root bark<sup>‡</sup>, bark<sup>§</sup>, fruits\*, whole plant<sup>°</sup>.

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Acacia nilotica</i> subsp. <i>adstringens</i> (Schumach. & Thonn.) Roberty	3092/DMT	Bouana	Leguminosae	Fruit, whole plant	*Crushed form taken orally with water. °Cooked into a paste and applied topically.	0.03	Internal and external pain
<i>Annona senegalensis</i> Pers.	0012/DMT	Mandé sounsoun	Annonaceae	Root, root bark	†,‡Decoction taken orally. †,‡Crushed form applied topically with shea butter and potash.	0.03	Rheumatism, External pain, stomach ache
<i>Anogeissus leiocarpa</i> (DC.) Guill. & Perr.	0964/DMT	Krékélé	Combretaceae	Bark, leaves	§Crushed form applied topically with shea butter. #Decoction taken orally and used to bathed in.	0.02	Nerve pain
<i>Anthocleista djalonensis</i> A. Chev.	2318/DMT	Samatlo	Gentianaceae	Root, bark, fruit	†, §, *Decoction taken orally. †, §, ‡Crushed form of the root of <i>Anthocleista djalonensis</i> taken orally in association with the bark of <i>Zanthoxylum zanthoxyloides</i> or with the root of <i>Cassia sieberiana</i> .	0.06	Stomach ache, pain due to malaria, menstrual pain, constipation
<i>Anthonotha crassifolia</i> (Baill.) J. Léonard	2421/DMT	Firimi	Leguminosae	Root bark	‡Crushed form taken orally.	0.01	Stomach ache, back pain, tooth ache

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Baccharoides adoensis</i> var. <i>kotschyana</i> (Sch. Bip. ex Walp.) “Isawumi, El-Ghazaly & B.Nord.”	0929/DMT	Boié	Compositae	Root	†Crushed form taken orally.	0.01	Stomach ache
<i>Bobgunnia madagascariensis</i> (Desv.) J. H. Kirkbr. & Wiersema	3045/DMT	Frikama	Leguminosae	Root	†Crushed form taken orally.	0.01	Menstrual pain
<i>Bombax costatum</i> Pellegr. & Vuill.	2092/DMT	Kapoké	Malvaceae	Bark, root	†, ‡Decoction taken orally.	0.01	Pain due to pregnancy
<i>Boscia angustifolia</i> A. Rich.	1546/DMT	Béré	Capparaceae	Leaves	#Crushed form applied topically with shea butter.	0.01	Analgesic, external pain
<i>Burkea africana</i> Hook.	2460/DMT	Siri	Leguminosae	Leaves	#Decoction applied topically with a cloth. #Decoction taken orally and bathed in.	0.02	External pain
<i>Calotropis procera</i> (Aiton) Dryand.	1156/DMT	Fogofoko	Apocynaceae	Leaves	#Crushed form taken orally. #Crushed form applied topically.	0.02	Headache, muscle ache, pain due to sickle cell disease

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Cassia sieberiana</i> DC.	2057/DMT	Sindjan	Leguminosae	Root bark, root, leaves	†,‡, #Decoction or crushed form taken orally. ‡, #Crushed form with shea butter or the decocted material is applied topically. †Also associated with: - leaves of <i>Combretum molle</i> and bark of <i>Sarcocephalus latifolius</i> - roots of <i>Anthocleista djalonensis</i>	0.22	Stomach ache (76%), menstrual pain (4%), back pain (4%), pain due to sickle cell disease (4%), pain after childbirth (12%)
<i>Chamaecrista nigricans</i> (Vahl) Greene	1347/DMT	Djalaniba	Leguminosae	Leaves, whole plant	#, °Cold maceration taken orally	0.02	Stomach ache, hernia, pain due to ulcer, pain due to pregnancy
<i>Chrozophora senegalensis</i> (Lam.) A. Juss. ex Spreng	1678/DMT	Dabada	Euphorbiaceae	Leaves	#Decoction of leaves of <i>Chrozophora senegalensis</i> and of leaves of <i>Combretum micranthum</i> taken orally	0.01	Pain due to pregnancy
<i>Cissus populnea</i> Guill. & Perr.	13/68/DMT	Garó	Vitaceae	Root bark	‡Paste applied topically	0.01	External pain
<i>Cissus quadrangularis</i> L.	2327/DMT	Woulouyoloko	Vitaceae	Whole plant	°Use of decoction as a bath	0.01	Pain due to sickle cell disease
<i>Cochlospermum tinctorium</i> Perr. ex A. Rich.	2298/DMT	Tiribara	Bixaceae	Root	†Crushed form taken orally.	0.02	Stomach ache, pain due to malaria
<i>Combretum glutinosum</i> Perr. ex DC.	2680/DMT	Tiangara	Combretaceae	Leaves	#Decocted leaves applied topically.	0.02	Pain due to sickle cell disease, external pain

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Combretum micranthum</i> G. Don	2765/DMT	N'Golobé	Combretaceae	Leaves	#Decoction taken orally or used to bathed in. Can be used in association with leaves of <i>Chrozophora senegalensis</i> .	0.04	Stomach ache, pain due to pregnancy, pain due to diabetes
<i>Combretum molle</i> R. Br. ex G. Don	3057/DMT	N'Gagnaka	Combretaceae	Leaves, root	#, †Decoction taken orally. #Can be used in association with roots of <i>Cassia sieberiana</i> and bark of <i>Sarcocephalus latifolius</i> .	0.02	Stomach ache, hernia
<i>Combretum nigricans</i> var. <i>elliottii</i> (Engl. & Diels) Aubrév.	0986/DMT	Samabali	Combretaceae	Leaves	#Decoction or Crushed form taken orally.	0.01	Stomach ache, menstrual pain
<i>Crossopteryx febrifuga</i> (Afzel. ex G. Don) Benth.	602L. Aké Assi	Balembo	Rubiaceae	Leaves	#Decoction taken orally or bathed in.	0.01	Stomach ache
<i>Daniellia oliveri</i> (Rolfe) Hutch. & Dalziel	0914/DMT	Sanan	Leguminosae	Leaves	#Decoction taken orally or bathed in.	0.05	Headache, chest pain, stomach ache
<i>Datura metel</i> L.	3087/DMT	Almoukaikai	Solanaceae	Leaves	#Crushed or decocted applied topically. Can be mixed with potash or shea butter.	0.03	External pain, hernia
<i>Detarium microcarpum</i> Guill. & Perr.	2908/DMT	Tabacouba	Leguminosae	Leaves, root	#, †Decoction taken orally.	0.03	Stomach ache, nerve pain, joint pain
<i>Dichrostachys cinerea</i> (L.) Wight & Arn.	1798/DMT	Goro, N'giliki	Leguminosae	Leaves	#Calcinated form applied topically.	0.01	External pain

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Diospyros mespiliformis</i> Hochst. ex A. DC.	0174/DMT	Sounsounfing	Ebenaceae	Leaves	#Crushed form applied topically with shea butter. # Use of decoction.as a bath	0.02	Headache, joint pain
<i>Entada africana</i> Guill. & Perr.	1799/DMT	Samanéré	Leguminosae	Root, juice from whole plant	†Infusion taken orally. °Juice applied topically.	0.02	Stomach ache, abdominal pain, external pain
<i>Erythrina senegalensis</i> DC.	2239/DMT	N'Ti	Leguminosae	Bark, whole plant	§, °Decoction or crushed form taken orally.	0.02	Stomach ache
<i>Euphorbia hirta</i> L.	0952/DMT	Bodiaka, dabadablén	Euphorbiaceae	Whole plant	°Decoction taken orally.	0.02	Stomach ache, constipation menstrual pain
<i>Faidherbia albida</i> (Delile) A. Chev.	1269/DMT	Balanzan	Leguminosae	Bark	§Crushed form taken orally.	0.01	Gastric ulcer
<i>Feretia apodanthera</i> Delile	0951/DMT	Djoula sonkalani	Rubiaceae	Leaves	#Decoction taken orally and bathed in.	0.01	Pain due to sickle cell disease
<i>Flueggea virosa</i> (Roxb. ex Willd) Royle	1699/DMT	Balambalam	Phyllanthaceae	Root bark, root, leaves	†, ‡, #Decoction or crushed form taken orally. Use of decoction as a bath. †, ‡, #Decoction taken orally and used a bath in association with <i>Securidaca longipedunculata</i> .	0.08	Headache (20%), stomach ache (60%), pain due to diabetes (10%), menstrual pain (10%)

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Gardenia sokotensis</i> Hutch.	0769/DMT	Farakolotji	Rubiaceae	Leaves	#Decoction taken orally and bathed in. Can be associated with leaves of lemon tree and leaves of <i>Parinari curatellifolia</i> .	0.02	Stomach ache, tiredness
<i>Gardenia ternifolia</i> Schumach. & Thonn.	2269/DMT	Bourentié	Rubiaceae	Root	†Crushed form taken orally.	0.01	Stomach ache
<i>Gossypium barbadense</i> L.	1776/DMT	Coton	Malvaceae	Leaves	#Decoction or infusion taken orally.	0.01	Stomach ache, muscle ache. Sleeping difficulty
<i>Guiera senegalensis</i> J. F. Gmel.	0991/DMT	Gundié	Combretaceae	Leaves, root, whole plant	†, #, °Decoction or crushed form taken orally †Applied topically with shea butter.	0.06	Muscle ache, joint pain, back ache, stomach ache, headache
<i>Gymnanthemum coloratum</i> (Willd.) H.Rob. & B.Kahn	2974/DMT	Kossafouné	Compositae	Leaves	#Decoction taken orally.	0.01	Stomach ache
<i>Heliotropium indicum</i> L.	0037/DMT	Nonssikou	Boraginaceae	Leaves, whole plant	#, °Decoction taken orally and bathed in.	0.03	Stomach ache, pain due to pregnancy, menstrual pain
<i>Khaya senegalensis</i> (Desr.) A.Juss.	2257/DMT	Diala	Meliaceae	Bark	§Crushed form taken orally or applied topically with shea butter and potash.	0.03	Stomach ache, pain due to malaria, external pain
<i>Lannea acida</i> A. Rich.	1146/DMT	Bembé	Anacardiaceae	Leaves	#Decoction taken orally and used as a bath.	0.01	Menstrual pain

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Lannea velutina</i> A. Rich.	1466/DMT	Bakoronpegou, Mpekoubagnégné	Anacardiaceae	Bark	§Decoction is taken orally and bathed in. §The decocted material or the crushed form with shea butter is applied topically.	0.03	External pain, back pain, nerve pain
<i>Leptadenia lancifolia</i> (Shumach.& Thonn.) Decne.	3015/DMT	Zognié	Apocynaceae	Leaves, whole plant	#, °Decoction taken orally and bathed in.	0.04	Stomach ache, pain due to malaria, pain due to diabetes
<i>Lophira alata</i> Banks ex C. F. Gaertn.	0275/DMT	Kobi	Ochnaceae	Root	†Decoction taken orally and bathed in.	0.01	Pain in the whole body, nerve pain
<i>Mitragyna inermis</i> (Willd.) Kuntze	603L. Assi	N'djoun	Rubiaceae	Leaves	#Maceration of leaves of <i>Sarcocephalus latifolius</i> and leaves of <i>Mitragyna inermis</i> is taken orally.	0.01	Stomach ache
<i>Moringa oleifera</i> Lam.	2836/DMT	Moringa	Moringaceae	Root, bark, leaves	†, §Decoction taken orally. †, §, #The decocted material applied topically. Potash can be added.	0.03	Analgesic, back pain, external pain
<i>Opilia amentacea</i> Roxb.	1420/DMT	Korong goï	Opiliaceae	Leaves	#Decoction or crushed form taken orally and bathed in.	0.03	Menstrual pain, tiredness, back pain, pain due to sickle cell disease
<i>Oxytenanthera abyssinica</i> (A. Rich.) Munro	2897/DMT	Boo	Poaceae	Leaves	#Decocted leaves applied topically.	0.01	External pain

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Parinari curatellifolia</i> Planch. ex Benth.	0086/DMT	Toutou	Chrysobalanaceae	Leaves	#Decoction of leaves of <i>Gardenia sokotensis</i> , lemon tree and <i>Parinari curatellifolia</i> taken orally and bathed with.	0.01	Stomach ache
<i>Pericopsis laxiflora</i> (Benth. ex Baker) Meeuwen	1715/DMT	Kolokolo	Leguminosae	Leaves	#Decoction or crushed form with shea butter applied topically. #Decoction taken orally and bathed in. Can be associated with leaves of <i>Prosopis africana</i> .	0.11	Muscle pain (25%), dislocation (6%), tiredness (12%), nerve pain (6%), stomach ache (6%), back pain (6%), pain due to diabetes (6%), external pain (31%)
<i>Prosopis africana</i> (Guill. & Perr.) Taub.	1103/DMT	Guélé	Leguminosae	Root, bark, leaves	§Crushed form with shea butter applied topically. †, §, #Decoction taken orally and bathed in. #Can be associated with leaves of <i>Pericopsis laxiflora</i> .	0.04	External pain, body pain, dislocation, stomach ache
<i>Pseudocedrela kotschyi</i> (Schweinf.) Harms	0063/DMT	Sinzan, lombo	Meliaceae	Root, root bark	†, ‡Decoction or crushed form is taken orally.	0.04	Stomach ache, hernia, pain due to malaria
<i>Saba senegalensis</i> (A. DC.) Pichon	0082/DMT	Zaban	Apocynaceae	Leaves	#Use of decoction as a bath	0.01	Stomach ache

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Sarcocephalus latifolius</i> (Sm.) E.A.Bruce	2481/DMT	Baro	Rubiaceae	Root, bark, leaves	†, §, # Infusion, decoction or crushed form taken orally. #Can be associated with: -leaves of <i>Mitragyna inermis</i> -roots of <i>Cassia sieberiana</i> and leaves of <i>Combretum molle</i> .	0.08	Stomach ache (100%)
<i>Sclerocarya birrea</i> (A.Rich.) Hochst.	2200/DMT	N'gunan	Anacardiaceae	Root, bark, leaves	†, §, #Crushed form taken orally. §Applied topically.	0.03	Stomach ache, muscle ache
<i>Securidaca longipedunculata</i> Fresen.	2220/DMT	Dioro	Polygalaceae	Root, root bark	†, ‡Crushed form applied topically with shea butter. †Decoction taken orally and bathed in. Can be associated with <i>Flueggea virosa</i>	0.04	Headache, rheumatism
<i>Senna occidentalis</i> (L.) Link	2840/DMT	Balambala, N'golondjé	Leguminosae	Root	†Crushed form applied topically. †Decoction taken orally.	0.01	Analgesic
<i>Spondias mombin</i> L.	1148/DMT	Mingò	Anacardiaceae	Bark	§Crushed form applied topically with shea butter or taken orally.	0.01	External pain, tiredness
<i>Stylosanthes erecta</i> P. Beauv.	1746/DMT	Diofaga	Leguminosae	Leaves	#Decoction taken orally and bathed in or applied topically with a cloth.	0.02	Stomach ache, external pain
<i>Tamarindus indica</i> L.	2301/DMT	Tamarin	Leguminosae	Root	†Crushed form taken orally.	0.01	Stomach ache

Scientific name	Col. Nb.	Vernacular name	Family	Part used	Method of preparation	RFC	Pain conditions (FL when RFC >0,10)
<i>Trichilia emetica</i> Vahl	2656/DMT	Sura Sinzan, Flosinzan	Meliaceae	Root, bark, leaves	†, §, #Decoction taken orally and bathed in.	0.05	Headache, hernia, stomach ache, back pain, muscle ache
<i>Vitellaria paradoxa</i> C. F. Gaertn.	1965/DMT	Shi	Sapotaceae	Leaves	#Decoction applied topically.	0.01	External pain
<i>Vitex madiensis</i> Oliv.	2196/DMT	Koronifin	Lamiaceae	Leaves	#Decoction taken orally.	0.01	Pain due to pregnancy
<i>Ximenia americana</i> L.	0764/DMT	N'Tongué	Olacaceae	Root, root bark	†, ‡Decoction taken orally.	0.03	Pain due to malaria, stomach ache
<i>Zanthoxylum zanthoxyloides</i> (Lam.) Zepren. & Timler	703L. Assi	Aké Wo	Rutaceae	Root, bark, leaves	†, §, #Decoction taken orally and bathed in. §Crushed form can be taken orally in association with roots of <i>Anthocleista djalonensis</i> or applied topically with shea butter.	0.13	Toothache (27%), nerve pain (7%), external pain (13%), stomach ache (33%), chest pain (7%), muscle ache (7%), pain due to sickle cell disease (7%)
<i>Ziziphus jujuba</i> Mill.	2223/DMT	Tomono	Rhamnaceae	Root bark	‡Infusion or crushed form taken orally.	0.03	Stomach ache, hernia, pain due to malaria, pain due to pregnancy

## 4. Discussion

The present survey documents traditional medicinal plants commonly used for pain management and treatment in the South of Mali. The first observation of this study was that the average age of traditional healers is relatively high: 57% of traditional healers were over 60 years old and the new generation has not yet taken over; only 7% of traditional healers were under 40 years old. In future years, this could lead to the loss of precious knowledge about plants and their uses. Thus, it is important to record traditional medicines and validate them in order to give more credit to this knowledge.

In regard to pathologies, stomach ache was the most cited pain condition, followed by external pain, as recently reported by several authors (Amri and Kisangau, 2012; Priyamka Sreekeesoon and Fawzi Mahomoodally, 2014). Most recipes involved decoctions. Administration was either orally or applied topically. The plant family with the largest number of citations was Leguminosae, which may be linked to the fact that Leguminosae is the third-largest flowering plant family, comprising 750 genera and approximately 19,500 species (Colville et al., 2015), many of which have been used as traditional medicines as well as components of pharmaceutical products (Gao et al., 2010).

Although some plants have been reported in the literature for their analgesic properties or their use in the treatment or management of pain, others are reported here for the first time: *Anthonotha crassifolia*, *Cissus populnea*, *Gardenia sokotensis*. Among the most cited plants, validated by previous pharmacological studies, *Cassia sieberiana*, *Zanthoxylum zanthoxyloides*, *Pericopsis laxiflora*, *Flueggea virosa* and *Sarcocephalus latifolius* were frequently mentioned during the study ( $RFC \geq 0,08$ ).

*Cassia sieberiana* was the most frequently cited plant; it was described as being used mainly against stomach ache (FL = 76%). In Senegal, it is traditionally used as a purgative and diuretic, and it shows antibiotic activity against Gram-positive bacteria (Kerharo and Adam, 1974). This may partially explain the common use of *Cassia sieberiana* against stomach pain. Headache and rheumatism are also reported as being traditional complaints treated with *Cassia sieberiana* (Arbonnier, 2009). In Ghana, the root bark is used to treat abdominal pains, ulcers and general body pain (Irvine, 1961 ; Mshana et al., 2000). Moreover, analgesic and anti-inflammatory activities have been demonstrated *in vivo* (Duwiejua et al., 2007; Sy et al., 2009). Aqueous root extract inhibited abdominal cramps in an acetic acid-induced writhing test on mice (78% of inhibition at 300 mg/mL) (Sy et al., 2009). The authors assumed that the analgesic effect was linked to its cyclooxygenase inhibitory activity since (-)-Epiarazepine, extracted from the root bark of *Cassia sieberiana* (Kpegba et al., 2010) was found to inhibit cyclooxygenase-1 (COX-1) (Su et al., 2002).

*Zanthoxylum zanthoxyloides*'s traditional uses in Mali are: stomach ache (FL = 33%), toothache (FL = 27%) mainly, as well as pain due to sickle cell disease (FL = 7%). COX-1 inhibitory effects of the roots and bark have already been investigated to validate its traditional use against toothache and rheumatic pain in Ghana (Larsen et al., 2015). In Senegal, it is known as a powerful antiparasitic (Kerharo and Adam, 1974). *N*-Isobutyldeca-*trans*-2-*trans*-4-dienamide was isolated from roots and stem bark and possesses a slight anaesthetic effect on mucosa (Bowden and Ross, 1963) as well as antifungal and antibacterial properties (Zhou et al., 2011). Antisickling properties have been associated with the presence of divanilloylquinic acids (Ouattara et al., 2009). These reports therefore correlate with the traditional uses of *Zanthoxylum zanthoxyloides*.

*Pericopsis laxiflora* was identified as being used mainly against external pain (FL = 31%) and muscle pain (FL = 25%). Leaves have been described as being used traditionally as an analgesic against rheumatism (Arbonnier, 2009), stomach ache, headache and chest pain

(Eklun-Natey and Balet, 2012). Biochanin A and genistein have been isolated from the wood (Fitzgerald et al., 1976). Their analgesic properties were investigated from an extract of *Retama raetam*. They inhibited respectively 75% and 57% of abdominal cramps in an acetic acid-induced writhing test on mice (Djeddi et al., 2013). The leaves have not been described as containing these molecules, but they contain alkaloids (N-methylcytisine, ammodendrine, choline) flavonoids (afroformosin) and catechuit tannins (Forestieri et al., 1996). Moderate analgesic effects of the leaves were reported in an acetic acid-induced-writhing test and a hot-plate test in mice (Forestieri et al., 1996).

*Flueggea virosa* was reported as being used mainly against stomach ache (FL = 60%) and headache (FL = 20%). In Nigeria, the leaves are commonly taken to treat malaria, stomach ache, intestinal worms and dysentery. The sap is used against headache and is applied to limbs to treat feverish stiffness and pain (Borokini and Omotayo, 2012). Sedative properties (Magaji et al., 2008) as well as antimicrobial and free radical scavenging activities have been reported (Dickson et al., 2006).

*Sarcocephalus latifolius* was indexed exclusively against stomach ache (FL = 100%). Previous studies revealed that the root barks possessed anti-bacterial, spasmolytic activities (Ogunlana, 1975), anxiolytic and sedative properties (Ngo Bum et al., 2009) as well as anti-nociceptive, anti-inflammatory and anti-pyretic effects (Abbah et al., 2010). This may explain the various traditional uses of *Sarcocephalus latifolius* (Magili et al., 2014).

The most frequently cited plants have been investigated for their analgesic properties such as *Cassia sieberiana* (Duwiejua et al., 2007; Sy et al., 2009), *Pericopsis laxiflora* (Forestieri et al., 1996), *Sarcocephalus latifolius* (Abbah et al., 2010), *Anthocleista djalonensis* (Kagbo and Simon, 2015), *Guiera senegalensis* (Jigam et al., 2011), *Daniellia oliveri* (Onwukaeme, 1995) and *Trichilia emetica* (Sanogo et al., 2006). Thus frequently cited plants, used traditionally in Mali, were found to be effective in reducing pain in *in vivo* tests. In the quest for new analgesic molecules with novel modes of action, it will be of interest to identify the compounds responsible for the analgesic activity and so discover novel mechanisms to relieve pain.

## 5. Conclusion

This survey has catalogued plant-based traditional remedies with potential analgesic activities. 108 traditional healers were interviewed in south of Mali. 66 plant species, distributed across 29 families, were recorded. Stomach aches and external pains were the most frequently-cited pain conditions. *Cassia sieberiana*, *Zanthoxylum zanthoxyloides*, *Pericopsis laxiflora*, *Flueggea virosa* and *Sarcocephalus latifolius* were the most cited plants. Even though their analgesic properties have already been investigated, proving the efficacy of traditional medicine in the South of Mali, it is important to note that no compound responsible for the analgesic activity has been isolated. The investigation of their secondary metabolites is currently under progress. In addition, other plants have been reported here for the first time, such as *Anthonotha crassifolia*, *Cissus populnea*, *Gardenia sokotensis*. These plants will soon be scientifically investigated in order to validate their traditional use. This may represent an important source of innovation in the management and treatment of pain and might bring new solutions to people suffering from acute and chronic pains in the form of new approved drugs or of improved traditional medicine for local communities.

## Competing interests

The authors declare that there are no competing interests. The interviews of traditional healers were undertaken with the agreement of the FeMaTh, and the results of this study were shared with the interested parties (associations and healers). Moreover, the funding sources had no involvement in the study.

### **Associated content**

The questionnaire used in the study is available as on-line supplementary data.

### **Authors' contributions**

PC and SD designed the project. PC, DD and LS conceptualized the study. OD, AS and BF performed the interviews with the healers. DD and AS identified all plant materials described. OD analysed the field data with PC, CF and CE. AE, FM and CRC helped define analgesic terms to use during interviews. OD reviewed the research proposal, which was corrected by PC and SD.

All the authors have read and approved the final manuscript.

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Dakar

SENEGAL

Banjul

THE GAMBIA

Bissau

GUINEA-BISSAU

Conakry

GUINEA

Freetown

SIERRA LEONE

Monrovia

LIBERIA

Kifou

Kayes

Bamako

Sibv

Dioila

Sikasso

Bobo-Dioulasso

BURKINA FASO

Ouagadougou

Niamey

Tamale

BENIN

Djougou

COTE D'IVOIRE

Bouake

Yamoussoukro

Abidjan

GHANA

Kumasi

Accra

TOGO

Lome

Porto-Novo

Lagos

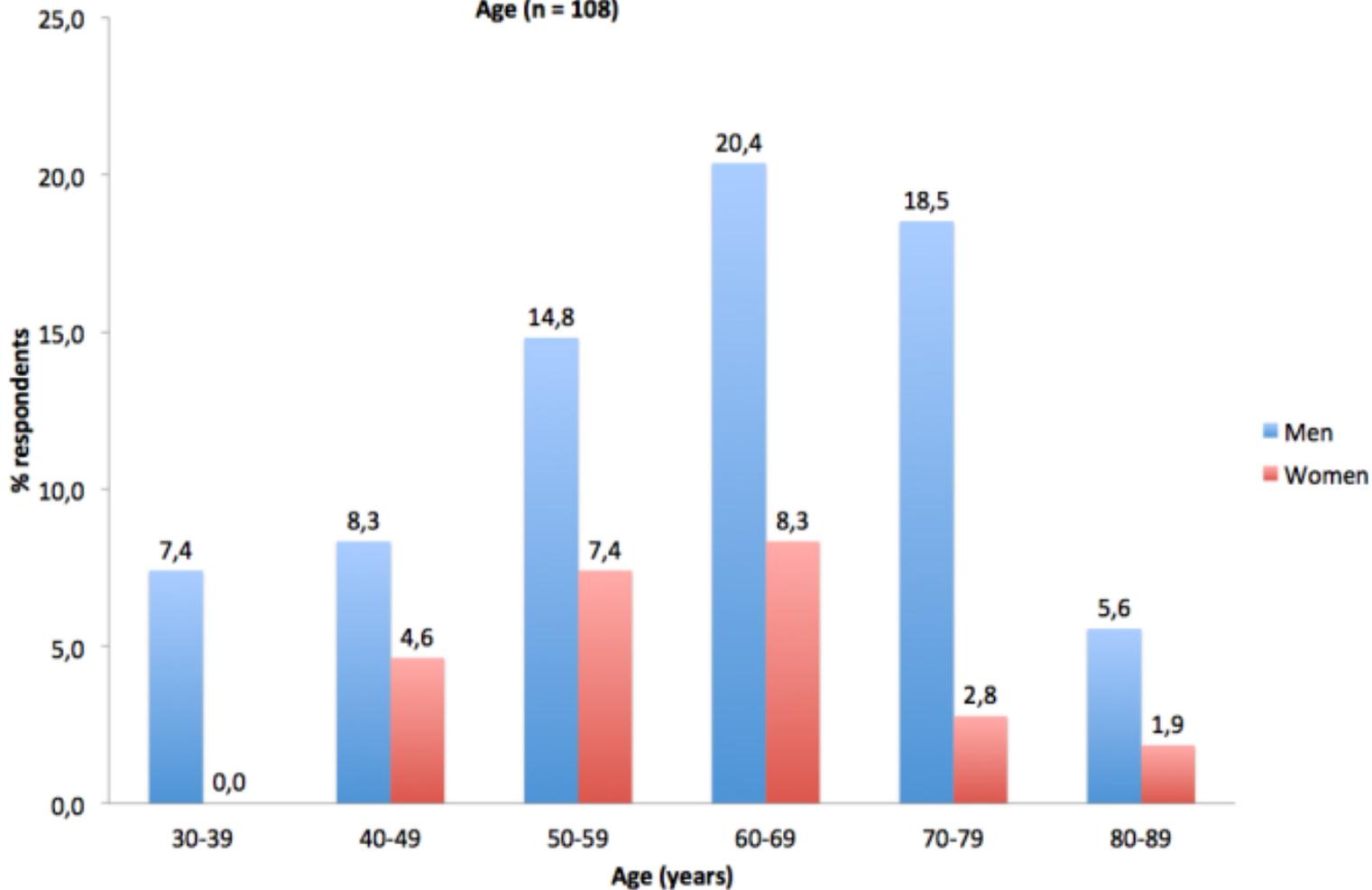
Cotonou

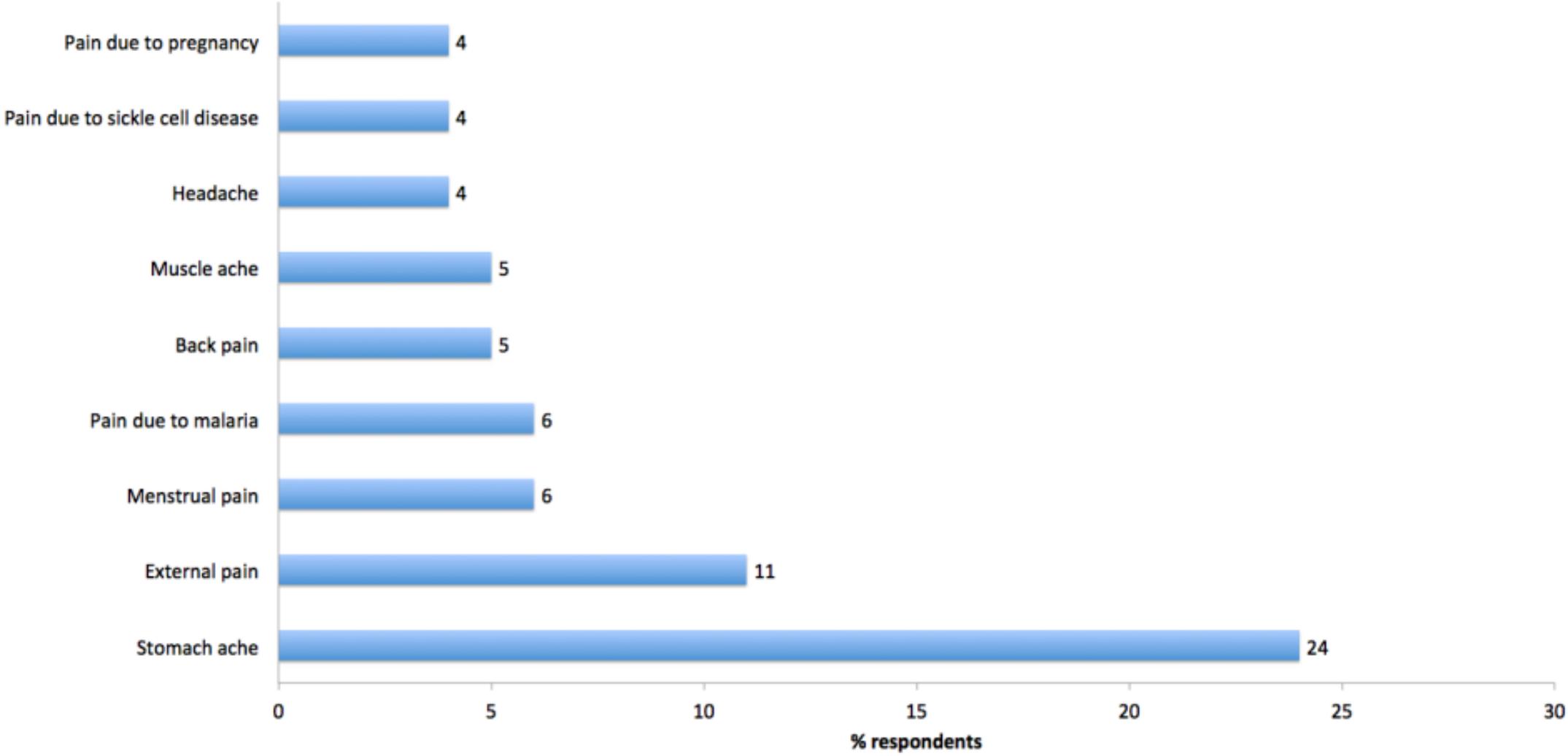
Oyo

Ibadan

Bight of Benin

Age (n = 108)





Pain

Ethnopharmacological  
survey in the south of Mali

66 plant species, 60 genera

112 recipes against pain  
conditions

Most cited plants :

*Cassia sieberiana* DC.

*Zanthoxylum zanthoxyloides* (Lam.) Zepren. & Timler

*Pericopsis laxiflora* (Benth.) Meeuwe

*Flueggea virosa* (Roxb. Ex Willd) Royle

*Sarcocephalus latifolius* (Sm.) E.A.Bruce

