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RESEARCH ARTICLE

Ethnobotanical knowledge of medicinal plants used in the treatment of male infertility in southern Benin

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Abstract

Infertility is a concern for couples, families and society. In almost half of the cases, it is due to male infertility. This infertility, in developing countries like Benin, often cured by the use of medicinal plants. This study aimed to enlist knowledge about medicinal plants used in the treatment of male infertility in southern Benin. An ethnomedicinal investigation has been conducted in southern Benin by questioning traditional healers and market herbalists using the method of semi-structured interview. Ethnopharmacological data has been analyzed by ethnobotanical indices such as informant consensus factor (ICF), frequency of citation for each plant species and contribution of each plant to drug recipes. 90 respondents including 36 market herbalists and 54 traditional healers participated in this study. Data collected allowed us to list 60 plant species belonging to 56 genera and 38 botanical families. Informants had a high degree of consensus (ICF = 0.58) on plants used for treatment of male infertility. The most plants cited by market herbalists were *Garcinia kola* (10.09%), *Cissus populnea* (10.09%), *Carpolobia lutea* (07.40%) and the parts of plants most used were roots and fruits. For traditional healers, *Garcinia kola* (10.15%), *Cyperus esculentus* (06.09%), *Citrus aurantiifiola* (06.09%) were the most plants cited and parts of plants the most used were leaves and roots. This study provided a list of medicinal plants used for the treatment of male infertility in southern Benin. Further pharmacological and toxicological studies will assess the therapeutic efficacy of these medicinal plants.

Keywords Male infertility · Medicinal plants · Ethnomedicinal · Benin

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Introduction

Infertility is a dysfunction of the reproductive system that is defined as the inability to give birth after at least 12 months of regular sexual activity without the use of contraception (Zegers-Hochschild et al. 2009). Nowadays, it is a real public health problem because of its prevalence, widespread distribution and the difficulties inherent in its management (Hajjami 2017). In 2004, the World Health Organization had estimated that 60–80 million people in the world were unable to give birth, one person over ten people (World Health Organization 2004). Epidemiological data conclude that about 15% of couples go through troubles in having children and refer to physicians in search of solutions (Trussell 2013). Infertility, as a psychological crisis, imposes a lot of stress on infertile couples and in different ways threatens their mental health. The most emotional and psychological problems of infertile couples are disappointment, frustration, fear and anxiety, and are less associated with anger and aggression (Musavi et al. 2018).

Of all the continents, Africa is the most affected by this reproductive health problem with variations from one region to another (Larsen et al. 2006; Mascarenhas et al. 2012). Male infertility is a contributing factor in 40% of infertility cases, 40% were related to women and 20% related to both sexes (Hosseini and Abdi 2012; Agarwal et al. 2016).

Male infertility often results in a quantitative and qualitative deficit of male reproductive cells (Leaver 2016). Males with sperm parameters below the WHO normal values are considered to have male factor infertility (Placho et al. 2002). The most signifiant of these are low sperm concentration (oligospermia), poor sperm motility (asthenospermia), and abnormal sperm morphology (teratospermia). As high as 90% of male infertility problems are related to count and there is a positive association between the abnormal semen parameters and sperm count (Sabra and Al-Harbi 2014). The problem with sperm count, motility, and morphology stems from disarray in control mechanism, including pre-testicular, testicular, and post-testicular factors (Iwamoto et al. 2007).

Several reasons can lead to male infertility. It can be a hormonal imbalance (Khourdaji et al. 2018), genetic anomaly (Plaseska-Karanfilska et al. 2012), systemic disease (Mahmoud and Comhaire 2006), spermatogenic defect (Yan 2009), microbial infections (Emokpae et al. 2009), immunological disorders (Hinting et al. 2009), endocrine disruptors (Rehman et al. 2018), environmental pollutants and lifestyle (Durairajanayagam 2018) (taking steroids for muscles, tobacco, alcohol, obesity, cellphone waves, and tight pants), drug factors etc.

In this era of advanced biomedical technology, several modern treatment options such as in vitro fertilization (IVF) techniques, sperm freezing techniques and the development of pro-fertilizing drugs have changed the point of view of society on male infertility, which is no longer a fatality but becomes a pathology accessible to medical treatment (Royère et al. 2011). However, the difficulty of access to modern drugs and these new techniques related to their cost, the ethical issues raised by these new techniques are leading the populations of developing countries to turn to alternative solutions based on the use of medicinal plants, which now appears as the first reflex. Therefore, many plants used to improve male fertility. These include *Alpinia galanga (*L.) Willd. (Mazaheri et al. 2014); *Rosmarinus officinalis* L. (Touazi et al. 2018); *Ficus carica* L. (Naghdi et al. 2016); *Tribulus terrestris* L. (Bashir et al. 2009; Khaleghi et al. 2017); *Cardiospermum halicacabum* L. (Peiris et al. 2015); *Urtica dioica* L. (Jalili et al. 2014); *Camellia sinensis* (L.) Kuntze (Das et al. 2017); *Withania somnifera* (L.) Dunal (Ambiye et al. 2013) etc.

Benin, a West African country, has an interesting ethnopharmacological potential. The investigation of Adjanohoun et al. (1989) documented nearly 501 plant species and that of Akoègninou et al. (2006) identified 2807 plant species. In traditional Beninese medicine, traditional healers and market herbalists who are the main actors make use of several medicinal plants in the traditional management of male infertility. Unfortunately, no ethnobotanical data exist at the present stage on plants used in the treatment of male infertility. However, many ethnobotanical surveys have been conducted in some African countries on plants used to treat male infertility (Hadj-Seyd et al. 2016; Tsobou et al. 2016; Coulibaly and Yapi 2017). From this observation, the following questions emerge:

What are the medicinal plants and their uses in the traditional treatment of male infertility in southern Benin?

How do endogenous knowledge about traditional male infertility treatment in southern Benin vary with the socio-demographic profile of the respondents?

This study aimed to enlist knowledge about medicinal plants used in the treatment of male infertility in southern Benin.

Material and methods

Study area and materials

The ethnopharmacological survey have been conducted in the major cities of the four southern departments of Benin: Zou, Atlantic, Littoral and Oueme for a period of 4 months (from September 2018 to December 2018). These include the Bohicon, Abomey, Djidja, Zakpota and Zogbodomey towns on behalf of the department of Zou; Ouidah and Abomey Calavi towns for the department of Atlantic, Cotonou town for the department of Littoral; Dangbo and Porto Novo towns for the department of Ouémé (Fig. 1). The region of South Benin is located between 6° 25 N and 7° 30 N and covers an area of 17,109 km^2. The climate is subequatorial, characterized by a bimodal rainfall regime with two rainy seasons alternated by two dry seasons. The average annual temperature is 28 °C and the humidity varies between 69 and 97% (Akoègninou 2004). Dominant soils are ferralitic soils on clay sediments, hydromorphic soils in valleys, shallows and alluvial plains, vertisols in the Lama depression and tropical eutrophic brown soils (Igue et al. 2013). It belongs to the Guineo-Congolese zone, which includes a mosaic of islands of dense rain forest, savannah, grassland, mangrove and fallow land. There are 1170 plant species recorded (Adomou et al. 2011). The population of southern Benin is 5,369,774 with a density ranging from 100 inhabitants/km^2 in general to 322 inhabitants/km^2 in the Atlantic. The dominant ethnic groups are Fon and related ones (39.2%), Adja and related ones (15.2%) and Yoruba and related ones (14.5%) (INSAE 2013). The dominant economic activities are trade and agriculture. Market gardening, livestock farming, fishing, crafts and tourism are also practiced.

Ethical approval and consent to participate

The committee of the "Doctoral School Life and Earth Science (ED-SVT)" of the University of Abomey-Calavi (UAC-Benin) under the number 10185509 has authorized this study. Verbal consent obtained from the participants. This choice is justified by the fact that the study population consists mainly of illiterates.

Data collection

Ethnopharmacological investigation was conducted by questioning each individual traditional healer and market herbalists using the method of semi-structured interview (Klotoé et al. 2013; Dassou et al. 2015; Houmenou et al. 2017). The informants were randomly selected and interviewed in one of the local languages (Fon, Goun, Mahi, Aïzo and Adja). The information collected were relative to the socio-demographic data of respondent (origin, sex, age, ethnic group, educational level) and ethnopharmacological data (plant used, composition of the recipe, method of preparation of recipe and their mode of use).

Identification of plant species

The species mentioned by the market herbalists were purchased and those indicated by the traditional healers were harvested. These collected samples were identified (scientific name, botanical family) at the National Herbarium of Benin of the University of Abomey-Calavi (UAC-Benin) using the analytical flora of Benin by Akoègninou et al. (2006). The botanical nomenclature of the "The Plant List" database available on the website www, the plantlist.org was used for this identification.

Data analysis

A descriptive and quantitative statistical method was used to analyze the socio-demographic data of the informants. ANOVA One-way and Independent Samples *T* test were used to assess the degree of endogenous knowledge of the respondents. All statistical analyses were carried out with Statistical Package for Social Science (SPSS) version 16 and Microsoft Excel 2016. The level of significance is set at 5%. The Graph Pad Prism 7 and Microsoft Excel 2016 software were used for plotting figures and tables.

The ethnobotanical data were analyzed using Informant Consensus Factor (ICF), Frequency of citation (FC) and Contribution of each plant to the constitution of the recipes (Cpr).

Informant consensus factor (ICF)

The consensus factor help to evaluate the degree of homogeneity of the information given by the respondents (Heinrich et al. 1998). It has been determined by informant category using formula (Dassou et al. 2014):

$$\mathrm{ICF} = \mathrm{Nuc} - \mathrm{Ns}/\mathrm{Nuc} - 1$$

Nuc: Number of use citations in each informant's category, Ns: Number of plant species cited by informants in this category, ICF varies from 0 to 1

- The value 0 is the lowest level and corresponds to different points of view on the part of the respondents in the use of plants to treat a disease;
- Values below 0 and 0.5 are considered low and indicate a low consensus of plant use;
- The value 0.5 is the average degree of the factor and indicates an average consensus of use of plants;
- The values between 0.5 and 1 are the relatively strong degrees and show a relatively high degree of agreement in the use of plants to treat the disease.
- The value 1 is the highest degree of consensus in the use of plants to treat the disease.

Frequency of citation (FC)

The frequency of citation for each of the listed species has been calculated using the formula used by several authors (Dassou et al. 2014; Kouassi et al. 2017; Dougnon et al. 2018):

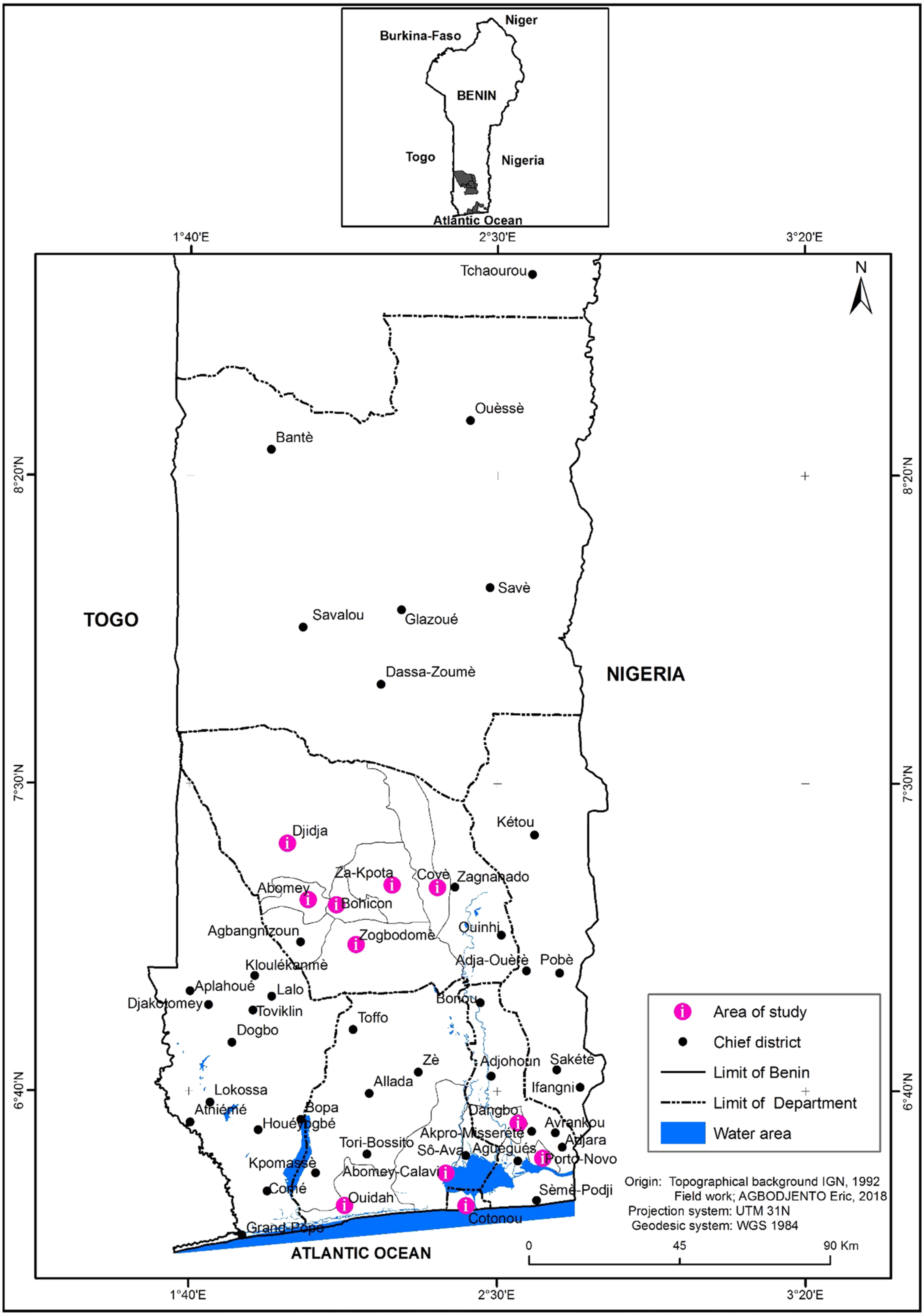

Fig. 1 Map of southern Benin showing the municipalities surveyed

FC = NP/NT

NP: number of times that the plant is cited; NT: total citations of species

Contribution of each plant to the constitution of the recipes (Cpr)

The contribution of each plant to the constitution of the recipes (Cpr) was determined using the method as described by Dassou et al. (2014) and Kouassi et al. (2017). It allowed to know the frequency of implication of a plant in the recipes and expressed by the following formula:

$$Cpr = (Nr/Nt) \times 100$$

Nr: Number of recipes where the plant is involved; Nt: total number of recipes.

Results

Socio-demographic characteristics of the informants

Ninety respondents including 54 traditional healers (all male) and 36 market herbalists (all female) participated in this study (Table 1). These informants had quite remarkable experience (majority had more than 10 years of experience) in the practice of traditional medicine in Benin. No significant difference was noted between the number of years of experience of the respondents and their endogenous knowledge ($P > 0.05$) (Table 1). Moreover, the respondents had varying degrees of knowledge of medicinal plants and their use in the treatment of male infertility in southern Benin. Traditional healers have more endogenous knowledge of medicinal plants and their traditional uses for the treatment of male infertility than market herbalists ($P < 0.05$).

In this study, the majority of respondents had between 40 and 60 years old (72%) followed by those aged 20–39 years old (19%). Respondents over 60 years old were in the minority (9%). These same characteristics of the respondents were listed in other ethnobotanical studies realized for other affections in Benin (Déléké Koko 2011; Fah et al. 2013; Klotoé et al. 2013; Agbankpé et al. 2014; Koudokpon et al. 2017). This indicates that plant knowledge used in the treatment of male infertility in southern Benin are not restricted to a particular group of traditional healers and market herbalists. Moreover, the difference between the age groups and the degree of knowledge of respondents about the uses of medicinal plants for the treatment of this reproductive health problem was significant ($P < 0.05$). Older respondents

Table 1 Demographic profile of informants interviewed

Variables	Categories	Total	Percentages (%)	*P* value
Gender	Male (traditional healers)	54	60	0.002
	Female (market herbalists)	36	40	
Year of experience	0–10 years	11	12	0.069
	11–20 years	50	56	
	> 20 years	29	32	
Age	20–39 years	17	19	0.0001
	40–60 years	65	72	
	> 60 years	8	9	
Educational status	Illiterate	76	84	0.0001
	Primary	8	9	
	Secondary	6	7	
Ethnic	Fon	48	53	0.024
	Adja	11	12	
	Aizo	2	2	
	Mahi	15	17	
	Hogbonouto	3	3	
	Weme	10	11	
	Yoruba	1	1	

(40–60 years old) had more knowledge than less aged respondents (20–39 years old).

Regarding the education level of the respondents, the majority of informants were illiterate (84%). 9% and 7% of respondents were in primary and Secondary School respectively. In addition, the difference between the education level and the endogenous knowledge of the respondents was significant ($P < 0.05$). The illiterate had more endogenous knowledge than the literate.

The informants who participated in this study belong to seven (7) different ethnic groups. This shows that knowledge of medicinal plants is not exclusive to one ethnic group. Nevertheless, the majority of respondents were Fon group ethnic (53%). Mahi (17%) and Adja (12%) followed them. Moreover, endogenous knowledge for the treatment of male infertility between different ethnic groups had varied significantly ($P < 0.05$). Informants of the Fon group ethnic had good knowledge of the traditional uses of the listed plant species.

Ethnopharmacological data analysis

Informant consensus

The informant consensus factor reflects a good knowledge of medicinal plants and a collective knowledge of their uses

(Heinrich et al.1998; Amiguet et al. 2005). In this study, the Informant Consensus Factor (IFC) obtained for plants used in the treatment of male infertility in southern Benin is relatively high (ICF = 0.58) (Table 2). This reflects the high degree of agreement among traditional healers and market herbalists surveyed on the use of the plants identified in the traditional treatment of male infertility in southern Benin. However, there is some difference according to informant category. The ICF is relatively high for the traditional healers (ICF = 0.60) and low for the market herbalists (ICF = 0.2) (Table 2). This shows that traditional healers had a high degree of agreement on the uses of medicinal plants identified for the treatment of male infertility in southern Benin.

Diversity of medicinal plants and their use value

Sixty plant species belonging to 56 genera and 38 botanical families were identified on the basic of 70 recipes were provided by the informants (Table 3). These 60 plant species represent 2.3% of Benin's total flora, which is composed of 2807 species (Akoègninou et al. 2006) and 5.12% of the flora in southern Benin with 1170 species (Adomou et al. 2011). In addition, the listed plant species belong at different botanical families. The most represented were Malvaceae (13.15%) Annonaceae (10.52%), Arecaceae (10.52%), Apocynaceae (10.52%) and Leguminoseae (10.52%) (Fig. 2).

Among market herbalists, 34 plant species were identified of the 30 recipes that were provided by these informants. The most plants cited were *Garcinia kola* Heckel (10.09%), *Cissus populnea* Guill. & Perr. (10.09%), *Carpolobia lutea* G.Don. (07.40%), *Xylopia Aethiopica* (Dunal) A.Rich (07.40%), *Cocos nucifera* L. (05.50%). Among traditional healers, 47 medicinal plants were identified on the basis of the 59 recipes indicated by these informants. The most plants cited were *Garcinia kola* (10.15%), *Cyperus esculentus* L. (06.09%), *Citrus aurantiifiola* (Christm.) Swingle (06.09%), *Rourea coccinea* (Thonn. ex Schumach.) Benth (05.08%), *Annona senegalensis* Pers. (05.08%) (Table 3).

Parts of the medicinal plants used

Several parts of the listed plant species such as leaves, roots, fruits, bark, seeds are used in various ways by the respondents in the preparation of recipes used for treatment of male infertility. Among market herbalists, roots followed by fruits were the most cited plant organs, whereas in traditional healers leaves were the most used followed by roots (Fig. 3).

Table 2 Result of consensus factor (ICF)

	N	N_{uc}	N_s	ICF
Market herbalists	36	42	34	0.20
Traditional healers	54	100	41	0.60
All informants	90	142	60	0.58

Composition and methods of remedy preparations

Medicinal plants listed variously used in the preparation of medicinal recipes for the treatment of male infertility. Some recipes are composed of a single plant whereas the others were a combination of two to seven plants (multi-compound recipes). Traditional healers provided more recipes with one plant that market Herbalists (Fig. 4). The listed plant species contribute to variable proportions in the used recipes constitution for the treatment of male infertility (Table 3). Therefore, *Garcinia kola* involved in 31.43% of the recipes; *Cyperus esculentus* contributed to 14.29% and *Cissus populnea* and C*ocos nucifera* contributed to 10% each. *Rourea coccinea*, *Musa paradisiaca* L. and *Carpolobia lutea* each was involved in making up 08.74% of recipes. Among the plants with a low contribution (01.43%), there are *Abrus precatorius* L., *Borassus aethiopum* Mart. and *Caesalpinia bonduc* (L.) Roxb.

Different ways of preparing the recipes were indicated by the respondents. Maceration and trituration were the methods of preparation of the most used recipes by the respondents (Fig. 5). In addition, the respondants indicated that all the preparations of recipes were administered orally. The duration of treatment varies from 1 week until satisfaction. Some non-vegetable substances like sugar, milk, chicken eggs added sometimes to various preparations. Moreover, market herbalists and traditional healers reported no adverse effects associated to the use of these recipes. However, the traditional healers indicated a precaution. They recommended that during treatment, the patient should be faithful to his wife in order to increase the therapeutic effectiveness of the recipes.

Discussion

In this study, informants belong to two categories: market herbalists and traditional healers. They had varying degrees of knowledge of medicinal plants and their use in the treatment of male infertility in southern Benin. Traditional healers had more endogenous knowledge of medicinal plants and their traditional uses for the treatment of male infertility than market herbalists. This is even more justified since the consensus factor obtained for the plants cited by the traditional healers is high (ICF = 0.60). Similar data obtained in other ethnobotanical studies carried out at the national scale (Déléké Koko 2011; Fah et al. 2013; Klotoé et al. 2013; Agbankpé et al. 2014; Koudokpon et al. 2017). This can be explained by the fact that in traditional Beninese medicine, traditional healers are considered specialists

Table 3 Informations about plants species used in Southern Benin in the treatment of male infertility

Nos.	Scientific name of the plant	Botanical family	Vernacular name	Collection site	Voucher number	Herbarium name	Parts used	FC (%)	Cpr (%)	MP	Previous references
1	*Abrus precatorius* L.	Leguminosae	Vivima (f); Liane réglisse (fr)	Abomey-Calavi	YH 282/HNB	HNB	Roots	1.01	1.43	Mac	Mahre et al. (2017), Gigani et al. (2012), Ogbuewu et al. (2011), Saalu (2016), Sinha (1990) and Talukder et al. (2011)*
2	*Acalypha segetalis* Müll. Arg.	Euphorbiaceae	Jivijivi (f)	Ouidah	YH 283/HNB	HNB	Leaves	0.34	1.43	Dec; Pow	
3	*Acridocarpus smeathmannii* (DC.) Guill. & Perr.	Malpighiaceae	Gbanguina (f)	Abomey-Calavi	YH 284/HNB	HNB	Roots	1.68	5.71	Dec; Mac	
4	*Adansonia digitata* L.	Malvaceae	Kpassa (f)	Bohicon	YH 285/HNB	HNB	Bark	0.67	1.43	Mac	Oyewopo et al. (2016)
5	*Aframomum melegueta* K. Schum.	Zingiberaceae	Atakoun (f)	Abomey-Calavi	YH 286/HNB	HNB	Seed	3.36	5.71	Mac; Pow	Ajiboye et al. (2016)
6	*Allium sativum* L.	Amaryllidaceae	Ayo (f, g)	Abomey-Calavi	YH 287/HNB	HNB	Bulb	1.01	2.86	Mac	Hammami et al. (2016), Hammami and El May (2013), Memudu et al. (2015) and Hammami et al. (2008)*
7	*Annona senegalensis* Pers.	Annonaceae	Nyiglwe gbéminton (f)	Ouidah	YH 288/HNB	HNB	Leaves	3.69	4.29	Tri	Obiora Nwonuma (2015)
8	*Argemone mexicana* L.	Papaveraceae	Houètchegnon (f), Pavot épineux (fr)	Ouidah	YH 289/HNB	HNB	Leaves	0.67	1.43	Tri	
9	*Bombax brevicuspe* Sprague	Malvaceae	kpatin dèhoun (f), Kapokier de clôture (fr)	Ouidah	YH 291/HNB	HNB	Roots	0.34	1.43	Mac	
10	*Borassus aethiopum* Mart.	Arecaceae	Agonté, kolaka (f. g); Rônier (fr)	Abomey-Calavi	YH 292/HNB	HNB	Roots	0.67	1.43	Pow	
11	*Bridelia ferruginea* Benth.	Phyllanthaceae	Honsukokwe, hongla (f, g)	Ouidah	YH 293/HNB	HNB	Fruit	0.34	1.43	Dec.	Odo et al. (2018)
12	*Caesalpinia bonduc* (L.) Roxb.	Leguminosae	Ajikun (f), Bonduc (fr)	Ouidah	YH 296/HNB	HNB	Roots	0.34	1.43	Mac	Bibarani et al. (2018) and Peerzade et al. (2009)*

Table 3 (continued)

Nos.	Scientific name of the plant	Botanical family	Vernacular name	Collection site	Voucher number	Herbarium name	Parts used	FC (%)	Cpr (%)	MP	Previous references
13	*Calotropis procera* (Aiton) Dryand	Apocynaceae	Kpinto man, amouman (f) Arbre à soie (fr)	Abomey-Calavi	YH 297/HNB	HNB	Leaves	0.67	1.43	Tri	Abdelgader and Elsheikh (2018) and Ahmed et al. (2016)*
14	*Carica papaya* L.	Caricaceae	Kpen (f), Papayer (fr)	Abomey-Calavi	YH 298/HNB	HNB	Roots	1.01	1.43	Mac	Kusemiju et al. (2002) and Udoh et al. (2005)*
15	*Carissa spinarum* L.	Apocynaceae	Ahanzo (f)	Abomey-Calavi	YH 290/HNB	HNB	Roots	1.34	4.29	Dec, Mac	
16	*Carpolobia lutea* G.Don	Polygalaceae	Avia (f) oshin shin (y, n).	Abomey-Calavi	YH 299/HNB	HNB	Roots	3.02	8.57	Dec; Mac	Manfo et al. (2011) and Yakubu and Jimoh (2015)
17	*Cassytha filiformis* L.	Lauraceae	Agbegbekan abebekan (f)	Djidja	YH 262/HNB	HNB	Whole plant	4.03	4.29	Tri	
18	*Cissus petiolata* Hook.f.	Vitaceae	Assankan wéwé (f)	Djidja	YH 301/HNB	HNB	Stem/Roots	2.01	7.14	Mac	
19	*Cissus populnea* Guill. & Perr.	Vitaceae	Assankan ou Dèdô	Abomey-Calavi	YH 302/HNB	HNB	Roots	6.71	10	Mac	Olaolu et al. (2018), Olaolu and Rotimi (2018) and Oremosu (2013)
20	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae	Klé (f)	Abomey	YH 303/HNB	HNB	Fruit	4.36	7.14	Mac; Tri	Aprioku and Obianime (2014), Komeilifard and Hemayat khahjahromi (2016) Christopher et al. (2018) and Okon and Etim (2017)*
21	*Cocos nucifera* L.	Arecaceae	Agonkè tin (f), Cocotier (fr)	Ouidah	YH 304/HNB	HNB	Fruit	4.36	10	Mac	Kunle-Alabi et al. (2014) and Nair and Rajamohan (2014)
22	*Cola acuminata* (P.Beauv.) Schott & Endl.	Malvaceae	Vi (f), avi (g)	Abomey-Calavi	YH 305/HNB	HNB	Seed	0.34	1.43	Mac	Aprioku and Clement (2018)*
23	*Cola nitida* (Vent.) Schott & Endl.	Malvaceae	Golo tin (f), Colatier (fr)	Abomey-Calavi	YH 306/HNB	HNB	Seed	1.01	2.86	Mac; Tri	Adisa et al. (2010), Nna et al. (2014) and Umoh et al. (2014)*

Table 3 (continued)

Nos.	Scientific name of the plant	Botanical family	Vernacular name	Collection site	Voucher number	Herbarium name	Parts used	FC (%)	Cpr (%)	MP	Previous references
24	*Croton lobatus* L.	Malvaceae	Alôvi aton, alo aton, gbodu jogo (f, g)	Abomey-Calavi	YH 308/HNB	HNB	Bark	0.67	2.86	Mac	
25	*Cyperus esculentus* L.	Cyperaceae	Fio (f), amande de terre (fr)	Abomey-Calavi	YH 309/HNB	HNB	Fruit	5.03	14.29	Mac; Pow	Al-Shaikh et al. (2013) and Ekaluo et al. (2015)
26	*Desmodium velutium* (Willd.) DC.	Leguminosae	Tèd'avowu (f) ema agiva (y, n)	Ouidah	YH 310/HNB	HNB	Roots	1.68	5.71	Mac; Raw	
27	*Dichapetalum madagascariense* Poir.	Dichapetalaceae	Gbaglo (f)	Ouidah	YH 311/HNB	HNB	Leaves	0.34	1.43	Dec	
28	*Elaeis guineensis* Jacq.	Arecaceae	Detin (f)	Ouidah	YH 312/HNB	HNB	Stem	2.35	4.29	Mac; Tri	Ikegwu et al. (2014) and Isaac et al. (2017)
29	*Ficus polita* Vahl	Moraceae	Vo tin (f)	Ouidah	YH 313/HNB	HNB	Fruit	0.67	1.43	Pow	
30	*Flacourtia flavescens* Willd.	Salicaceae	Gbohounkadjè (f) kakandika oshere (y, n)	Ouidah	YH 314/HNB	HNB	Roots	0.67	1.43	Mac	
31	*Garcinia kola* Heckel	Clusiaceae	Ahowé	Bohicon	YH 260/HNB	HNB	Seed	10.40	31.43	Mac; Dec; Pow; Tri	Omotola et al. (2017), Ralebona (2012) Abu et al. (2013), Mesembe et al. (2013) and Okechukwu et al. (2016)*
32	*Gardenia ternifolia* Schumach. & Thonn. Spp ternifolia.	Rubiaceae	Dakpla Asu (f)	Djidja	YH 263/HNB	HNB	Roots	1.68	5.71	Mac; Pow	
33	*Hybanthus enneaspermus* (L.) F.Muell.	Violaceae	Abiwèrè (y, n), wonye (f)	Ouidah	YH 315/HNB	HNB	Leaves	1.01	2.86	Pow	
34	*Hydrocotyle bonariensis* Comm. ex Lam.	Araliaceae	Adodowe (f); Adodo (g), Sakan (a)	Cotonou	YH 300/HNB	HNB	Leaves	0.34	1.43	Tri	Sainath et al. (2011) Heidari et al. (2007, 2012) and Yunianto et al. (2017)*

Table 3 (continued)

Nos.	Scientific name of the plant	Botanical family	Vernacular name	Collection site	Voucher number	Herbarium name	Parts used	FC (%)	Cpr (%)	MP	Previous references
35	*Imperata cylindrica* (L.) Raeusch.	Poaceae	Sè (f), Chiendent (fr)	Ouidah	YH 316/HNB	HNB	Roots	1.01	1.43	Mac	Widyastuti et al. (2018)*
36	*Kalanchoe crenata* (Andrews) Haw.	Crassulaceae	Afama (f)	Ouidah	YH 295/HNB	HNB	Leaves	0.34	1.43	Tri	
37	*Lophira lanceolata* Tiegh. ex Keay	Ochnaceae	Wugo (f);	Ouidah	YH 294/HNB	HNB	Bark	0.34	1.43	Pow	
38	*Manihot esculenta* Crantz	Euphorbiaceae	Fenyen (f)	Abomey-Calavi	YH 317/HNB	HNB	Fruit	2.01	7.14	Pow	
39	*Mondia whitei* (Hook.f.) Skeels	Apocynaceae	Chririgoun (f)	Abomey-Calavi	YH 318/HNB	HNB	Roots	2.01	4.29	Mac	Watcho et al. (2001, 2004)*
40	*Monodora myristica* (Gaertn.) Dunal	Annonaceae	Sasalikun (f)	Abomey-Calavi	YH 319/HNB	HNB	Seed	0.67	1.43	Mac	
41	*Morinda lucida* Benth.	Rubiaceae	Xwèsin (f), oju ologbo (y, n)	Abomey-Calavi	YH 320/HNB	HNB	Roots	0.67	2.86	Mac; Dec	Raji et al. (2005)*
42	*Musa acuminata* Colla	Musaceae	kokwé sotoumo (f)	Abomey-Calavi	YH 321/HNB	HNB	Fruit	0.67	1.43	Pow	
43	*Musa paradisiaca* L.	Musaceae	Kokwé alôga	Abomey-Calavi	YH 322/HNB	HNB	Fruit	3.69	8.57	Pow; Raw	Alabi et al. (2013) and Yakubu et al. (2013)
44	*Musa* L.	Musaceae	Gounkokwé (g)	Abomey-Calavi	YH 323/HNB	HNB	Fruit	0.67	2.86	Mac; Pow	
45	*Newbouldia laevis* (P.Beauv.) Seem.	Bignoniaceae	Hysope africain (fr); kpatin, Désréguè (f)	Abomey-Calavi	YH 324/HNB	HNB	Roots	1.01	1.43	Mac	Anderson et al. (2015) and Simeon and Emeka (2014)
46	*Ocimum gratissimum* L.	Lamiaceae	Tchiayo (f)	Abomey-Calavi	YH 325/HNB	HNB	Leaves	0.67	1.43	Pow; Dec	Obianime et al. (2010) and Parandin and Haeri Rohani (2015)*
47	*Pachycarpus lineolatus* (Decne.) Bullock	Apocynaceae	Agboaguin (f)	Abomey-Calavi	YH 326/HNB	HNB	Roots	2.35	5.71	MacPow	
48	*Paullinia pinnata* L.	Sapindaceae	Ganganlissè (f)	Abomey-Calavi	YH 307/HNB	HNB	Leaves	0.34	1.43	Tri	

Table 3 (continued)

Nos.	Scientific name of the plant	Botanical family	Vernacular name	Collection site	Voucher number	Herbarium name	Parts used	FC (%)	Cpr (%)	MP	Previous references
49	*Phoenix dactylifera* L.	Arecaceae	Dattier (fr), Datte (f)	Abomey-Calavi	YH 327/HNB	HNB	fruit	0.34	1.43	Mac	Dillasamola et al. (2019), El-kott et al. (2014), El-Neweshy et al. (2013) and Mehraban et al. (2014)
50	*Piper guineense* Schumach. & Thonn.	Piperaceae	lènlènkoun (f, g)	Abomey-Calavi	YH 328/HNB	HNB	fruit	1.01	1.43	Pow	Giwa et al. (2016) and Mbongue et al. (2005)
51	*Prosopis africana* (Guill. & Perr.) Taub.	Leguminosae	Kakè (f), aka-kanyi (y)	Abomey-Calavi	YH 329/HNB	HNB	Roots	0.67	1.43	Mac	
52	*Pupalia lappacea* (L.) Juss.	Amaranthaceae	Trèdoagboko (f)	Abomey-Calavi	YH 330/HNB	HNB	Flower/leave	0.34	2.86	Pow; Tri	
53	*Psidium guajava* L.	Myrtaceae	Kinkounman (f)	Abomey-Calavi	AA 6694/HNB	HNB	Leaves	2.68	1.43	Dec	Akinola et al. (2007) and Choudhury and Sinha (2014)
54	*Rourea coccinea* (Thonn. ex Schumach.) Benth.	Connaraceae	Vikplomba-Ganganlissè (f)	Zakpota	YH 261/HNB	HNB	Leaves	1.68	8.57	Tri; Pow	Yakubu and Atoyebi (2018)
55	*Sesamum radiatum* Schumach. & Thonn.	Pedaliaceae	Agboma (f)	Ouidah	YH 331/HNB	HNB	Leaves	1.01	2.86	Tri	Ashamu et al. (2010)
56	*Spondias mombin* L.	Anacardiaceae	Akikontin (f)	Ouidah	YH 332/HNB	HNB	Leaves	0.67	1.43	Tri	Oloye et al. (2017) and Asuquo (2012)*
57	*Uvaria chamae* P.Beauv	Annonaceae	Aylaha (f)	Abomey-Calavi	AA 6687/HNB	HNB	Roots	2.01	5.71	Dec, Mac	
58	*Xylopia aethiopica* (Dunal) A. Rich.	Annonaceae	Kpéjélékun (f)	Abomey-Calavi	YH 333/HNB	HNB	Seed	3.02	5.71	Mac	Hambe et al. (2018), Woode et al. (2011) and Adienbo et al. (2017)*
59	*Zea mays* L.	Pontederiaceae	gbadé (f)	Abomey-Calavi	YH 334/HNB	HNB	Fruit	1.34	2.86	Dec	

Table 3 (continued)

Nos.	Scientific name of the plant	Botanical family	Vernacular name	Collection site	Voucher number	Herbarium name	Parts used	FC (%)	Cpr (%)	MP	Previous references
60	*Zingiber officinale* Roscoe	zingiberaceae	Dotè (f), gingembre (fr)	Abomey-Calavi	YH 335/HNB	HNB	Seed	1.01	2.86	Tri; Mac	Afzali and Ghalehkandi (2018), Hosseini et al. (2016), Mohammadi et al. (2014) and Sutyarso et al. (2016)

FC citation of frequency, *Cpr* contribution of each species to drug receipes, *MP* mode of preparation, *Mac* maceration, *Tri* trituration, *Pow* powder, *Dec* decoction, ()* activity antifertility, *f* Fon, *g* Goun, *y* Yoruba, *a* Adja, *n* Nago, *fr* French, *HNB* National Herbarium of Benin

in the traditional treatment of various diseases due to their effectiveness.

Moreover, the majority of respondents were aged 40–60 years old and had the highest medicinal plants knowledge. Similar data obtained in other regions of Benin (Dassou et al. 2015; Guinnin et al. 2015). These findings reflect, on the one hand, that older respondents hold much of the traditional knowledge that is part of the oral tradition and, on the other hand, that there has been a loss of information about medicinal plants for young people. This can be explained by the distrust of some young people who nowadays are very little interested in phytotherapy due to the influence of modernization and the influence of exotic culture. Thus, the transmission of traditional knowledge from generation to generation is at risk, as transmission between the elderly and younger generations is not always ensured (Klotoé et al. 2013). Regarding the education level of the respondents, the majority of informants were illiterate and had a more medicinal plant knowledge. This trend has remained unchanged from Adjanohoun et al. (1989) to date Dougnon et al. (2018). These observations indicate that the practice of traditional Beninese medicine remains the prerogative of the majority illiterate populations.

The informants who participated in this study belong to different ethnic groups. Their majority were Fon group ethnic and had good knowledge of the traditional uses of the listed plant species. These data coincide with the conclusions of the report of the demographic survey carried out by the INSAE in 2013 (INSAE 2013). The report states that in southern Benin, the dominant ethnic groups were Fon and related (39.2%), Adja and related (15.2%) and Yoruba and related (14.5%).

The current ethnopharmacological documentation recorded 60 plant species belonging to 56 genera and 38 Botanical families. This diversity of medicinal plants is greater than 31; 26 and 21 plant species listed respectively by Erhabor et al. (2013) in North West Nigeria, Coulibaly and Yapi (2017) in Yopougon, in Ivory Coast and Tsobou et al. (2016) in Cameroon. This reflects a diversity of plants used for the treatment of male infertility in southern Benin. The most botanical families represented were Malvaceae, Annonaceae, Arecaceae, Apocynaceae and Leguminosea. These results are in agreement with those of Tsobou et al. (2016) obtained in Cameroon but contrary to those obtained by Erhabor et al. (2013). These authors found that the plants used in the Akwa Ibom State of Nigeria to treat male infertility mostly belong to the Poaceae family. From these findings, it appears that the spermatogenic properties of plants are not the particularity of the plant species of a single botanical family.

The plants identified in this study do not have the same use value. Plant species such as *Garcinia kola*, *Cissus populnea, Carpolobia lutea* were the most used by market

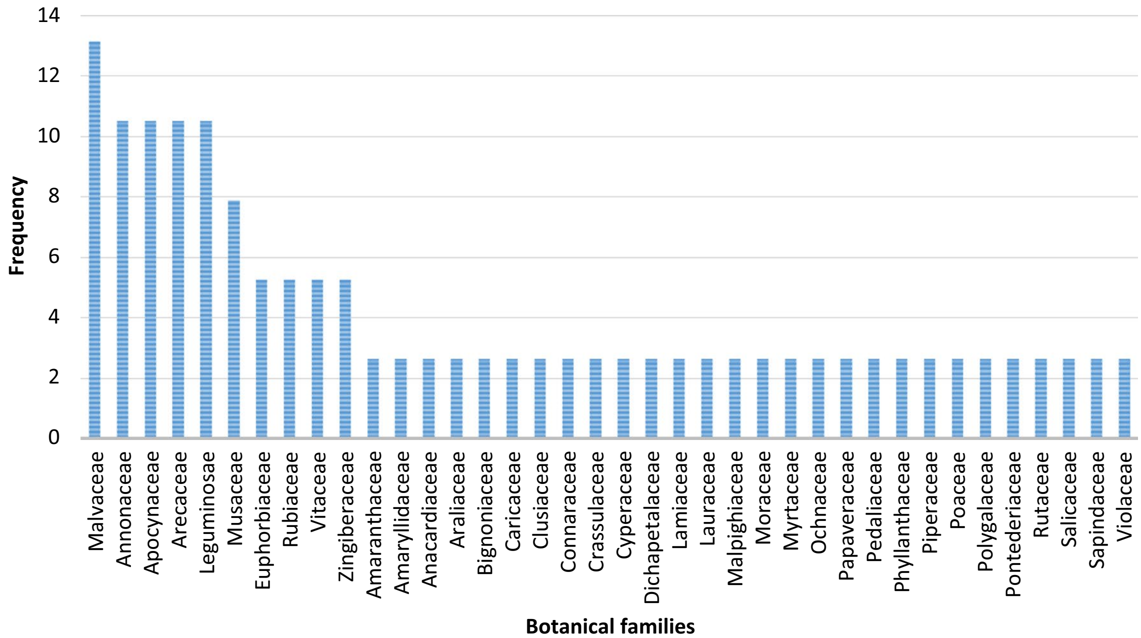

Fig. 2 Frequency of botanical families represented

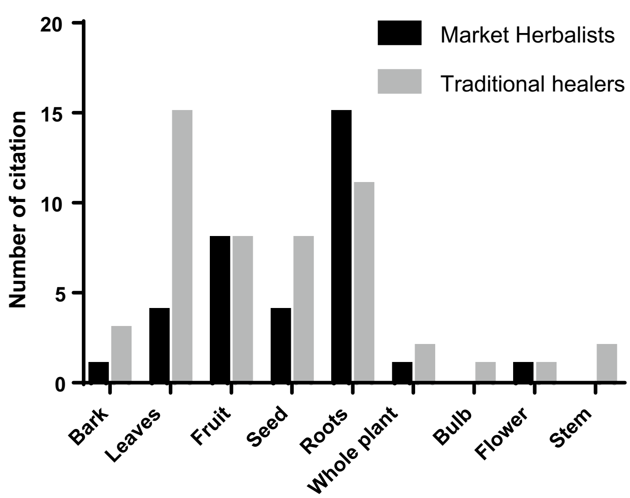

Fig. 3 Parts of plant used by the respondents

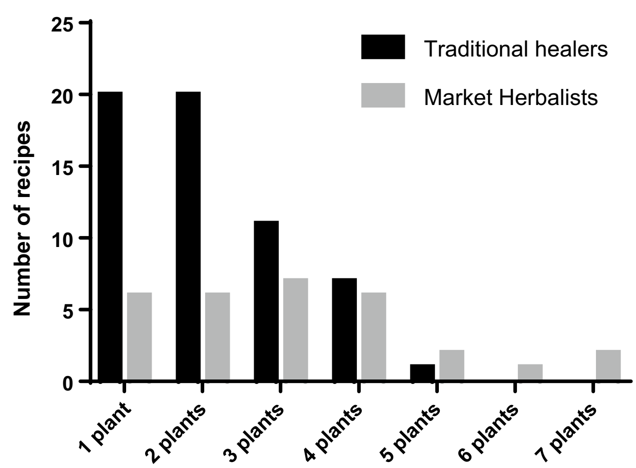

Fig. 4 Number of plants according to recipes

herbalists while traditional healers, *Garcinia kola*, *Cyperus esculentus* and *Citrus aurantiifiola* were the most used. A literature review has conducted on the identified plant species regarding their spermatogenic activity. The data obtained indicates that no scientific study has been conducted in Benin for the spermatogenic activities exploration of the listed 60 plant species. This study provided for the first time a list of medicinal plants used for the treatment of male infertility in southern Benin. Further toxicological and pharmacological studies will assess the toxicity and efficacy of these plants in the treatment of sperm abnormalities.

Nevertheless, there are some pharmacological studies carried out in other countries on some plant species identified in this survey. In South Africa, a study showed that ethanolic extract of *Garcinia kola* improved the sperm parameters by increasing the number and the mobility of spermatozoa in the Wistar rats (Ralebona 2012). In Nigeria, an aqueous extract of *Cyperus esculentus* administered to Wistar rats during 9 weeks assured weight growth of testis and epididymis, an increase in the number and motility of spermatozoa (Ekaluo et al. 2015). Polyphenolic fractions of *Garcinia kola* showed a prophylactic effects on the histology and hormones of the pituitary–testicular axis of male

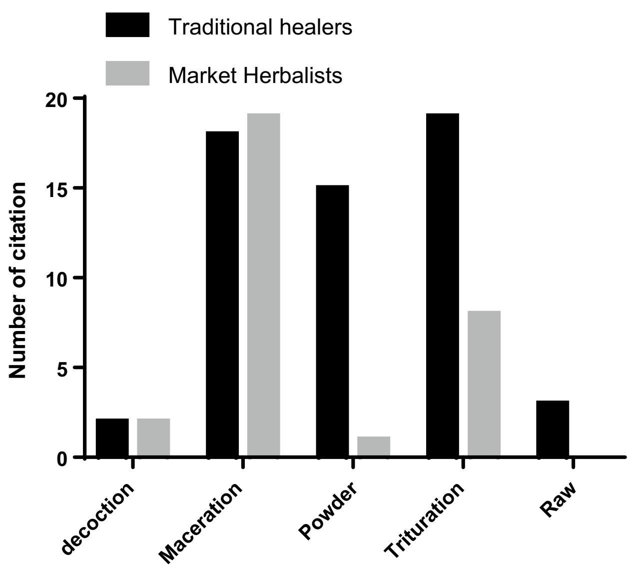

Fig. 5 Method of preparation of recipes

Wistar rats (Omotola et al. 2017). Another study carried out in Nigeria indicates that root infusion of *Cissus populnea* administered to male Wistar rats caused an increase in the secretion of male sex hormones such as testosterone and gonadotropins, thereby enhancing the fertility of these rats (Olaolu et al. 2018). In the same way, *Cocos nucifera* water improved reproductive indices in the Wistar rat (Kunle-Alabi et al. 2014). A study carried out In Iraq indicated that *Cyperus esculentus* had a protective effect on testicular and sperm abnormalities induced by lead acetate in Wistar rats (Al-Shaikh et al. 2013). These studies show that the pharmacological properties of these plants seem to be related to polyphenolic components, especially flavonoids, which have the capacity to neutralize the free radicals at the origin of oxidative stress (Methorst and Huyghe 2014). Indeed, it is well documented that oxidative stress is one of the major causes of male infertility (Alahmar 2019). The flavonoids present in vegetable samples have an antioxidant power and are able to optimize the action of enzymatic antioxidants of the body's antioxidant system. These antioxidants act by interrupting the chain reactions leading to the production of reactive oxygen species that can alter quantitatively and qualitatively the male reproductive cells (Methorst and Huyghe 2014). This above-mentioned scientific evidence shows the good knowledge of market herbalists and traditional healers of Benin on plants used in the treatment of male infertility.

Medicinal plants listed variously used in the preparation of medicinal recipes for the treatment of male infertility. The majority of these recipes were composed of a combination to several medicinal plants (multi-compound recipes). In these associations of plants, not all the plant species of a recipe have the same importance. This indicates that in the mixtures of plant organs of various plants, it is the association or the synergy that exists among the bioactive molecules, which is very responsible for the desired pharmacological effect. Several studies carried out on the traditional treatments of various affections in Africa underlined this complexity in the preparation and the content of the traditional remedies, which rarely count only one plant species Bayaga et al. (2017). Joy et al. (2001) and Fleurentin et al. (2011) supported this idea and emphasized that the real therapeutic activities of some medicinal plants cannot be explained by the only presence of any one of the constituents. However, other authors have argued that the preponderance of recipes of a only one plant in the treatment of affections is the benefit to patients and that association of poorly matched plants are sometimes dangerous (Zerbo et al. 2007; Béné et al. 2016). This form of association of various plant species in the treatments could present risks of interaction or toxicity (Yemoa et al. 2008). Moreover, in the preparation of recipes the respondents use in various ways several parts of the listed plant species such as leaves, roots, fruits, bark, seeds. Roots, leaves, fruits were most used. The frequency of use of roots and leaves were also reported in the traditional treatment of other diseases such as diabetes (Fah et al. 2013) and infections (Koudokpon et al. 2017; Dougnon et al. 2018) in southern Benin. This frequency of use of the leaves could be justified by the ease, the facility and the speed of harvest, but also by an important physiological process owing to the fact that they are seats of the photosynthesis and sometimes storage of the secondary metabolites responsible for the biological properties of the plant (Ndombe et al. 2016). However, the use of plant parts in the preparation of recipes could have adverse ecological impacts on the life of plant species. If the use of fruits and leaves does not seem to affect the plant, the use of roots and barks is detrimental to the plant (Cunningham 2001; Houmenou et al. 2017).

Respondents reported the use of several modes of recipes preparations. Maceration and trituration were the most used. These observations are contrary to those reported by Ndombe et al. (2016) who found that it is the decoction that is the most used mode for recipes used in the treatment of male infertility in Kenge in the RD Congo. Moreover, decoction is a form of preparation of medicinal recipes that can alter under the effect of the high temperature certain active ingredients contrary to the forms of preparations of recipes without cooking such as maceration, trituration and powder.

Conclusion

Beninese flora has a variety of medicinal plants used in the treatment of male infertility. The market herbalists and traditional healers of southern Benin who participated in this study have a good knowledge of these plants and their traditional uses. Their degree of knowledge varies according to age, ethnic and level of education. This study provided for the first time an ethnopharmacological documentation for the treatment of male infertility in southern Benin. Further toxicological and pharmacological studies will assess the toxicity and efficacy of these plants in the treatment of sperm abnormalities.

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Authors contributions EA and JRK participated in all stages of the production of this article. JMA and DV provided the scientific direction of the works. IS and ED participated in the survey. LT participate in the botanical identification of plant species. All authors participated in reading and editing the manuscript.

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Compliance with ethical standards

Ethical statement The study is part of a thesis. The committee of the "Ecole Doctorale Science de la Vie et de la Terre (ED-SVT)" of the University of Abomey-Calavi (UAC) under the No. 10185509 has authorized it. Verbal consent obtained from the participants. This choice is justified by the fact that the study population consists mainly of illiterates.

Conflict of interest Eric Agbodjento has no conflict of interest. Jean Robert Klotoé has no conflict of interest. Téniola Isabelle Sacramento has no conflict of interest. Victorien Dougnon has no conflict of interest. Frontenel Lopez Tchabi has no conflict of interest. Esther Dégué-non has no conflict of interest. Jean-Marc Atègbo has no conflict of interest.

Availability of data and materials The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Consent to publication Not applicable.

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