Ethnobotanical Kknowledge of Medicinal Plants Used in the Treatment of Male Infertility in Southern Benin

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Abstract

Background: Infertility is a concern for couples, families and society. In almost half of the cases, it is due to male infertility, which results in the azoospermia and oligospermia. This infertility, in developing countries like Benin, is often care by the use of medicinal medicinal plants. However, very few data exist on plants with spermatogenic benefits at the current stage. Therefore, this work aimed to enlist knowledge about plants used in the treatment of male infertility in southern Benin.

Methods : An ethnomedicinal investigation has been conducted by questioning traditional healer and market herbalists using the method of semi-structured interview. 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. Ethnopharmacological data has been analyzed by ethnobotanical indices such as informant consensus factor (ICF), frequency of citation (FC) for each plant species and contribution of each plant to drug recipes (Cpr) to establish indicators on the use values attributed to plants listed.

Results: 90 respondents including 34 market herbalists and 54 traditional healers participated in this study. Data collected allowed us, on the basic of 70 recipes provided by the informants, to list 60 plant species belonging to 57 genera and 40 botanical families. Informants had a high degree of consensus (ICF = 0.58) on plants used for treatment of male infertility. The most plants cited were Garcinia kola (10.09%), Cissus populnea (10.09%), Carpolobia lutea (7.40%) among market herbalists and Garcinia kola (10.15%), Cyperus esculentus (06.09%), Citrus aurantifiola (06.09 %) among traditional healers. The recipes composed of 1 to 7 plants prepared mainly in the form of maceration and trituration.

Conclusion : Beninese flora has a variety of plants used in the treatment of male infertility. This study provided for the first time a list of medicinal plants used for the treatment of male infertility in southern Benin. Further pharmacological and toxicological studies may be undertaken for the scientific validation of the therapeutic effect of these medicinal plants.

1. 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 [1]. Nowadays, it is a real public health problem because of its prevalence, widespread distribution and the difficulties inherent in its management [2]. In 2004, the World Health Organization had estimated that 60 to 80 million people in the world were unable to give birth, one person over ten people [3]. Epidemiological data conclude that about 15% of couples go through troubles in having children and refer to physicians in search of solutions [4]. 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 [5].

Of all the continents, Africa is the most affected by this reproductive health problem with variations from one region to another [6, 7]. Male infertility is a contributing factor in 40% of infertility cases, 40% were related of women and 20% of both sexes [8, 9].

Male infertility often results in a quantitative and qualitative deficit of male reproductive cells [10]. Males with sperm parameters below the WHO normal values are considered to have male factor infertility [11]. 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 [12]. The problem with sperm count, motility, and morphology stems from disarray in control mechanism, including pre-testicular, testicular, and post-testicular factors [13].

Several reasons can lead to male infertility. It can be a hormonal imbalance [14], genetic anomaly [15, 16], systemic disease[17], spermatogenic defect [18], microbial infections [19], immunological disorders [20], endocrine disruptors [21], environmental pollutants and lifestyle [22] (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 [23].

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 galangal* [24]; *Rosmarinus officinalis* [25]; *Ficus carica* [26]; *Tribulus terrestris* [27, 28]; *Cardiospermum halicacabum* [29]; *Urtica dioica* L. [30]; *Camellia sinensis* [31]; *Withania somnifera* [32] etc…

Benin, a West African country, has an interesting ethnopharmacological potential. The investigation of Adjanohoun et al. [33] documented nearly 501 plant species and that of Akoègninou et al. [34] 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 [35–37]. 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.

2. Materials And Methods

2.1. 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 four 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 17109 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% [38]. 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 [39]. 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 [40]. 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%) [41]. The dominant economic activities are trade and agriculture. Market gardening, livestock farming, fishing, crafts and tourism are also practiced.

2.2 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.

2.3 Data collection

Ethnopharmacological investigation was conducted by questioning each individual traditional healer and market herbalists using the method of semi-structured interview [42–44]. 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).

2.4 Identification of plant species

The species mentioned by the markets herbalist were purchased and those indicated by the traditional healers were harvested. Herbaria were formed from these samples. The taxonomic identification of these species (scientific name, family) was made at the National Herbarium of Benin of the University of Abomey-Calavi. The full name of the plant species was searched in the Prota4u database.

2.5 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).

2.5.1 Informant Consensus Factor (ICF),

The Consensus Factor help to evaluate the degree of homogeneity of the information given by the respondents [45]. It is determined by informant category by formula:

ICF = Nuc – Ns / Nuc – 1 [46]

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.

2.5.2 Frequency of citation (FC)

The frequency of citation for each of the listed species has been calculated using the formula used by several authors [46–48]:

FC = NP / NT

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

2.5.3 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. [46] and Kouassi et al. [47]. It allowed to know the frequency of implication of a plant in the recipes and expressed by the following formula:

Cpr = (Nr / Nt) x 100

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

3. Results

3.1 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 [42, 49–52]. 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 (40–60) had more knowledge than less aged respondents (20–39).

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.

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	44	
Year of experience	0-10ans	11	12	0.069
	11-20ans	50	56	
	> 20ans	29	32	
Age	20 -39	17	19	0.0001
	40-60	65	72	
	> 60	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	

3.2 Ethnopharmacological data analysis

3.2.1 Informant Consensus

The informant consensus factor reflects a good knowledge of medicinal plants and a collective knowledge of their uses [45, 53]. 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.

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

3.2.2 Diversity of medicinal plants and their use value

60 plant species belonging to 57 genera and 40 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 [34] and 5.12% of the flora in southern Benin with 1170 species [40]. In addition, the listed plant species belong at different botanical families. The most represented were Annonaceae (10%), Arecaceae (10%), Euphorbiaceae (10%) and Musaceae (7.5%) (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* (10.09%), *Cissus populnea* (10.09%), *Carpolobia lutea* (7.40%), *Xylopia Aethiopica* (7.40%), *Cocos nucifera* (5.50%). Among traditional healers, 47 medicinal plants were identified on the basis of the 59 recipes that provided identified among these informants. The most plants cited were *Garcinia kola* (10.15%), *Cyperus esculentus* (06.09%), *Citrus aurantifiola* (06.09%), *Rourea coccinea* (5.08%), *Annona senegalensis* (5.08%) (Table 3).

Table 3

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

N°	Scientific name of the plant	Botanical Family	Vernacular name (Fon)	Parts used	FC (%)	Cpr (%)	MP	Adm	Previous references
1	*Abrus precatorius L.*	Fabaceae	Viviman Kannon	Roots	1.01	1.43	Mac	Oral	[73] [74–78]*
2	*Acalypha crenata* Hochst. ex A.Rich.	Euphorbiaceae	Djividjivi	Leaves	0.34	1.43	Dec ; Pow	oral	
3	*Acridocarpus smeathmannii (DC.) Guill. & Perr.*	Malpighiaceae	Gbanguina	Roots	1.68	5.71	Dec ; Mac	oral	
4	*Adansonia digitata L*	Bombacaceae	kpassa	Bark	0.67	1.43	Mac	oral	[79]
5	*Aframomum sceptrum (Oliv. & T.Hanb.) K.Schum.*	Zingiberaceae	Attakoun	Seed	3.36	5.71	Mac ; Pow	oral	[80]
6	*Allium sativum L.*	Alliaceae	Ail	Bulb	1.01	2.86	Mac	oral	[81–83] [84]*
7	*Annona senegalensis Pers.*	Annonaceae	Gniglwe	Leaves	3.69	4.29	Tri	oral	[85]
8	*Argemone mexicana L.*	Papaveraceae	Houètchegnon	Leaves	0.67	1.43	Tri	oral	
9	*Bombax brévicuspe*	Bombacaceae	kpatin dèhoun	Roots	0.34	1.43	Mac	oral	
10	*Borassus aethiopum Mart.*	Arecaceae	Agonté	Roots	0.67	1.43	Pow	oral	
11	*Bridelia ferruginea Benth.*	Euphorbiaceae	Houssoukokwé	Fruit	0.34	1.43	Dec.	oral	[86]
12	*Butyrospermum paradoxum subsp. parkii (G. Don) Hepper*	Sapotaceae	wugo	Bark	0.34	1.43	Pow	oral	
13	*Bryophyllum pinnatum (Lam.) Oken*	Crassulaceae	Affaman	Leaves	0.34	1.43	Tri	oral	
14	*Caesalpinia bonduc (L.) Roxb.*	Césalpiniaceae	Adjikouindô	Roots	0.34	1.43	Mac	oral	[87, 88]*
15	*Calotropis procera (Aiton) R.Br.*	Asclépiadaceae	Kpintoman	Leaves	0.67	1.43	Tri	oral	[89, 90]*
16	*Carica papaya L.*	Caricaceae	Papayer	Roots	1.01	1.43	Mac	oral	[91, 92]*
17	*Carissa spinarum L.*	Apocynaceae	Ahanzo	Roots	1.34	4.29	Dec ; Mac	oral	
18	*Carpolobia lutea G.Don*	Polygalaceae	Aviadô	Roots	3.02	8.57	Dec ; Mac	oral	[93, 94]
19	*Cassytha filiformis L.*	Lauraceae	Agbegbekan	Whole plant	4.03	4.29	Tri	oral	
20	*Centella asiatica (L.) Urb.*	Apiaceae	Sakan	Leaves	0.34	1.43	Tri	oral	[95] [96–98]*

21	*Cissus petiolata Hook.f.*	Vitaceae	Assankan wéwé	Stem/Roots	2.01	7.14	Mac	oral	
22	*Cissus populnea Guill. & Perr.*	Vitaceae	Assankan ou Dèdô	Roots	6.71	10	Mac	oral	[60, 99, 100]
23	*Citrus aurantifolia (Christm. & Panzer) Swingle*	Rutaceae	Klé	Fruit	4.36	7.14	Mac ; Tri	oral	[101, 102] [103, 104]*
24	*Cocos nucifera L.*	Arecaceae	Cocotier	Fruit	4.36	10	Mac	oral	[61, 105]
25	*Cola acuminata (P.Beauv.) Schott & Endl.*	Sterculiaceae	vi	Seed	0.34	1.43	Mac	oral	[106]*
26	*Cola nitida (Vent.) Schott & Endl.*	Sterculiaceae	Cola rouge	Seed	1.01	2.86	Mac ; Tri	oral	[107–109]*
27	*Connarus africanus Lam.*	Connaraceae	Ganganlissè	Leaves	0.34	1.43	Tri	oral	
28	*Croton lobatus L.*	Euphorbiaceae	Alôvi aton	Bark	0.67	2.86	Mac	oral	
29	*Cyperus esculentus L.*	Cyperaceae	Fio	Fruit	5.03	14.29	Mac ; Pow	oral	[58, 62]
30	*Desmodium velutium*	Fabaceae	Trèdavorhou	Roots	1.68	5.71	Mac ; Raw	oral	
31	*Dichapetalum madagascariense Poir.*	Chailletiaceae	Gbaglo	Leaves	0.34	1.43	Dec	oral	
32	*Elaeis guineensis Jacq.*	Arecaceae	Palmier	Stem	2.35	4.29	Mac ; Tri	oral	[110, 111]
33	*Ficus carica*	Moraceae	Votin	Fruit	0.67	1.43	Pow	oral	[26]*
34	*Flacourtia flavescens Willd.*	Flacourtiaceae	Gbohounkadjè	Roots	0.67	1.43	Mac	oral	
35	*Garcinia kola Heckel*	Clusiaceae	Ahowé	Seed	10.40	31.43	Mac ; Dec ; Pow ; Tri	oral	[57, 59] [112–114]*
36	*Gardenia ternifolia Schumach. & Thonn.*	Rubiaceae	Dakpla Asu	Roots	1.68	5.71	Mac ; Pow	oral	
37	*Hybanthus enneaspermus (L.) F.Muell.*	Violaceae	Abiwèlè	Leaves	1.01	2.86	Pow	oral	
38	*Imperata cylindrica (L.) Raeusch.*	Graminea	Sê	Roots	1.01	1.43	Mac	oral	[115]*
39	*Manihot esculenta Crantz*	Euphorbiaceae	Manioc	Fruit	2.01	7.14	Pow	oral	
40	*Mondia whitei (Hook.f.) Skeels*	Asclepiadaceae	Chririgoun	Roots	2.01	4.29	Mac	oral	[116] [117]*
41	*Monodora myristica (Gaertn.) Dunal*	Annonaceae	Sasalikoun	Seed	0.67	1.43	Mac	oral	

42	*Morinda lucida Benth.*	Rubiaceae	Houinssindô	Roots	0.67	2.86	Mac ; Dec	oral	[118]*
43	*Musa chinensis Sweet.*	Musaceae	kokwé sotoumè	Fruit	0.67	1.43	Pow	oral	
44	*Musa paradisiaca* L.	Musaceae	Kokwé alôga	Fruit	3.69	8.57	Pow ; Raw	oral	[119, 120]
45	*Musa sinensis Sagot ex Baker*	Musaceae	Goukokwé	Fruit	0.67	2.86	Mac ; Pow	oral	
46	*Newbouldia laevis Seem. ex Bureau*	Bignoniaceae	Hyssope	Roots	1.01	1.43	Mac	oral	[121, 122]
47	*Ocimum gratissimum* L.	Lamiaceae	Tchiayo	Leaves	0.67	1.43	Pow ; Dec	oral	[123, 124]*
48	*Pachycarpus lineolatus (Decne.) Bullock*	Asclepiadaceae	Agboaguin	Roots	2.35	5.71	Mac ; Pow	oral	
49	*Phoenix dactylifera* L.	Arecaceae	Datte	fruit	0.34	1.43	Mac	oral	[125–128]
50	*Piper guineense Schumach. & Thonn.*	Piperaceae	Linlinkoun	fruit	1.01	1.43	Pow	oral	[129, 130]
51	*Prosopis africana (Guill. & Perr.) Taub.*	Mimosoideae	Kakè	Roots	0.67	1.43	Mac	oral	
52	*Pupalia lappacea (L.) A.Juss.*	Amaranthaceae	Trèdagbokor	Flower/leave	0.34	2.86	Pow ; Tri	oral	
53	*Psidium guajava* L.	Myrtaceae	Kinkounman	Leaves	2.68	1.43	Dec	oral	[131, 132]
54	*Rourea coccinea (Thonn. ex Schumach.) Benth.*	Connaraceae	Vikplomba-Ganganlissè	Leaves	1.68	8.57	Tri ; Pow	oral	[133]
55	*Sesamum indicum* L.	Pédaliaceae	Agborman	Leaves	1.01	2.86	Tri	oral	[134]
56	*Spondias mombin* L.	Anacardiaceae	Akounkonman	Leaves	0.67	1.43	Tri	oral	[135] [136]*
57	*Uvaria chamea* L.	Annonaceae	Aylaha	Roots	2.01	5.71	Dec, Mac	oral	
58	*Xylopia aethiopica (Dunal) A.Rich.*	Annonaceae	kpedjelekun	Seed	3.02	5.71	Mac	oral	[137, 138] [139]*
59	*Zea mays* L.	Poaceae	Maïs	Fruit	1.34	2.86	Dec	oral	
60	*Zingiber officinale Roscoe*	zingibéraceae	Dotè	Seed	1.01	2.86	Tri ; Mac	oral	[140–143]

Legend: FC= Citation of Frequency; **Cpr:** contribution of each species to drug receipes; **MP:** Mode of preparation; **Mac**: Maceration; **Tri**: Trituration; **Pow:** Powder; **Dec**: Decoction **Adm**: Administration; ( )*= activity antifertility

3.2.3 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).

3.2.4 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 oligo-azoospermia treatment (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*, and *Carpolobia lutea* each was involved in making up 8.74% of recipes. Among the plants with a low contribution (01.43%), there are *Abrus precatorius*, *Borassus aethiopum* and *Caesalpinia bonduc*.

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 one 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.

4. 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 [42, 49–52].This can be explained by the fact that in traditional Beninese medicine, traditional healers are considered specialists 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 [42, 43, 52, 54]. 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 [42]. 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. [33] to date [48, 52, 55]. 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 [41]. 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 57 genera and 40 Botanical families. This diversity of medicinal plants is greater than 31; 26 and 21 plant species listed respectively by Erhabor et al. (40) in North West Nigeria, Coulibaly and Yapi [37] in Yopougon, in Ivory Coast and Tsobou et al [35] in Cameroon. This reflects a diversity of plants used for the treatment of male infertility in southern Benin. The most botanical families represented were Annonaceae, Arecaceae and Euphorbiaceae. These results are in agreement with those of Tsobou et al. [35] obtained in Cameroon but contrary to those obtained by Erhabor et al.[56]. 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 relatively the most used among market herbalists while among traditional healers, *Garcinia kola*, *Cyperus esculentus and Citrus aurantifiola* 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. Subsequent 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 [57]. In Nigeria, an aqueous extract of *Cyperus esculentus* administered to Wistar rats during nine weeks assured weight growth of testis and epididymis, an increase in the number and motility of spermatozoa [58]. Polyphenolic fractions of *Garcinia Kola* showed a prophylactic effects on the histology and hormones of the pituitary-testicular axis of male Wistar rats [59]. 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 [60]. In the same way, *Cocos nucifera* water improved reproductive indices in the Wistar rat [61]. 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 [62]. 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 [63]. Indeed, it is well documented that oxidative stress is one of the major causes of male infertiliyt [64]. 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 [63]. 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. Joy et al. [66] and Fleurentin et al. [67] 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 [68, 69]. This form of association of various plant species in the treatments could present risks of interaction or toxicity [70]. 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 [51] and infections [48, 52] 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 [44]. 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 [44, 72].

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. [71] 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 RDC. 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. Subsequent toxicological and pharmacological studies will assess the toxicity and efficacy of these plants in the treatment of sperm abnormalities.

Declarations

Ethical approval and consent to participate
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 number 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.
Consent to publication
Not applicable
Availability of data and material
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.
Competing interests:
No conflict of interest
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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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Figures

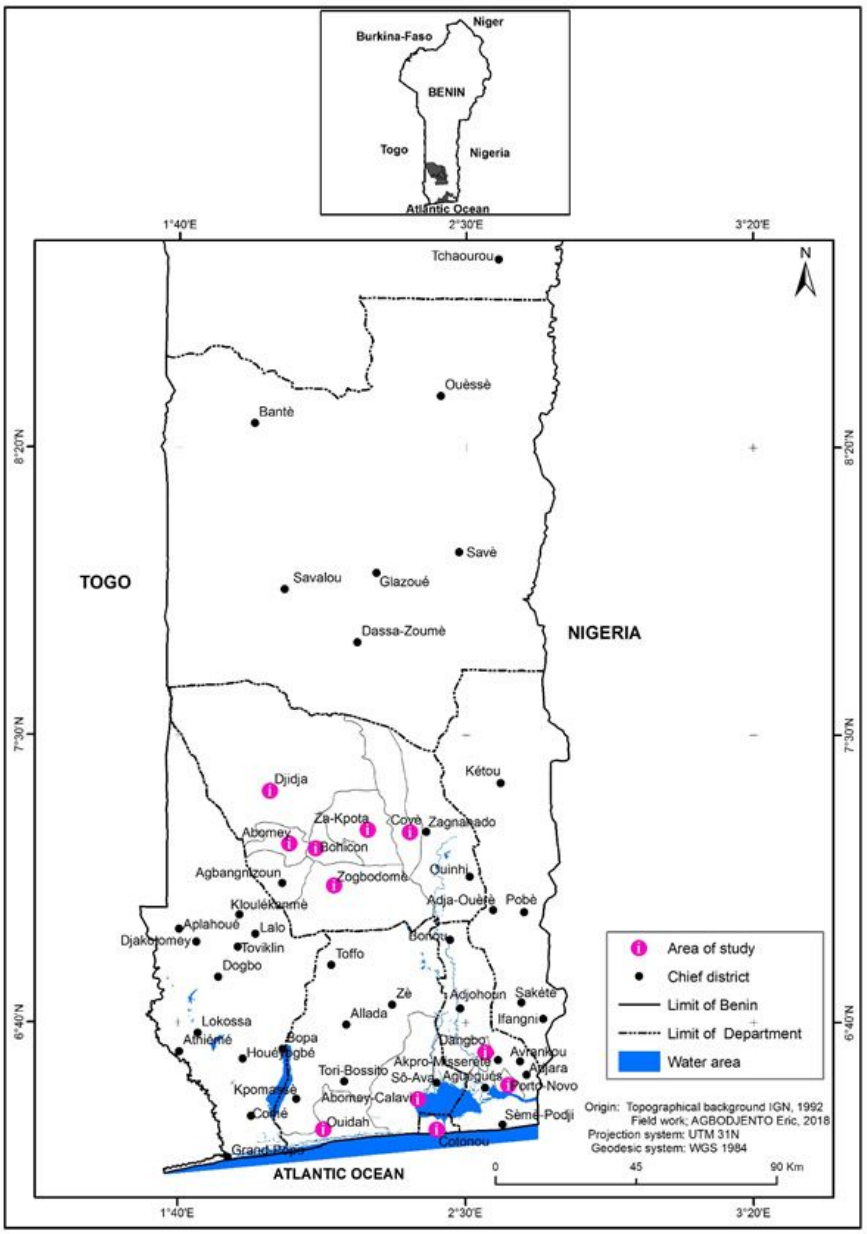

Figure 2

Map of southern Benin showing the municipalities surveyed

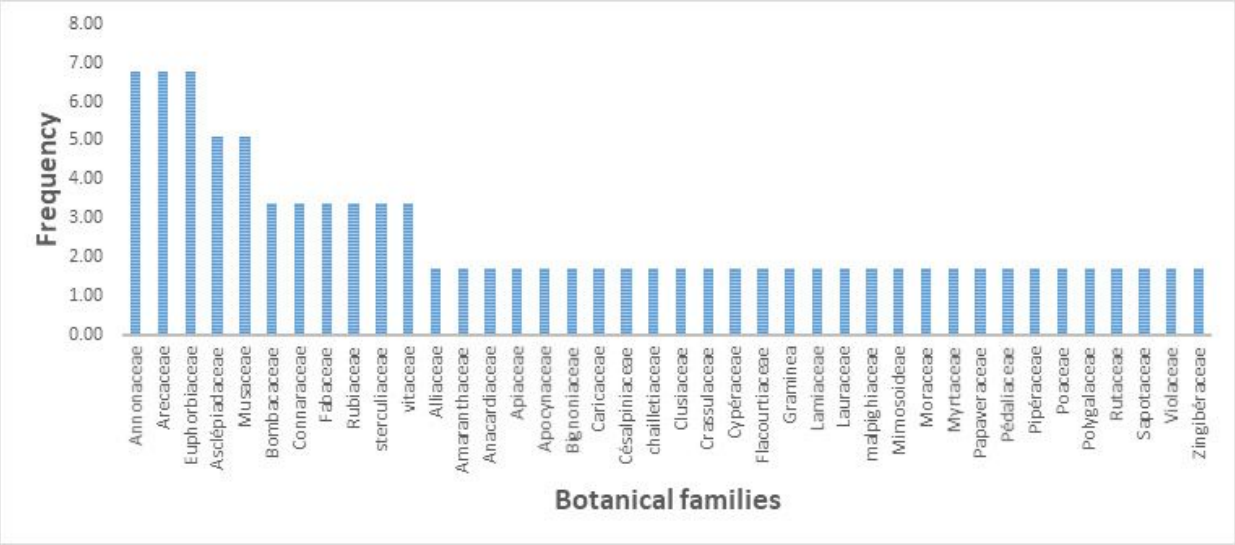

Figure 4

Frequency of botanical families represented

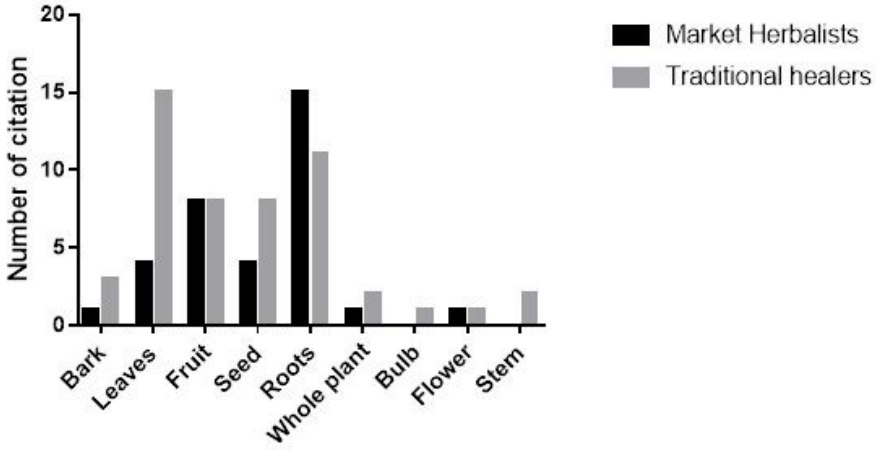

Figure 6

Parts of plant used by the respondents

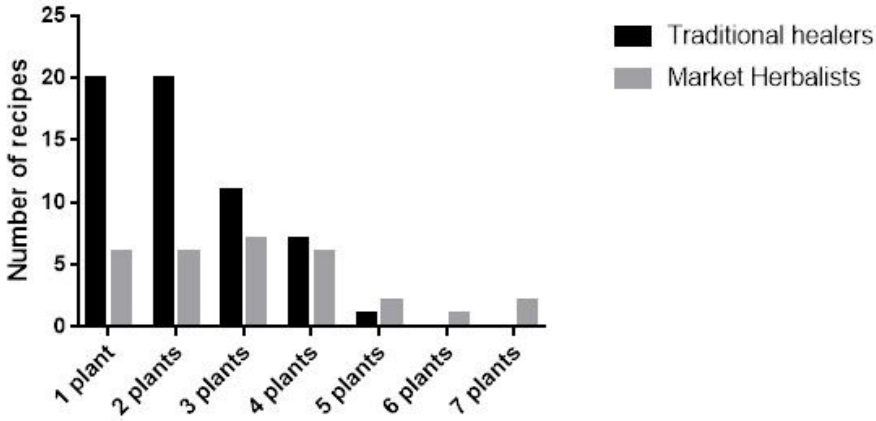

Figure 8

Number of plants according to recipes

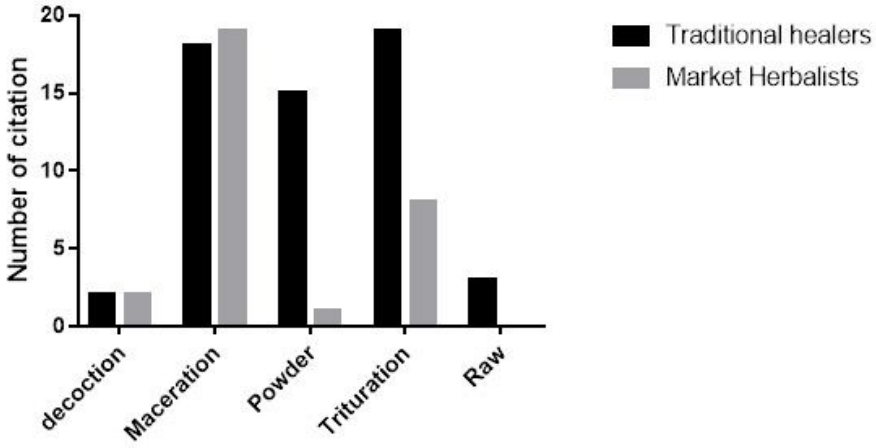

Figure 10

Method of preparation of recipes