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Anogeissus leiocarpus (DC.) Guill. & Perr. (Combretaceae), a medicinal plant traditionally used in small ruminant breeding in West and Central Africa: zootechnical performances, pharmacological activities and chemical compositions (bibliography synthesis)

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Key words: Ethno veterinarian, Anogeissus leiocarpus, Chemical composition, Pharmacological, Zootechnical utility and Small ruminant.

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Abstract

The genus *Anogeissus* has eight (8) species, of which 5 are found in Tropical Asia, 2 in Arabia and 1 in Tropical Africa. The only species of the genus *Anogeissus* found in Africa is *Anogeissus leiocarpus*. Also known as *Anogeissus leicarpa* or *Anogeissus schimperi,* Hochest. Ex Hutch & Dalz., *Anogeissus leiocarpus* is a multipurpose tree widely used in traditional medicine. However, it is less used in ethno-veterinary medicine and

its pharmacological evidence and especially in the treatment of parasitic diseases caused by *Haemonchus contortus* are poorly documented. This review is aimed at synthesizing current knowledge on the chemical composition, pharmacological and zootechnical utility of *A. leiocarpus in order* to explore gaps and propose research perspectives. Google Scholar was the main database used to compile most of the information available on *A. leiocarpus* in this review. Overall, 44 publications were analyzed, out of which 65.9% addressed the pharmacological properties of *A. leiocarpus*. The anthelmintic, antidiabetic, antioxidant, antimicrobial, antibacterial, antispasmodic, analgesic, anti-inflammatory, antihypertensive are the most pharmacological properties found in those publications. Similarly, many secondary metabolites including alkaloids, flavonoids, tannins, saponins, quinones, coumarins found in *A. leiocarpus* give it its pharmacological properties. The factorial correspondence analysis performed for the variable extracts and chemical compounds showed that the presence of a given chemical compound does not depend on the type of extract. This review allowed to gather essential information on *A. leicocarpus* and justifies its traditional use in the small ruminant breeding in West and Central Africa.

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Introduction

Plants are the basis of the traditional medical system (Dramane *et al.*, 2010) and represent a primary resource for traditional medicine. Because of their importance in the prevention and treatment of human and animal diseases, several studies were conducted and aimed at identifying the chemical compounds responsible for their actions. In fact, in developing countries, more than 80% of the population use medicinal plants for the first intention because of their easy access compared to modern drugs (Muthu *et al.*, 2006; OMS, 2014). In Benin, the accessibility and availability of medicinal plants throughout the country lead people, especially in the villages, to use them to treat diseases. Among these plants, there is *Anogeissus leiocarpus* belonging to the Combretaceae family and found in West Africa, from Senegal to Cameroon and extended to Ethiopia and East Africa (Arbab, 2014). Growing in dry forests and gallery forests (Arbab, 2014; Ouédraogo *et al.*, 2013), its distribution goes from the borders of the Sahara to the outer layer of tropical rain forests. It is a 15 to 18 m tall tree with a trunk up to 1 m in diameter, found in woodlands and savannas of the Sudanese regional center of endemism, with drooping branches bearing alternate, opposite, pubescent, ovate and lanceolate leaves of 2 to 8 cm long and 1.3 to5 cm wide. The leaves are acute at the apex, attenuated at the base, pubescent below and the barks are greyish to beige in color with fine scales, a yellowish edge streaked with brown (Arbab, 2014). It is used in the manufacture of chewing sticks for oral hygiene (Arbab, 2014; Sereme *et al.*, 2008) and in the treatment of some diseases (Olutayo *et al.*, 2011). This literature review aims to gather information available on the zootechnical utility, pharmacological activities and chemical composition of *A. leiocarpus* in order to shed more light on this medicinal plant little documented in the literature.

Methodology

Study protocol

Information on the pharmacological properties and the zootechnical importance of *A. leiocarpus* in the breeding system was collected through publications selected using inclusion and exclusion criteria, data source, criteria for preliminary evaluation of papers. The retrieved papers were manually reviewed to identify and exclude any work that did not meet the above criteria.

Literature review strategy

The main electronic database used for the review is Google scholar. It was chosen after consulting other databases such as PubMed and SCORPUS which had almost the same publications with available information on *A. leiocarpus*. The review was carried out from March 2020 to April 2021 using keywords or expressions (see Table 1) to collect as much information as possible on the plant and its pharmacological properties. The strategy adopted is that used by (Li *et al.*, 2013). The English correspondents for each of the keywords in Table 1 were used. This strategy allowed the inventory of 52 documents and the selection of 44 ones based on their close link with the research topic. Publications either in English or in French addressing the pharmacological properties of the plant via laboratory tests were identified and recorded. Data collected were inserted into the Excel spreadsheet (2016) for encoding, processed with the GraphPad Prism 8.4.3 software for graphs and histograms and analyzed using the R software 3.6.3 version for factorial correspondence analysis (CFA) to determine relations between the extracts and the chemical compounds obtained. The variables were linked to the pharmacological properties of the plant, the type of test (*in vitro* or *in vivo*) and of extract used, the field of application of the research (ethno-veterinary or ethnomedicine), the part of the plant used, and the country where the research was carried out. The animal model used was specified for *in vivo* tests and only the variables “extracted” and “chemical compounds” were considered for factorial analysis of the correspondences.

Inclusion and exclusion criteria

The preliminary review consisted of a careful reading of the papers’ title and abstract to ensure that they are linked with the research theme. Papers that passed

this stage were assessed on the quality and relevance of information. Those with supporting laboratory procedures (*in vitro* and or *in vivo* activities) were used as they ensure the accuracy of the results. Original research papers from 1983 to 2021 were included in the research. Equally, some references cited in publications were used to find other papers.

Results

Literature review

The literature review carried out over a one-year - period allowed to select 44 documents published after a careful screening out of a total of 52 identified publications (research papers, conference reports and study reports). Among the 44 publications used, 29 dealt separately with the pharmacological properties of *A. leiocarpus,* representing 65.9% of the selected publications of interest.

The synthesis of data revealed 13 pharmacological properties of *A. leiocarpus* in West Africa, in Central Africa and in North Africa and also taking into account the unique publication dealing with several pharmacological properties in the same time as the case of Okpekon *et al.* (2004) in a single publication indicated three (3) different pharmacological properties which are: antimalarial, trypanocidal and anthelmintic properties (Table 3).

Table 1. Literature review strategy and terms used to identify data on the chemical composition, pharmacological and zootechnical uses of *Anogeissus leiocarpus* (Li *et al.*, 2013).

Searched terms	1.*Anogeissus leiocarpus* or *Anogeissus leiocarpa*, 2. Properties, 3. Activities, 4. Effect, 5. Distribution, 6. Ecology, 7. Use, 8. Pharmacology, 9. Compound, 10. Chemistry, 11. Animal application, 12 Medicinal use, 13. Traditional use, 14. Local name, 15. Synonym, 16. Ethno veterinarian, 17. Zootechnical utility, 18. Pharmacological utility, 19. Importance in traditional medicine, 20. Chemical compounds, 21. Bioactive compounds, 22. Chemical composition, 23. Secondary metabolites, 24. Herbal medicine efficacy 25. Antibacterial properties, 26. Antispasmodic properties, 27. Gastroenteritis properties, 28. Anthelmintic properties, 29. Antimicrobial properties, 30. Antimicrobial properties, 31. Antidiabetic properties, 32 Antiparasitic properties, 33. Antidiarrhoeal properties
Strategy used	1 and (2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33).

Table 2. Vernacular names of *A. leiocarpus.*

Country	Ethnic group	Local name	References
Benin	Fon	*Abangnahi, hlihon*	(Salifou *et al.*, 2017)
	Hausa	*Marke*	(Onoja *et al.*, 2018)
	Fulani	*Kojoli*	
	Kanuri	*Annum*	
	Yoruba	*Ayin*or orin-odan ainy	
	Igbo	*Atara*	
	Nupe	*Kukunchi*	
Burkina-Faso	Mooré	*Siiga*	(Zongo *et al.*, 2017)
Cameroon	Sulphide	*Kodjoli*	(Gautier *et al.*, 2002)
	Bornouam	*Anum*	
	Doayo	*Tarko*	
	Guziga	*Duwui*	
	Mada	*Euwe*	
	Maha	*Dawai*	
	Mandara	*Nawaya*	
	Mundang	*Kiere*	
	Toupouri	*Seou*	
Côte d'Ivoire	Sinematiali population	*Guenmin, N'galama*	(Koné *et al.*, 2019)
Niger	Niamey region	*Maréké, N'gongo*	(Souley Kallo *et al.*, 2018)

It is also important to note that in addition to these properties, the medicinal species is used against various ailments in traditional medicine in several African countries (Table 4).

Table 3. Pharmacological properties of *A. leiocarpus*, field of study carried out, part of the plant and extracts used.

Pharmacological properties	Experimental model	Type of activity	Type of extract	Part of the plant used	Country	Field of study	References
Anthelmintic properties	Rats	*In vivo*	Methanolic extract	Bark	Nigeria	Ethno veterinarian and ethnomedicine	(Ibrahim *et al.*, 1983)
Antimalarial, trypanocidal and anthelmintic properties	-	*In vitro*	Methanolic extract	Leaves, bark, roots	Ivory Coast	Ethno veterinarian / Ethnomedicine	(Okpekon *et al.*, 2004)
Anthelmintic properties	-	*In vitro*	Ethanolic extract	Roots	Ivory Coast	Ethno veterinarian	(Koné *et al.*, 2005)
Anthelmintic properties	Sheep	*In vivo*	Raw aqueous extract	Leaves	Nigeria	Ethno veterinarian	(Agaie *et al.*, 2007a)
Anthelmintic properties	-	*In vitro*	Aqueous extract	Leaves	Burkina-Faso	Ethno veterinarian	(Kabore *et al.*, 2009)
Anthelmintic properties	Sheep	*In vivo*	Aqueous extract	Leaves	Burkina-Faso	Ethno veterinarian	(Kaboré, 2009)
Anthelmintic properties	-	*In vitro*	Acetone extract and fractions (hexane, chloroform, butanol and 35% water in the methanol fractions)	Leaves	Nigeria	Ethno veterinarian	(Ademola *et al.*, 2011)
Anthelmintic properties	Sheep	*In vivo*	Ethanolic extract	Roots	Ivory Coast	Ethno veterinarian	(Dramane *et al.*, 2013)
Anti trypanosomal properties	Rats	*In vitro*	Aqueous and mehanolic extracts	Leaves, bark and roots	Nigeria	Ethno veterinarian	(Wurochekke *et al.*, 2012)
Trypanocidal properties	Rats	*In vivo*	Methanolic extract	Stem bark	Nigeria	Ethno veterinarian	(Awobode *et al.*, 2015)
Antioxidant properties	-	*In vitro*	Methanolic extract	Sheets	Nigeria	Ethnomedicine	(Olutayo *et al.*, 2011)
Antioxidant properties	-	*In vitro*	Ethanolic extract	Stem bark	Nigeria	Ethnomedicine	(Olugbami *et al.*, 2014)
Antioxidant properties	-	*In vitro*	Aqueous extract	Root bark	Nigeria	Ethnomedicine	(Salau *et al.*, 2015)
Antioxidant properties	Rats	*In vivo*	Aqueous extract	Root bark	Nigeria	Ethnomedicine	(Salau *et al.*, 2015)
Anti-quorum and antioxidant properties	-	*In vitro*	Methanolic extract	Stem bark	Burkina-Faso	Ethnomedicine	(Ouedraogo *et al.*, 2016)
Antioxidant and antibacterial properties	-	*In vitro*	Methanolic extract	Leaves	Ghana	Ethnomedicine	(Barku *et al.*, 2013)
Antibacterial properties	-	*In vitro*	Methanolic extract	Stem bark	Niger	Ethnomedicine	(Mann *et al.*, 2010)
Antibacterial properties	-	*In vitro*	Aqueous and ethanolic extracts	Roots	Nigeria	Ethnomedicine	(Gbadamosi *et al.*, 2014)
Antibacterial properties	-	*In vitro*	Aqueous and methanolic extracts	Stem bark	Ivory Coast	Ethnomedicine	(Sanogo *et al.*, 2016)
Antibacterial properties	-	*In vitro*	Ethanolic extract and ethyl acetate fraction	Sheets	Nigeria	Ethnomedicine	(Ganfon *et al.*, 2019)
Antimicrobial and antifungal properties	-	*In vitro*	Methanolic extract and fractions of petroleum ether, chloroform and ethyl acetate	Roots, leaves and stems	Sudan	Ethnomedicine	(Elsiddig *et al.*, 2015)
Antimicrobial, antibacterial and antifungal properties	-	*In vitro*	Aqueous extract	Rod	Senegal	Ethnomedicine	(Diatta *et al.*, 2019)
Antimicrobial properties	-	*In vitro*	Methanolic extract	Stem bark	Nigeria	Ethnomedicine	(Abdullahi, 2012)
Antimicrobial properties	-	*In vitro*	Aqueous, hexane, dichloromethane and ethanolic extracts	Stem bark	Nigeria	Ethnomedicine	(Usman *et al.*, 2020)
Antidiabetic and hypolipidemic properties	Rats	*In vivo*	Ethanolic extract	Leaves	Nigeria	Ethnomedicine	(Onoja *et al.*, 2018)
Antidiarrhoeal properties	Rats	*In vivo*	Aqueous extract	Leaves	Cameroon	Ethnomedicine	(Fokam Tagne *et al.*, 2019)
Antihypertensive properties	Rats	*In vivo*	Aqueous extract	Bark of the trunk	Burkina-Faso	Ethnomedicine	(Ouédraogo *et al.*, 2008)
Antihypertensive properties	Pigs	*In vivo*	Dichloromethane fraction	Stem bark	Burkina-Faso	Ethnomedicine	(Belemnaba *et al.*, 2013)
Antimalarial properties	Mice	*In vivo*	Methanolic extract	Bark	Nigeria	Ethnomedicine	(Akanbi, 2017)
Anti-leishmanian properties	-	*In vitro*	Methanolic extract / Aqueous and butanolic fractions	Stem bark	Nigeria	Ethnomedicine	(Shuaibu *et al.*, 2008)

Overview of *Anogeissus leiocarpus*

Anogeissus leiocarpus is a tree belonging to the phylum Spermaphytes, the family Combretaceae. It is from the Dicotyledonous class, Rosidae subclass and Myrtales order (Cronquist *et al.*, 1981). *A. leiocarpus* has various vernacular names depending on the country of origin and the ethnic group. For example, it is called in English "African birch"(Arbab, 2014) and is known as " Hlihon " in Fon in Benin (Salifou *et al.*, 2017). Other names are given in Table 2.

Table 4. Use of *A. leiocarpus* in traditional medicine.

Part of the plant used	Therapeutic indication	Country of the study	Medicinal preparation	References
Bark and seeds	Treatment or prevention of worm infestations in equine species, and in animal and human helminthoses.	Nigeria	-	(Ibrahim *et al.*, 1983)
Trunk bark powder with millet seeds	Jaundice, constipation, malaria, anorexia	Mali	Decoction	(Fane, 2003)
Trunk bark	Common cold		Infusion	
	Cough	Ivory Coast	Decoction	(Koné *et al.*, 2019)
Bark	Antioxidant virtues, blood pressure regulator	Burkina-Faso	Decoction	(Sereme *et al.*, 2008)
	Diarrhea, dewormer, wounds, eczema, psoriasis, carbuncles, boils and ulcers	Burkina-Faso	Decoction	(Sereme *et al.*, 2008)
	Febrifuge	Guinea (Upper Guinea)	Infusion	(Olutayo *et al.*, 2011)
	Cough	Sudan	Decoction	(Arbab, 2014)
	Trypanocidal effect on livestock	Burkina-Faso	Maceration	(Zongo *et al.*, 2017)
Bark of *Anogeissus leiocarpus* and *Khaya senegalensis*	Increased milk production in cows	Benin	Maceration	(Salifou *et al.*, 2017)
Bark, leaves and roots	Antimicrobial and anthelmintic action, yellow fever, jaundice, various forms of hepatitis, common colds and headaches	Burkina-Faso	Decoction	(Sereme *et al.*, 2008)
Leaves, roots, bark of trunk	Helminthiasis, trypanosomiasis, malaria and dysenteric syndrome	Ivory Coast	-	(Okpekon *et al.*, 2004)
Leaves and leafy twigs	Jaundice, amoebic dysentery, headache.		Decoction	(Fane, 2003)
Leaves and gum	Dermatosis	Burkina-Faso	Decoction	(Sereme *et al.*, 2008)
Leaves	Treatment of gastrointestinal parasitism in small ruminants (lyophilized product administered at a dose of 160 mg / kg)	Burkina-Faso	Decoction	(Kabore *et al.*, 2010)
Leaves	Changes in skin pigmentation, eye bath to fight against some ailments	Ivory Coast	Decoction	(Olutayo *et al.*, 2011)
	Stomach infections	Togo	Decoction	(Arbab, 2014)
Leaves, bark of stems and roots	Antifungal action against a number of pathogenic fungi	Burkina-Faso	Excerpts	(Sereme *et al.*, 2008)
Leaves, stems, roots	Liver infection	Ivory Coast	Decoction	(Koné *et al.*, 2019)
Vegetative organs	Malaria	Burkina-Faso	-	(Sereme *et al.*, 2008)
Sticks taken from *Anogeissus leiocarpus*	Strong activity against a broad spectrum of bacteria, including some that contribute to the deterioration of teeth.	Burkina-Faso	Chewing	(Sereme *et al.*, 2008)
Sticks	Oral hygiene	Nigeria	Chewing	(Arbab, 2014)
Roots	Intestinal worms, diarrhea, dysentery, anemia	Ivory Coast	-	(Koné *et al.*, 2005)
Plant	Parasitic diseases, malaria, trypanosomiasis, helminthiasis and dysenteric syndrome	Ivory Coast	-	(Arbab, 2014)
	Fungal infections such as dermatitis and yeast infection	Togo	-	(Arbab, 2014)
	Treatment of general diabetic ulcer, body pain, blood clots, asthma, cough and tuberculosis	Ghana	-	(Arbab, 2014)

Table 5. Chemical compounds according to extracts and organs used.

Extracts	Chemical compounds			References
	Sheets	Stem bark	Roots	
Methanolic		Hydrolyzable tannins, castalagine		(Shuaibu *et al.*, 2008)
-	Tannins, saponosides		Tannins, saponosides and flavonoids	(Yemoa *et al.*, 2008)
Methanolic		Alkaloids, flavonoids, saponins, tannins, phenolic compounds, cardiac glycosides and terpenoids		(Mann *et al.*, 2010)
Aqueous	Flavonoids, tannins and polyphenols			Kabore *et al.* (2010)
Methanolic	Tannins, glycosides, saponins, steroids and terpenoids			Olutayo *et al.* (2011)
Aqueous and ethanolic			Alkaloids, saponins, tannins, phenols and glycosides	Gbadamosi *et al.* (2014)
Aqueous		Saponosides, catechetical and gallic tannins, polyphenols, polyterpenes, anthocyanins, flavonoids		(Sanogo *et al.*, 2016)
Methanolic		Saponosides, catechic and gallic tannins, polyphenols, polyterpenes, anthocyanins, flavonoids, alkaloids		(Sanogo *et al.*, 2016)
Aqueous	Tannoids, catechetical tannins, flavonoids, coumarins and steroids			(Souley Kallo *et al.*, 2018)
Ethanolic	Alkaloids, tannins (catechetical and gallic), flavonoids, leuco-anthocyanins, quinone derivatives, saponosides and reducing compounds			Ganfon *et al.* (2019)
Aqueous		Alkaloids, saponins, flavonoids, tannins and reducing sugars and phenols		Usman *et al.* (2020)
Hexanic		Alkaloids, steroids		Usman *et al.* (2020)
Dichloromethane		Alkaloids, steroids and phenols		Usman *et al.* (2020)
Ethanolic		Alkaloids, saponins, flavonoids, tannins and reducing sugars and phenols		Usman *et al.* (2020)

Sometimes used as toothpicks for dental hygiene(Arbab, 2014; Sereme *et al.*, 2008), *A. leiocarpus* also has other therapeutic uses, especially in traditional medicine for the treatment of various ailments in some African countries (Table 4).

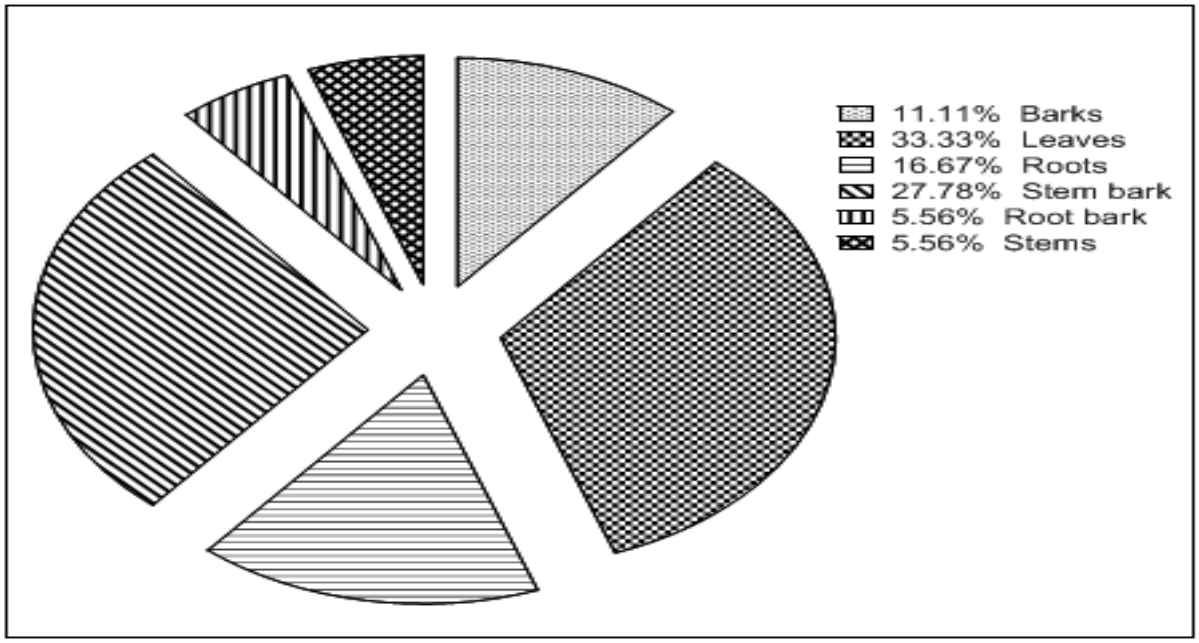

Fig. 1. Organs of *A. leiocarpus* used.

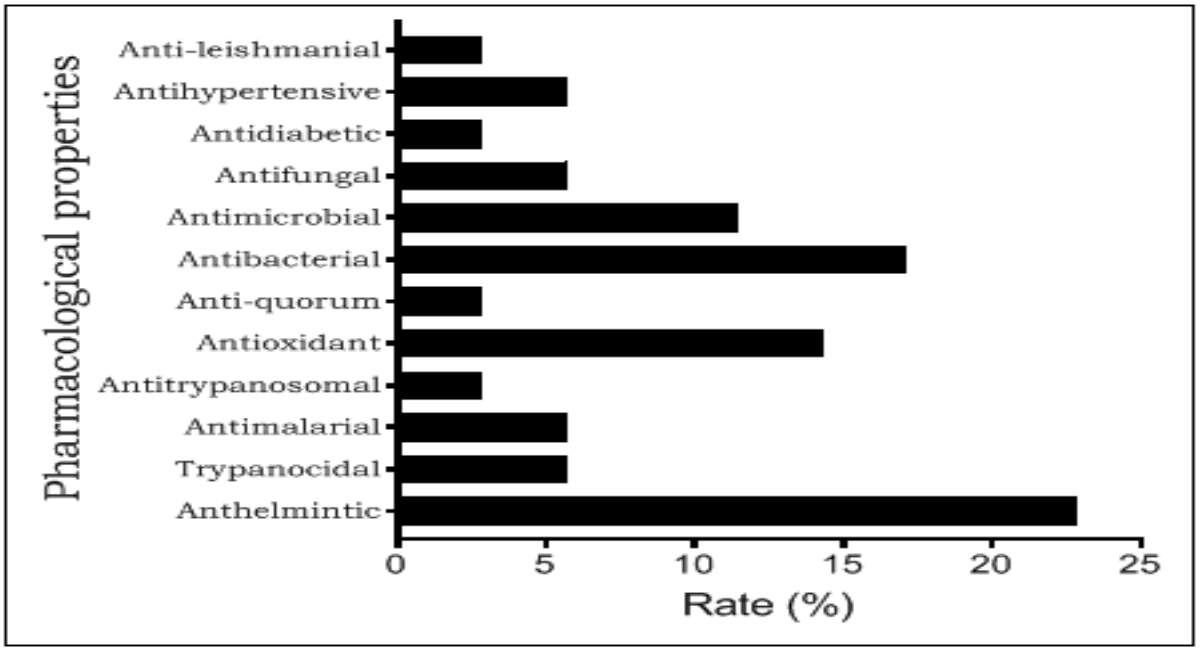

Fig. 2. Pharmacological properties of *A. leiocarpus*.

Pharmacological properties and zootechnical utilities of A. leiocarpus

A number of pharmacological studies have been carried out on the *A. leiocarpus* organs (Table 3). The literature has shown that the leaves are widely used (33.33%) against 25% for the bark of the stem (Fig. 1) over the 13 pharmacological properties found. The review also revealed that the plant is used more for its anthelmintic properties. This was assessed in Burkina-Faso using aqueous extracts *in vitro* and *in vivo* on nematodes, parasites of small ruminants. In addition to the anthelmintic properties, *A. leocarpus*

is also known for its antimicrobial, antibacterial and antioxidant properties (Fig. 2) with most of the studies conducted in Nigeria (Fig. 3). This could be explained by the fact that Nigeria is one of the coastal countries in West Africa where the plant is widely distributed and where local people have incorporated it into their traditional health care practices.

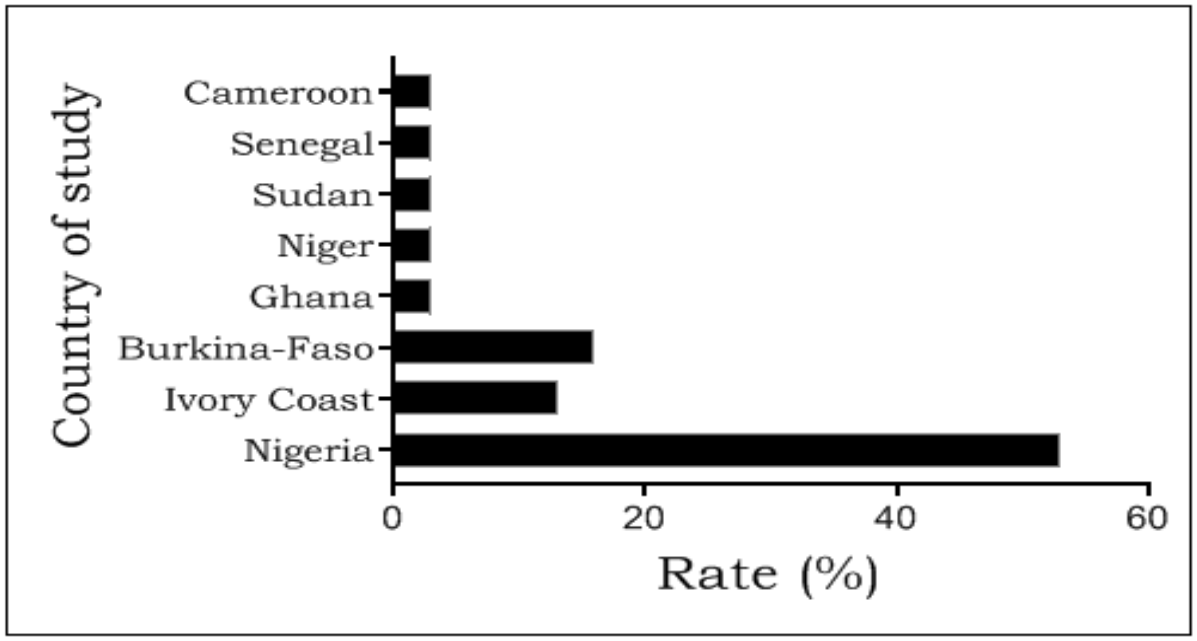

Fig. 3. Distribution of studies by country.

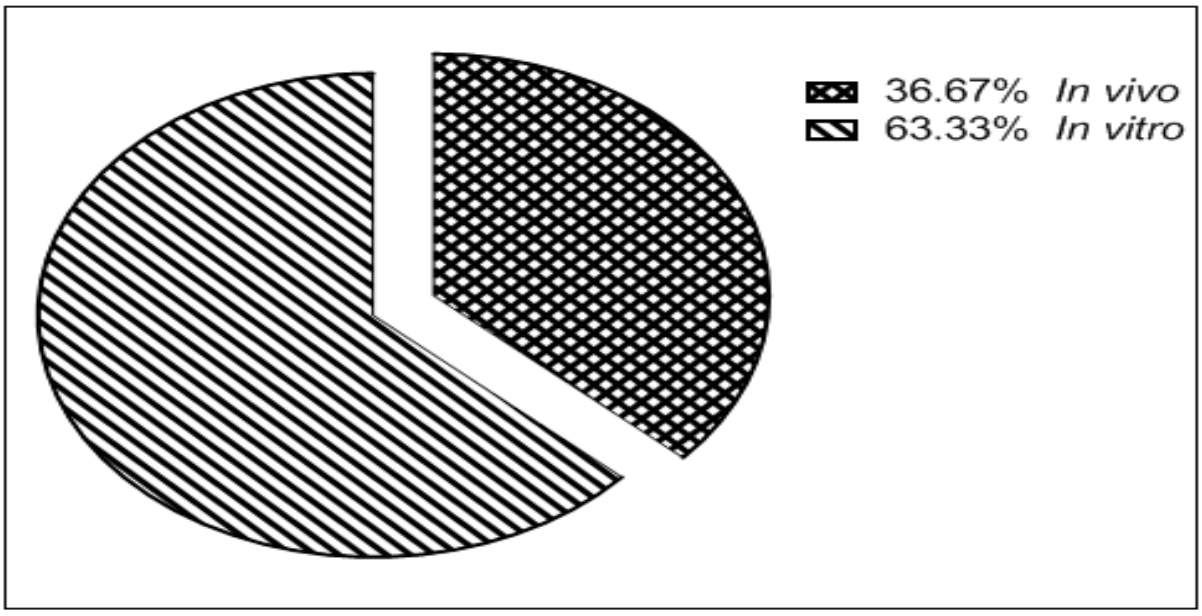

Fig. 4. Type of test carried out on the organs of *A. leiocarpus*.

More than 60% of the studies exploited in this review are *in vitro* studies (Fig. 4) using mainly rats as animal models. This is the rodent model typically used in ethnomedicine to assess the pharmacological properties or toxicity of a plant. This justifies the high rate of ethnomedical data found in this review (Fig. 5). Moreover, seven (7) types of solvents are used to extract chemical compounds and assess the pharmacological properties of *A. leiocarpus* (Fig. 6). The methanolic extract is widely used, followed by the ethanolic and n-hexane extracts, while the aqueous decoction is less used (Fig. 7).

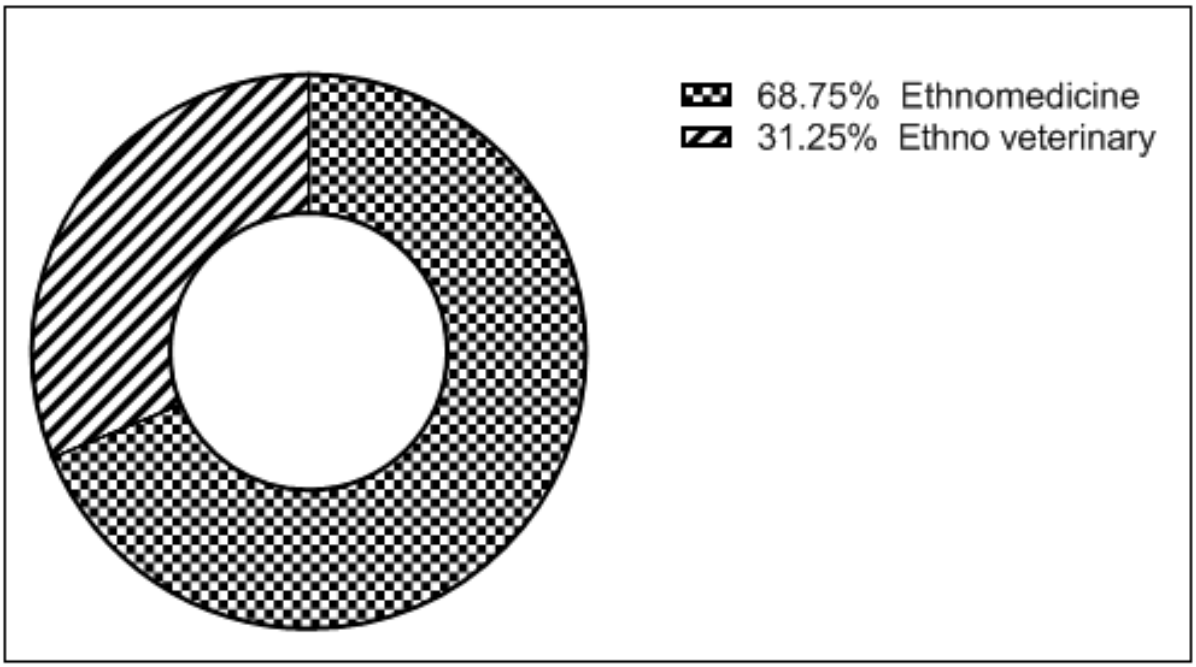

Fig. 5. Field of studies carried out on the organs of *A. leiocarpus*.

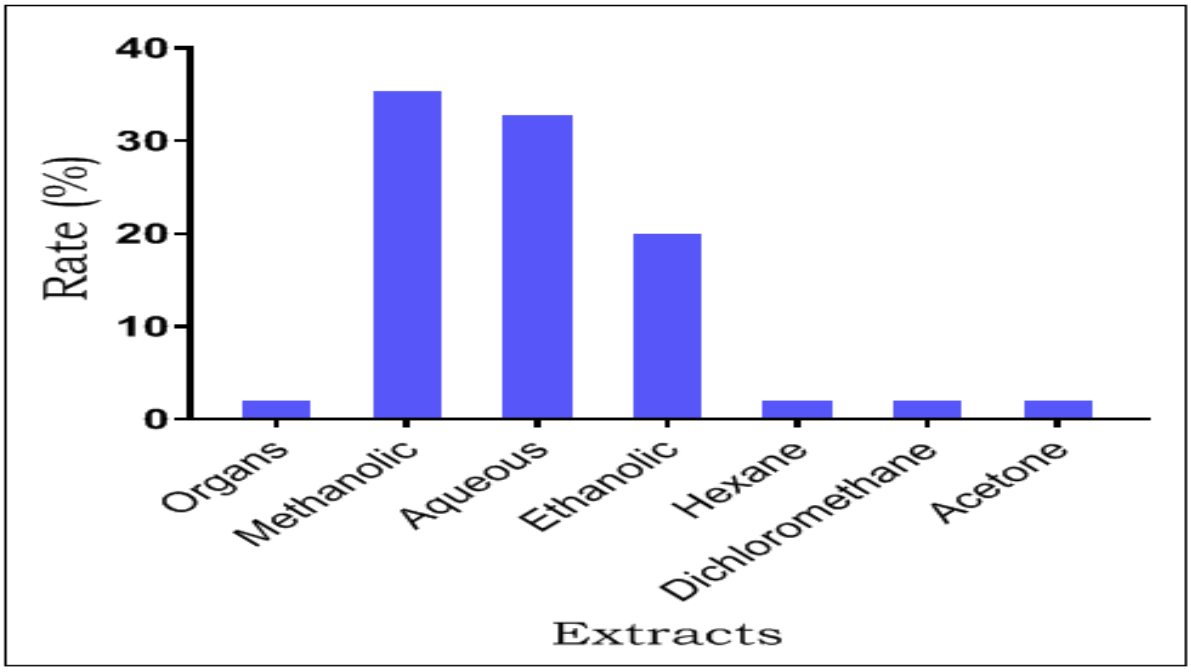

Fig. 6. Type of extract used in the studies.

Chemical composition of A. leiocarpus

The analysis of Table 5 shows that few chemical composition studies are conducted on the roots of *A. leiocarpus*. The few data available show that the roots contain alkaloids, flavonoids, saponins, tannins, phenols and glycosides (Fig. 9).

Some of these compounds, mainly tannins, saponins, alkaloids and flavonoids, are also present in the leaves and stem bark of the plant (Figs 7 and 8) and are responsible for some pharmacological activities in the plant. According to Akpona *et al.* (2009), alkaloids have a local anesthetic action, tannins (healing, anti-bacterial, antiseptic, antioxidant, enzymatic inhibition: 5-lipooxygenase), flavonoids (anti-inflammatory, antibacterial, antiviral *in vitro*), saponins (antibacterial, antiseptic, antiviral, anti-inflammatory, anti-edematous and analgesic),

terpenoids and steroids (antiviral, analgesic, anti-inflammatory and antiseptic). Regardless of the extract used, the leaves, roots and/or bark of the stem of *A. leiocarpus* contain flavonoids, saponins, tannins and alkaloids. In addition to these compounds, the leaves and bark of the stem contain terpenoids and steroids. The presence of chemical compounds does not depend on the extract.

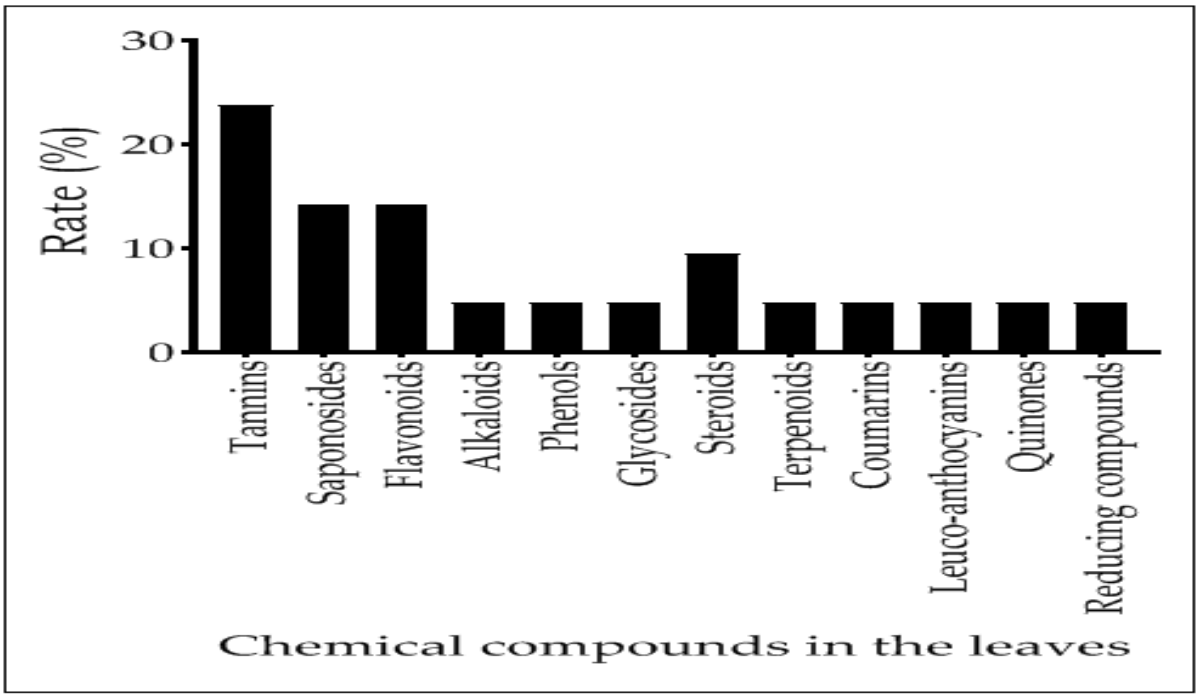

Fig. 7. Chemical compounds in the leaves of *A. leiocarpus*.

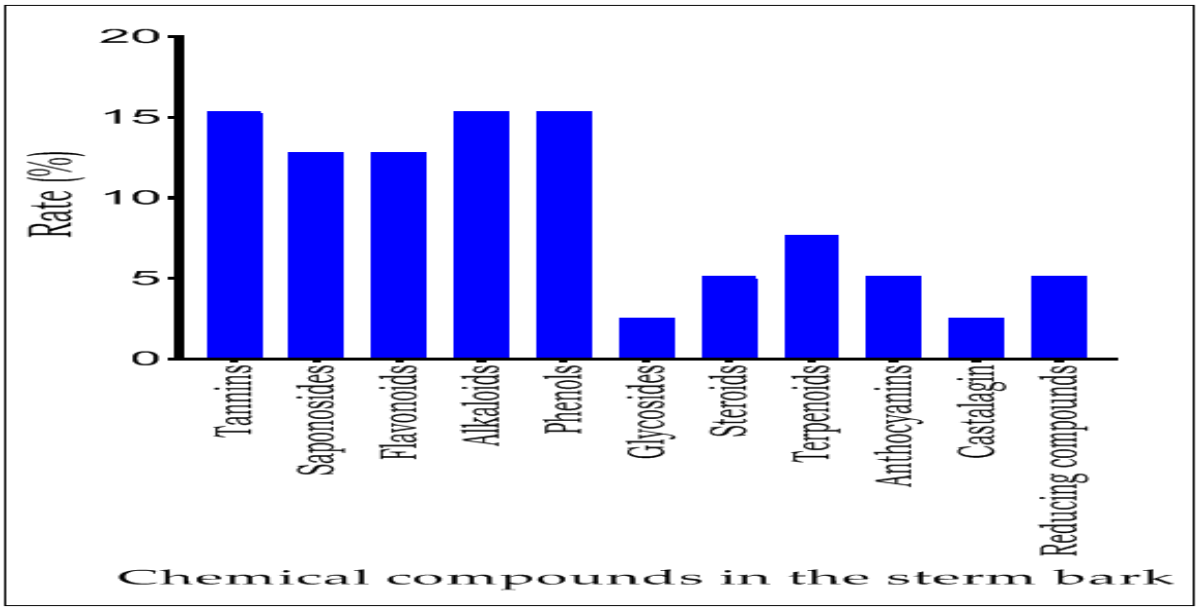

Fig. 8. Chemical compounds in the stem bark of *A. leiocarpus*.

Use of A. leiocarpus in animal husbandry

Anogeissus leiocarpus plays a key role in the management of pathologies. In Benin, it is used in animal production as a lactogenic plant in order to increase milk productivity in cows with a frequency of appearance in recipes amounting to 2.11(Salifou *et al.*, 2017). In addition, it is used in traditional medicine as an alicament for various diseases including parasitic diseases of small ruminants.(Agaie *et al.*, 2007a; Ibrahim *et al.*, 1983; Koné *et al.*, 2005; Wurochekke

et al., 2012).

Toxicity of A. leiocarpus

The use of *A. leiocarpus* as an alicament in African countries is of paramount necessity. Yet the reports of Ouédraogo *et al.* (2008) on the toxicity of the plant in Burkina Faso showed that the acute general toxicity of the aqueous extract of *A. leiocarpus* revealed a lethal dose 50 (LD_{50}) of 290.81 mg/kg body weight.

According to the WHO and Hodge and Sterner scales, such a drug would be classified as moderately toxic.

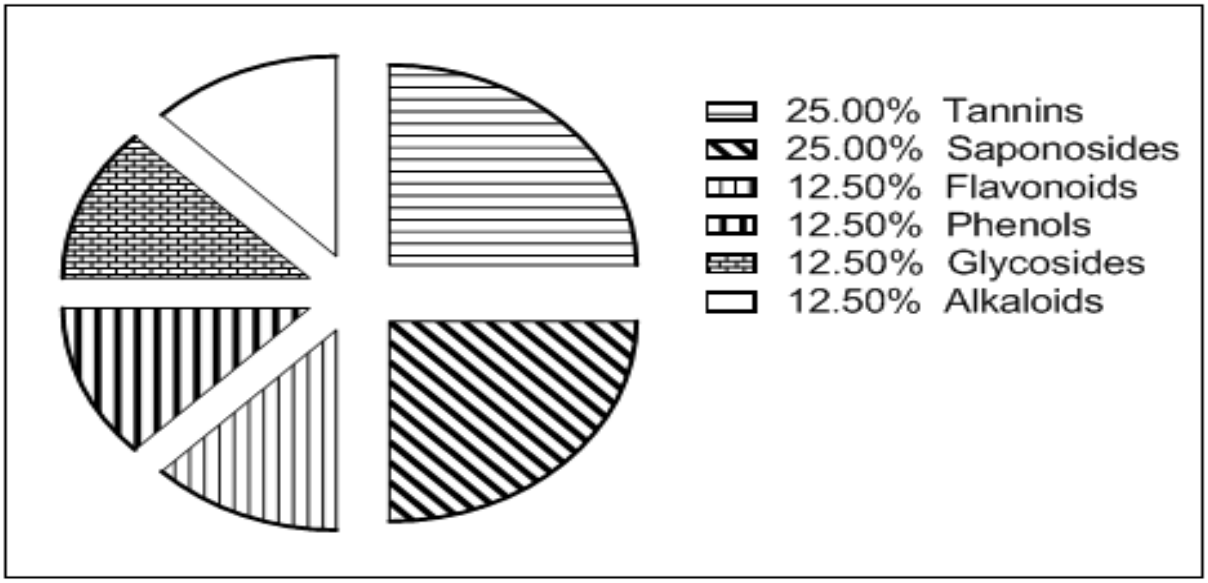

Fig. 9. Chemical compounds in the root of *A. leiocarpus*.

In addition, the reports of Agaie *et al.* (2007b) on the acute oral toxicity of the aqueous extract of the leaves of *A. leiocarpus* at a dose of 3200 mg/kg in Nigeria revealed that the animals showed signs of depression and inappetence, but no mortality was observed in the test groups. However, the intraperitoneal toxicity testing revealed signs of dose-related toxicity and deaths occurred in the test groups at doses of 1200, 1600, 2000 and 2400 mg/kg within 14 hours of administration of the extract, while the animals treated at the dose of 2800 mg/kg of extract died within 8 hours (Agaie *et al.*, 2007b). Likewise, the study of Kabore *et al.* (2010) on the acute toxicity of the aqueous extract of the leaves of *A. leiocarpus* in Burkina-Faso revealed a change in the behavior of mice at the dose of 2000 mg/kg resulting in fatigue and the loss of appetite. The work of Onoja *et al.* (2018) in Nigeria revealed that the ethanolic foliar extract of *A. leiocarpus* administered to rats orally in acute toxicity at a dose of 5000 mg/kg did not cause death. However, acute toxicity studies of the ethanolic fraction of the root bark of *A. leiocarpus* in Côte d'Ivoire by the oral route carried out in rats are non-toxic and are well tolerated by the animals at an LD50 of up to 5000 mg/kg body weight. As for subacute toxicity, doses up to 500 mg/kg body weight of the ethanolic fraction of the root bark of *A. leiocarpus* did not affect the behavior and body weight development of the rats in any way. No mortality was observed. Ultimately, the ethanolic fraction of *A. leiocarpus* has no negative effect on the normal development of the body and it is safe orally (Kouangbé *et al.*, 2019). Figures 10 and 11 show some organs of the species *A. leiocarpus*.

Discussion

About thirty studies dealing with the pharmacological properties of *A. leiocarpus* were included in this study, with most of them carried out in Nigeria. Most of the studies of interest were on human medicine (68.75%) against 31.25% on veterinary medicine, yet this plant has shown efficiency in traditional veterinary medicine (Ibrahim *et al.*, 1983; Zongo *et al.*, 2017).

Fig. 10. *A leiocarpus tree* and inflorescences (Photo Kuiseu, 2019).

With the exception of Nigeria, few scientific studies focused on *Anogeissus leiocarpus* in West Africa despite its wide distribution. However, *A. leiocarpus* was a species with multiple therapeutic potentials which can be very useful in traditional veterinary medicine as an alternative to conventional drugs which their ineffectiveness, high cost, counterfeiting and resistance were reported in some cases.

Fig. 11. Leaves and trunk bark of *A. leiocarpus* (Koné, 2009).

The promotion of *A. leiocarpus* in traditional veterinary medicine after having its scientific effectiveness evidence would relieve several farmers, especially smallholders who face many animal health problems in their herds, including parasitic diseases caused by gastrointestinal parasites that negatively affect the expression of the zootechnical performance of livestock and cause serious loss of income for herders. In the papers reviewed, leaves (33.33%) and stem bark (25%) were the organs of the plant more used as they contain several secondary metabolites. To assess the pharmacological properties, different types of extracts were made from the powders of the leaves and/or bark of the stem, root and trunk of *A.*

leiocarpus. Methanol was the most widely used extraction solvent, followed by water. It was the most polar solvent after water and its high polarity would be favorable to the elimination of metabolites such as flavonoids, phenols, saponins, tannins, phlobatanine, cardiac glycosides, alkaloids, terpéniodes, steroids, resins, proteins, carbohydrates, fats and oils, much more than ethanol, butanol, chloroform, petroleum ether, n-hexane or water. Although methanol has many metabolites, its use in medicine can have adverse effects on human and animal health. It would therefore be more difficult, if not impossible, for people with low income to have access to this solvent for the preparation of traditional herbal remedies. It would therefore be advisable to promote natural solvents such as water, which were available, non-toxic and easily accessible to rural populations.

Conclusion

The current review on the pharmacological knowledge of *A. leiocarpus* in traditional medicine shows that the plant has anthelmintic, antimalarial, antimicrobial, antibacterial, antihypertensive, antidiabetic and antidiarrhoeal properties. It is rich in alkaloids, flavonoids, saponosides, tannins, glycosides, steroids, terpenoids which give it its pharmacological properties. The documentation on this medicinal plant also revealed that it has many therapeutic properties but is underused in veterinary medicine. Therefore, the prospect of in-depth studies on this species in the application field of ethno-veterinary arises in order to support the promotion of *A. leiocarpus* as an anthelmintic in domestic ruminants for a better improvement of animal productivity.

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Conflicts of interest

The authors declare no conflict of interest regarding the publication of this paper.

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