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Pharmacognostical, biochemical activities and zootechnical applications of *Psidium guajava* (Myrtaceae), plant with high médicinal value in tropical and subtropical parts of the World: A review

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Abstract
In the search for new molecules capable of treating intestinal parasitosis with less risk in the short, medium and long term, the potential of medicinal plants is explored. *Psidium guajava* is plant used traditional medicine to treat gastrointestinal disorders and intestinal parasitosis. According to the synthesis of reviews presented here, very few studies have been devoted to the evaluation of anthelmintic activities of *Psidium guajava. Psidium guajava* has secondary metabolisms responsible for its demonstrated biological activities and reported medicinal uses. The leaves and fruits of *Psidium guajava* contain essential oils that know a great variation in the content of compounds. Geographic and edaphic conditions, and genetic factors are factors that influence the composition of essential oils. The direct consequence is the observation of several chemotypes of essential oils of *Psidium guajava*. Further studies are important to demonstrate the efficacy of *Psidium guajava* in the treatment of intestinal parasitosis.

Keywords: Anthelmintics, bibliographical review, essential oils, intestinal parasitoids, *Psidium guajava*

Introduction
Intestinal parasitosis is a real health problem in both veterinary and human medicine [1, 2]. In small ruminants, they cause production loss while threatening food security [2, 3]. In humans, they contribute to the perpetuation of poverty by compromising the physical and intellectual development of children and reducing the work capacity and productivity of adults [4]. In general, the treatment of these intestinal parasitoses relies on the administration of synthetic drugs (including anthelmintics). However, these drugs have more and more limitations related to side effects and reported parasite resistances [5-7]. It is then convenient to search for new substances, effective, accessible, without toxicity and with a wide spectrum of action, to face these parasitoses and medicinal plants are a great asset. The aim of this work is to make a bibliographic synthesis of the uses, compositions, biological activities of *Psidium guajava* species for a better exploitation in the treatment of human and small ruminant intestinal parasitosis.

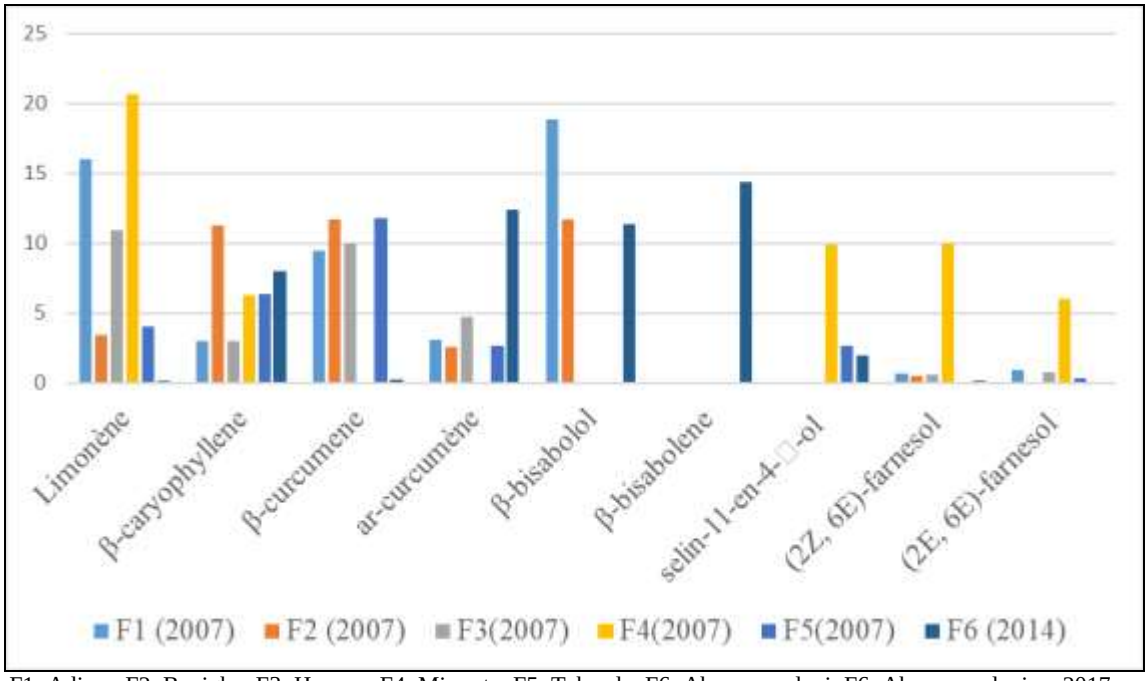
Material and method
The material consists of published scientific journals. The collection of these articles was done in the Google scholar engine. The articles are selected according to their relevance to the subject.

Results and discussion
Generalities
Psidium guajava is a plant in the Myrtaceae family is a 6-9m tall tree cultivated for its nutritional and mineral values [8, 9]. The leaves are opposite, the flowers are branch colored, and the fruits are small, 3-6 cm long, pear-shaped, and reddish-yellow in color when ripe. The fruit is a berry containing many seeds [8, 10]. *Psidium guajava* is used in tropical and subtropical countries as food and for its medicinal values [11, 12].

Indeed, in traditional medicine, it is used in the treatment of dysentery, diarrhea vomiting, rheumatism, diabetes, and gastroenteritis, pulmonary problems, to cure wounds, ulcer, rheumatism and intestinal parasitosis [13-16]. Phytochemical analyses of the plant reported the presence of the secondary metabolites flavonoids, catechic tannins, saponosides, leucoanthocyanins, anthocyanins, reducing compounds, mucilages, sterols and terpenes [17-19]. Differences in chemical composition may exist. They can be explained by the geographical origin, the nature of the soil, the mode of extraction, the type of organ collected [18]. *Psdium guajava* fruits are very rich in fiber, vitamin (C and A), minerals such as Potatitum (P), Copper and Maganese [8, 19].

Volatile compounds

The essential oil of *Psidium guajava* has been widely studied in the world [20]. In Benin, the analysis of the essential oils of *Psdium guajava* leaves was carried out by [21, 22], the major compounds are βcaryophyllene, epi-β-bisabolol, Limonene, β -curcumene, ar-curcumene, β-bisabolene.



F1: Adjara; F2: Banigbe; F3: Hounse; F4: Missrete; F5: Tchaada; F6: Abomey-calavi; F6: Abomey calavi en 2017

Fig 1: Majority of compounds identified in the essential oils of *Psidium guajava* leaves collected in Benin

Figure 1 presents the major compounds identified in the essential oils of *Psdium guajava* leaves collected in different areas in Benin. According to this figure there is a strong variation in the chemical compounds present in the essential oils of *Psidium guajava* leaves in Benin. This difference could be explained by several factors. Among others, the location, the season, the time of harvest of the organ, the light, the vegetative stage of the plant, the characteristics of the soil and the altitude but also the factors specific to the plant (anatomical, physical and genetic characteristics) [9, 20-22]. This difference is also reported by other authors in other countries of the world (Table 1). Since the biological activities of a plant are intimately related to its composition in chemical compounds, the differences observed in the composition of essential oils, influence the biological tests [14]. Table 1 summarizes the major compounds of essential oils identified by different authors in some countries of the world.

Tableau I: Non-exhaustive list of the main compounds of the essential oils of *Psidium guajava* identified in different countries of the world

Country	Parts	Majority compound	Most represented class	Comments
Benin [21]	Leave	limonene β-bisabolol epi-β-bisabolol (2E,6E)farnesol β-bisabolene 1,8-cineole sabinene β-caryophyllene (Z)β-ocimene		Majoritary compounds depend on the sampling stations
Benin [22]	Leave	β-bisabolene, ar-curcumene βbisabolol	Sesquiterpenes Hydrocarbon compound Hydrocarbon sesquiterpenes	
Brazil [25]	Leave	β-caryophyllene α-humulene aromadendrene oxide δ-selinene selin-11-en-4α-ol		
Egypt [9]		D-Limonen α-Pinene	Monoterpene hydrocarbons Sesquiterpene hydrocarbons	the majority compounds depend on the variety of the tree

		β-Caryophyllene Globulol	Oxygenated sesquiterpenes	
Egypt [23]	fruits	β-caryophyllene limonene		
	Leave	β-caryophyllene		
Mexico [24]	Leave	Eugenol		
Nepal [14]	Leave	(E)-nerolidol (E)-caryophyllene		
Egypt [15]	Leave	Limonène	Hydrocarbons Monoterpenes Oxygenated Monoterpenes	
Parkistan [26]	Leave	α-phellandrene eucalyptol α-terpineol spathulenol caryophyllene dihydrocarveol acetate nerolidol caryophyllene oxide	oxygenated monoterpene sesquiterpene hydrocarbons oxygenated sesquiterpene monoterpene hydrocarbons	the majority compounds depend on the variety of the tree
Oman [27]	Leave	iso-caryophyllene veridiflorence farnesene		
Pakistan [16]	Leave	β-caryophyllene	Sesquiterpene hydrocarbon	
Nakhon [28]	Leave	Limonene α- Pinene		
Alexandria [29]	Leave	α-pinene (E)-caryophyllene (E)-nerolidol		
FazendaTabuleiros II [30]	Leave	β-caryophyllene		
India [31]	Leave	α-terpinyl acetate trans-caryophyllene nerolidol		
Brazil [32]	Leave	α -Humulene β-caryophyllene β –Selinene α -Selinen	Sesquiterpene hydrocarbon	

The most represented compound classes are sesquiterpenes and hydrocabon compounds [22]. These results corroborate the observations of[20] that essential oils obtained from Psdium species are rich in mono- and sesquiterpene compounds. The promoter of monoterpenes is geranyl pyrophosphate (C10) and that of sesquiterpenes is farnesyl pyrophosphate [20]. The analysis of Table I, shows that *Psidium guajava* essential oils have several chemotypes [14].

Biological activities

Several authors have contributed to synthesize (literature review) the traditional uses, biological properties and chemical compounds present in *Psidium guajava* plant [11, 12, 33]. Biological properties: antibacterial, antifungal, antioxidant, antidiarrheal, antidiabetic, antinflammatory, cardioprotective, anticancer and lavicidal effects have been reported as a result of bioassays [12, 19, 34-36]. These reviews provide a general overview of the studies that have been conducted on the species. It is apparent that *Psidium guajava* has been widely studied for its antibacterial, antifungal, antioxidant properties, but very little for its antiparasitic activities especially anthelmintic. The numerous studies on the evaluation of antimicrobial activities of *Psidium guayava* have shown its potential in food preservation [37, 38], in the treatment of infectious and parasitic diseases [15, 18, 27]; in the treatment of tooth decay [17] the treatment of gastrointestinal disorders [39, 25]. The microorganisms *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Salmonella typhi*, *Vibrio cholerae* have been identified as responsible for gastrointestinal [39]. Gastrointestinal disorders are not only due to bacterial and or fungal infections. These observations are consistent with those of [40-42] who demonstrated the antidiarrheal potential of *Psidium guajava*. Gastrointestinal disorders (vomiting, diarrhea) are also manifestations of intestinal parasitosis.

Anthelmintic activity

Very few authors have studied the anthelmintic activity of *Psidium guajava* [43-47]. The common methods used for *in vitro* evaluation of anthelmintic activity of plant extracts are: egg hatch test, adult worm mobility test, and larval migration inhibition test. The helminthes used are *Haemonchus contortus* nematode of small ruminants [44, 47] and *Phaeritima posthuma* study model of human helminthes [43]. According to the results of [47], hydroalcoholic extracts of *Psdium guajava* stem barks act much more on the eggs by preventing their hatching. This has the advantage of suspending the life cycle of the parasite and limiting reinfestations and contamination of the pasture. These observations corroborate those of[49] who showed that *Psidium guajava* extracts can also cause paralysis of adult worms. The results obtained from these studies justify the use of *Psidium guajava* in the treatment of intestinal parasitosis of humans and small ruminants. The leaves could also be used as a food supplement as sources of tannins and those for the reinforcement of biological parameters in the fight against gastrointestinal parasitosis of small ruminants[48].

Conclusion

Psidium guajava is a fruit tree widely used for its nutritional and medicinal values. In Benin, it is used by the population in the treatment of diarrhea, dysentery and intestinal parasitosis. Although there are very few studies on the anthelmintic

activities of *Psidium guajava*, previous results have demonstrated its potential in the treatment of gastrointestinal disorders. Further studies are needed for proper use of *Psidium guajava* in the control of gastrointestinal nematodes of small ruminants and humans.

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