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Ethno-botanical, ethno-pharmacological and phytochemical characterization of tiger nut nutritional tubers cultivated and marketed in Benin

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Abstract
Yellow nutsedge (*Cyperus esculenstus*) is a weed plant with significant phytotherapeutic benefits. This work has made it possible to characterize through an ethnobotanical and ethnopharmacological survey the tiger nut tubers grown and marketed in Benin and to investigate the major phytochemical families contained therein. Thus, the two objectives aim to characterize tiger nut tubers through an ethnobotanical and ethnopharmacological survey and to investigate the major phytochemical families contained in tiger nut tubers. The methodology adopted consisted of carrying out a survey in different environments identified by stratified sampling techniques based on a prepared and corrected questionnaire. Then, the phytochemical screening is carried out on the tubers and the leaves of the variety according to the 3 varieties considered. The 100 survey respondents are made up of 42% of Otamari followed by 21% of Idaacha, 16% of Ditamaris, 12% of baribas and 9% of M'bèrèmè whose modal age class is represented by the 45-59 age group. As for ethnobotanical knowledge, reproductive problems account for more than 54% of the causes of tiger nut consumption, followed by 18% of problems relating to the digestive tract, increased blood, stomach aches and lactation. Then the treatment consists in consuming tubers directly with a percentage of 62%. As for the dosage of use, tiger nut tubers can be tied to the neck, chewed or infused. 24% of respondents say that to treat diseases from tiger nut, you have to use the beads to make a necklace and attach it to your neck. 45% believe that the best way to treat diseases from nutsedge is to chew the tubers and spit out the fibers. As for the remaining 31%, they think that tiger nut tubers should be infused and take 1 glass a day. It appears from the phytochemical screening that all three varieties contain 3 chemical groups, namely: Reducing compounds; Mucilages and Steroids. But unlike the other two varieties, the black one also contains a fourth compound, Leuco anthocyanes. Moreover, none of the three varieties does not contain toxic compounds such as cyanogenic derivatives and cardiotonic glycosides. The consumption of tiger nut leaves could induce health risks. On the other hand, the consumption of tubers does not present any risk. In addition, black tubers have the ability to eliminate free radicals in addition to those common to different varieties.

Keywords: Nutsedge tubers and leaves; Ethnobotanical and ethnopharmacological survey, Phytochemical screening, Food

Introduction
Plant resources form an important part of biological diversity. A distinction is made between cultivated and genetically improved plants and wild plants. These last taken from the wild, are called picking plants. These are generally plants that grow spontaneously without any human influence or even protected, maintained or domesticated plants or finally plants that are sown or cultivated (Okigbo, 1976) [1]. Yellow nutsedge (Cyperus esculenstus) is a perennial plant belonging to the Cyperaceae family (Aké, 2006) [2]. According to Alegria-Toran *et al*. And Farré-Rovira (2003) [3], yellow nutsedge, has a proximal composition of: 26% water content; 24.49 g of lipids; 8.91g of fiber; 5.04 g of protein; 15.42 g of total sugars and 43.30 g of carbohydrates. Beyond its nutritional and economic advantages, this weed plant has phytotherapeutic advantages. Thus, tiger nut is consumed by several populations for the lactogenic and aphrodisiac virtues supposedly associated with it (Mason *et al*., 2005; Muhammad *et al*., 2011) [4, 5]. The yellow variety gives more milk, contains less fat, more protein and fewer antinutritional factors, in particular polyphenols (Okafor *et al*., 2003) [6]. Tiger nuts are rich in dietary fiber (Toràn and Rovira, 2003) [3], which may be effective in the treatment and prevention of many diseases, including colon cancer (Adejuyitan *et al*., 2009) [7], coronary heart disease (Chukwuma *et al*., 2010) [8], obesity, diabetes, gastrointestinal disorders (Anderson *et al*., 2009) [9]. Tiger nut has been reported to be used in the treatment of flatulence,

indigestion, diarrhea and dysentery and its starch content likely provides prebiotic properties to bacteria in the colon (Toràn and Rovira, 2003) [3]. In view of the significant quantity of tiger nut grown and marketed in Benin, it is useful to know the phytotherapeutic advantages offered by the varieties of tiger nut from Benin. Thus, in order to verify the phytotherapeutic activity of tiger nut tubers, it is necessary to research the families of phytotherapeutic molecules present in the tubers and to associate them with the food uses of the populations of Benin.

Material and Methods

Study Framework

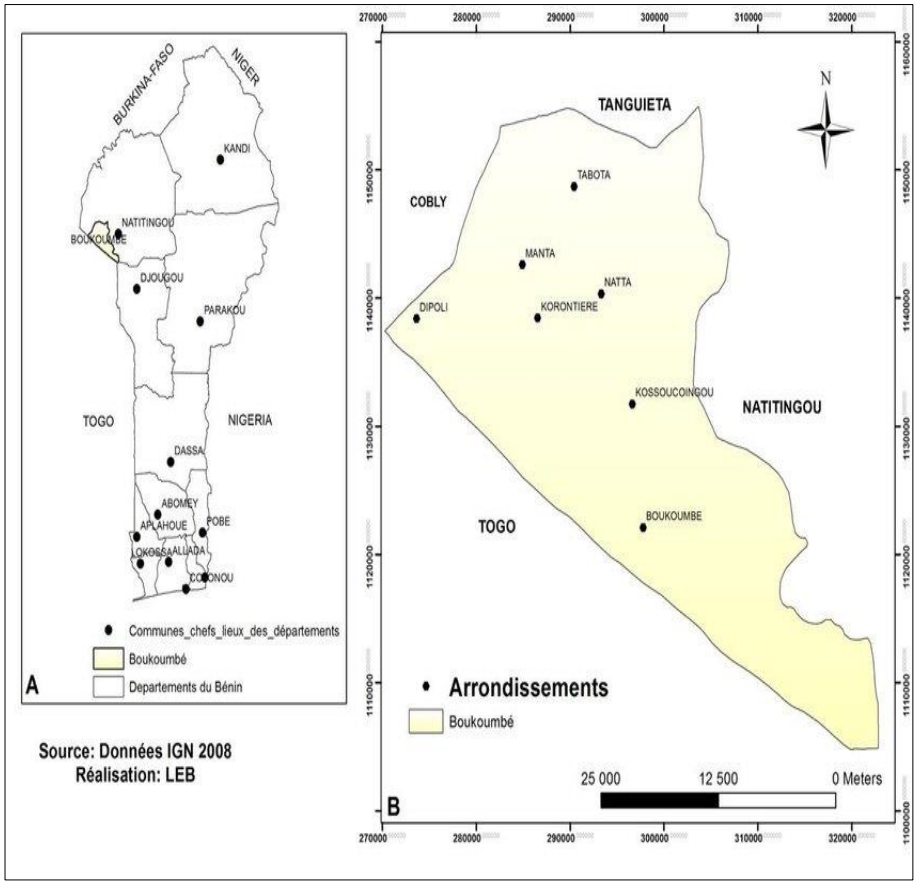

Fig 1: Map of Tiger nut Production areas in Benin

Technical material

For ethnobotanical and ethnomedicinal studies, conventional equipment made it possible to have access to plants and to take samples. In connection with the phytochemical screening, we used an oven at 33 °C to dry the samples that had become damp, before spraying them using an electric grinder. We used an electric balance for the different weighings, a water bath at 37 °C. A sand bath was used to evaporate the extracts in porcelain capsules. We had a water heater. This equipment also included spatulas for taking drug powders, absorbent cotton used as a filter, a protective hood against the powders ejected during the spraying of drugs, a trituration rod and tongs.

Plant material

The study required material represented by various tubers and tiger nuts leaves which were pulverized and used for the preparation of etheric, methanolic and aqueous extracts. After collection, the used parts of the plant (leaves and stems) were dried in a well-ventilated place, at room temperature and protected from light to avoid any modification or degradation of the constituents present. After drying, these parts were cut into small pieces, then subjected to extractions in order to extract the different classes of chemical compounds contained in our plant for phytochemical and biological tests.

Methods

Ethnobotanical Characterization of Different Varieties of *Cyperus esculentus*

The location of the different survey environments is identified by stratified sampling techniques (Daget and Godron, 1982, in Kahouadji 1986) [10, 11]. These techniques seem appropriate to us for carrying out varied ethnobotanical surveys from one area to another in the region studied. We delineated and surveyed as many areas as possible in the region studied. For this, two field campaigns are planned. And with the help of prepared and corrected questionnaires, we conducted ethnobotanical surveys in the region studied in order to have as much information as possible concerning the use of tiger nut by the local population. The identification of the samples, collected in the field, is made at the National Herbarium of Benin, using the herbaria available. Computer processing enabled the analysis of the data collected during our ethnobotanical surveys. For this, the computer software SPSS (System Package for Social Sciences, version 11.5) is used to perform a set of efficient operations in a short time. Our data were put together in a double-entry table K (i x j) and presented as rows that correspond to observations and columns to variables.

Ethnopharmacological Characterization of Different Varieties of *Cyperus esculentus*

The ethno-pharmacological characterization of the different varieties of tiger nut will be done through investigations that are carried out by ethno-medicinal approaches with traditional medicine actors, especially traditional healers and tiger nut traders in the major markets of Benin. Meetings with traditional healers are facilitated by a resource person from the region visited. For the quality of the data collected, they are coupled with collections of botanical samples. Among traditional healers, the method used is that of the semi-structured interview. The protocol for the collection of samples will be based on the purchase of recipes used in the treatment of ailments, like any sick person, who comes to seek the herbalist for treatment. The botanical and ethnobotanical characteristics relating to the plants used, their use in single recipes or in combination, the organs used, the methods of preparation, administration, dosage are noted and all the specimens are collected. The review of the literature on the medical potential of plants of the Cyperus genus, particularly from West Africa, will provide additional information. After coding, the data collected is analyzed using SPSS software (Statistical Package for the Social Sciences) version 16.0 to determine descriptive statistics in terms of percentage and mean. These quantitative data are then subjected to an analysis of variance (ANOVA) using the PROC GLM procedure of SAS software (Statistical Analysis System) version 9.2. Multiple mean comparisons are made with the Student Newman-Keuls test (Dagnelie, 1998) [12].

Phytochemical screening

Phytochemical screening will be carried out on the tubers and leaves of the variety according to the 3 varieties considered. The different chemical groups are identified according to the method presented in the following table:

Table 1: Highlight test and observations of phytochemicals

Phytochemicals compounds	Demonstration test	Reaction (positive results)
Alkaloids	Mayer's reagent Yellowish-white precipitate Dragendorff's reagent	Orange-red precipitate
Tannins	Ferric chloride	Blue-black coloring
Catechic Tannins	Stiasny's reagent	Precipitated pink
Gallic tannins	Ferric chloride and saturation with sodium acetate	blue tint
Flavonoids	Shinoda test with magnesium powder	orange coloring
Anthocyanines	50% hydrochloric acid and ammonia	Purple red color
Leuko-anthocyanins	Shinoda's reaction	Brown red coloring
Quinone Derivatives quinoniques	Born-trager's reagent	Pink or purplish red color
Saponosids	Foam index test	Significant presence of foam of at least 1 cm
Triterpénoids	Liebermann-Buchard reaction.	Blue, green or purple coloring
Stéroids	Kedde's reaction	Wine red coloring
Mucilages	Absolute alcohol test	Flaky precipitates
Reducing Compounds	Fehling liquor test	Precipitated brick red
Free Anthracenic	Test with chloroform and ammonia	No red coloring
Combined Anthracéniques Ohétérosides	Hydrochloric acid test with chloroform and ammonia	Red coloring
Cheteroside Combined Anthracenics	FeCl3 test with chloroform and ammonia	Red coloring

Source: Houghton & Raman (1998) [13].

Result and observations

Socio-demographic characteristics of respondents

Table 2 shows the distribution of educated respondents by age group, municipality and gender.

Table 2: Proportion (%) of respondents

Municipality	Sex	Ages					Total	
		[15-30]		[30-45]		[45-60]		
		FE	NFE	FE	NFE	FE	NFE	
Boukoumbé	F	1	2	2	6	1	6	18
	M	0	3	2	4	3	11	23
	T	1	5	4	10	4	17	41
Cobly	F	0	1	0	2	0	3	6
	M	0	1	0	4	0	0	5
	T	0	2	0	6	0	3	11
Matéri	F	0	0	1	1	0	0	2
	M	0	0	0	0	1	3	4
	T	0	0	1	1	1	3	6
Tanguiéta	F	1	0	0	2	0	2	5
	M	0	0	1	1	0	2	4
	T	1	0	1	3	0	4	9
kérou	F	1	0	0	1	0	2	4
	M	0	2	0	3	1	2	8
	T	1	2	0	4	1	4	12
Savè	F	0	1	1	2	0	0	4
	M	0	1	0	0	1	3	5
	T	0	2	1	2	1	3	9
Dassa-Zounmè	F	0	1	0	2	0	2	5

	M	0	1	0	5	0	1	7
	T	0	2	0	7	0	3	12
Total		3	13	7	33	7	37	100

FE: Formal Education; NFE: No Formal Education; F: Female; M: Male

Respondents vary from one municipality to another according to gender, age groups and level of education (Table 2). The proportion surveyed is mainly made up of 56% men and 44% women. 41% of the sample comes from the commune of Boukoumbé. The modal age group is between 45 and 60 years old and represents 44% of the total number of respondents. Furthermore, most of the respondents are uneducated. The proportion of uneducated respondents in all municipalities is estimated at 83%, of which 37% belong to the age group of 45 to 60 years.

Distribution of sociolinguistic groups

The proportions of respondents by municipality vary from one sociolinguistic group to another, depending on age (Table 3).

Table 3: Breakdown of sociolinguistic groups according to age and municipality

Age		Groupe sociolinguistiques des répondants													
		Otamari	Lokpa	Bariba	Dendi	Agni	Peulh	Itcha	Mahi	Idaacha	Fon	Nago / Yoruba	Ifè	M'bèrèmè	Ditamari
Boukoumbé	[15-30]	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	[30-45]	14	0	0	0	0	0	0	0	0	0	0	0	0	0
	[45-60]	19	0	0	0	0	0	0	0	0	0	0	0	0	2
	Total	39	0	0	0	0	0	0	0	0	0	0	0	0	2
Cobly	[15 - 30]	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	[30 - 45]	2	0	0	0	0	0	0	0	0	0	0	0	0	4
	[45 - 60]	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	Total	3	0	0	0	0	0	0	0	0	0	0	0	0	8
Matéri	[15 - 30]	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[30 - 45]	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	[45 - 60]	0	0	0	0	0	0	0	0	0	0	0	0	0	4
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Tanguiéta	[15 – 30]	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	[30 - 45]	0	0	0	0	0	0	0	0	0	0	0	0	4	0
	[45 - 60]	0	0	0	0	0	0	0	0	0	0	0	0	4	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	9	0
kérou	[15 - 30]	0	0	3	0	0	0	0	0	0	0	0	0	0	0
	[30 - 45]	0	0	4	0	0	0	0	0	0	0	0	0	0	0
	[45 - 60]	0	0	5	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	12	0	0	0	0	0	0	0	0	0	0	0
Savè	[15 - 30]	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	[30 - 45]	0	0	0	0	0	0	0	0	3	0	0	0	0	0
	[45 - 60]	0	0	0	0	0	0	0	0	4	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	9	0	0	0	0	0
Dassa-Zounmè	[15 - 30]	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	[30 - 45[	0	0	0	0	0	0	0	0	7	0	0	0	0	0
	[45 - 60[	0	0	0	0	0	0	0	0	3	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	12	0	0	0	0	0

The most represented sociolinguistic groups are the Otamaris in Boukoumbé (39%), Ditamari in Cobly Matéri (8% and 6% respectively), M'bèrèmè (9%) in Tanguiéta, Bariba (12%) in Kérou, and Idaacha in Savè and Dassa-Zounmè (9% and 12% respectively).

Distribution of years of experience

Distribution of respondents according to experience, gender and municipality (Table 4).

Table 4: Distribution of years of experience according to municipality and sex

	Commune	Age groups	Sex		Total
			Male	Female	
Years of experience	Boukoumbé	[0 - 5]	10	11	21
		[5 - 10]	4	4	8
		[10 - 15]	9	3	12
		[15 - 20]	0	0	0
		Total	23	18	41
	Cobly	[0 - 5]	1	1	2
		[5 - 10]	0	0	0
		[10 - 15]	4	5	9
		[15 - 20]	0	0	0
		Total	5	6	11
	Matéri	[0 - 5]	3	1	4
		[5 - 10]	0	0	0
		[10 - 15]	1	1	2

		[15 - 20]	0	0	0
		Total	4	2	6
	Tanguiéta	[0 - 5]	4	3	7
		[5 - 10]	0	0	0
		[10 - 15]	1	1	2
		[15 - 20]	0	0	0
		Total	5	4	9
	Kérou	[0 - 5]	8	4	12
		[5 - 10]	0	0	0
		[10 - 15]	0	0	0
		[15 - 20]	0	0	0
		Total	8	4	12
	Savè	[0 - 5]	4	3	7
		[5 - 10]	1	1	2
		[10 - 15]	0	0	0
		[15 - 20]	0	0	0
		Total	5	4	9
	Dassa-Zounmè	[0 - 5]	7	5	12
		]5 - 10]	0	0	0
		[10 - 15]	0	0	0
		[15 - 20]	0	0	0
		Total	7	5	12
	Total	[0 - 5]	37	28	65
		[5 - 10]	5	5	10
		[10 - 15]	15	10	25
		[15 - 20]	0	0	0
		Total	57	43	100

Respondents have years of experience that vary according to gender and age. Respondents to the survey are represented by 57% men and 43% women. The modal class of years of experience falls between the extrema 0 and 5 years. This class brings together 65% of respondents, 21 of whom come from Boukoumbé. Moreover, the Lokpa, Dendi, Agni, Itcha, Fon, Nago/Yoruba ethnic groups do not practice tiger nut cultivation.

Medicinal Uses of Nutsedge Tubers

The figures below show the different conditions that can be cured by tiger nut tubers (Figure 2) and how the drug is prepared (Figure 3).

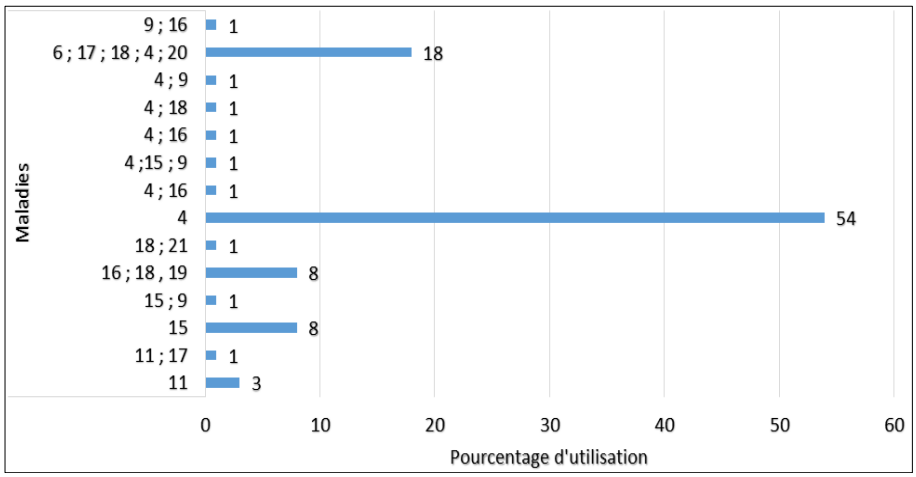

Fig 2: Medicinal uses of tigernut tubers

1 = Dermatological; 2= Respiratory; 3= Cardiovascular; 4= Reproduction; 5= Esteo-articular; 6= Digestive tract; 7= Neurological; 8= ENT (Nose George Ear); 9= Malaria; 10= Hemorrhoid; 11=Dentition; 12= Fever; 13= Epilepsy; 14= Blood (Diabetes); 15= hockey, 16= vomiting, 17= increased blood, 18= stomach ache, 19= cough, 20= lactation, 21= vitamin deficiency, 22= dysentery, 23= diarrhea, 24= Other

Thus, the respondents believe that the following diseases can be cured: reproduction, the digestive tract; malaria; teething; hockey, vomiting, increased blood, stomach pain, cough, lactation and vitamin deficiency. According to the population surveyed, in a medicinal approach, reproductive problems, represented at more than 54%, are the causes of tiger nut consumption, followed by 18% of problems relating to the digestive tract, increased blood, stomach aches and lactation.

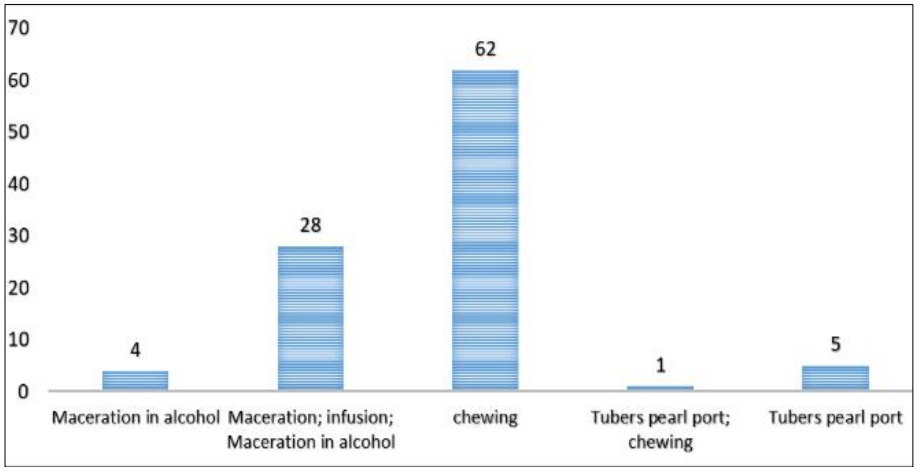

Fig 3: Methods of drug preparation

The drug contained in the tubers maximizes its effects depending on the conditions of its preparation. Thus, through Figure 3, the respondents expressed the best conditions for optimizing the quality of the drug. Figure 3 summarizes the different forms of tiger nut preparation in order to obtain the treatments. The methods of preparation are: the realization of pearl with the tubers, the raw and complete consumption of the tubers directly and the taking of a glass of the maceration of the tubers in alcohol (Sodabi). In order to make a satisfactory treatment, the respondents unanimously considered that the tiger nut tubers must be harvested at maturity and used in the dry state to benefit the most from the drug contained in the tubers. For this purpose, nutsedge tubers should be used in a dry state. The tuber drying process is defined by washing the tubers in sand and drying them in the sun. The common methods of preparing treatments are the consumption of the tubers directly with a percentage of 62%. In order to extract the maximum drug by using the infusion modality, only 2% declare that in case of maceration, 1 liter of water or sodabi is added to 1 kg of tuber. Moreover, the rest of the respondents did not make a point of honor on the amount of water to add to the tubers. Table 19 shows us the modalities of the duration of infusion or decoction to have a good potion. To this end, it appears from this table that 70% think that tiger nut tubers should be infused for 5 to 10 minutes, while the remaining 30% believe that the infusion should last more than 10 minutes.

Nutsedge Phytochemical Characteristics

This part of our study aimed to detect the different families of secondary metabolites by qualitative characterization reactions. As part of this study, the three (03) varieties were also taken into consideration. This study was carried out both on the leaves and on the tubers.

The results were evaluated as follows: +++: Strong positive; ++: Moderately positive; +: Weakly positive; -: Negative.

The three varieties of tiger nut taken into account in our theme were screened at the phytochemical level (Table 5).

Table 5: Characteristics of tiger nuts

	Black nutsedge		**Yellow nutsedge**		**Brown nutsedge**	
	Tuber	**leaf**	**Tuber**	**Leaf**	**Tuber**	**leaf**
Tanins	-	+	-	-	-	+
Catéchics Tanins	-	-	-	-	-	-
Gallics Tanins	-	+	-	-	-	+
Flavonoids	-	-	-	-	-	+
Anthocyans	-	+	-	-	-	+
Leuko anthocyanes	+	+	-	+	-	+
Alcaloids	-	-	-	-	-	-
Réducing Compound	++	+	++	+	++	+
Mucilages	+++	+	+++	+	+++	+
Saponosids	-	-	-	-	-	-
Cyanogénic compounds	-	-	-	-	-	-
Triterpens	-	-	-	-	-	-
Stéroids	++	+	++	+	++	+
Coumarins	-	-	-	-	-	+
Quinonic compounds	-	-	-	-	-	-
Free Anthracénics	-	-	-	-	-	-
C-hétérosids	-	-	-	-	-	-
D-hétérosids	-	-	-	-	-	-
Cardiotonic compound	-	-	-	-	-	-

*: Total number of species containing a given chemical group.

Through this table, we see that the results differ significantly from one matrix to another. The tubers of the black tiger nut variety show that only 3 families of phytochemical groups are represented in them. The said families are as follows. Leuco anthocyanins, reducing compounds and Steroids. Among these three large families, some are more represented than others. Thus we can notice that the mucilages are largely represented (***) followed to the same degree of reaction by

the steroids and the reducing compounds (**) and finally comes in last position the family of the leuco anthocyanins (*). The tubers of the three varieties all contain certain families of chemical groups, namely reducing compounds, mucilages and steroids. But the leuco anthocyanin family is only present in the tubers of the black tiger nut variety. The results of this screening on the leaves show that only seven (07) families of phytochemical groups are represented in the leaves of the black tiger nut sedge variety. These families are: gallic tannins, anthocyanins, leuco anthocyanins, reducing compounds, mucilages and steroids. Furthermore, phytochemical groups such as flavonoids, alkaloids, saponosides, cyanogenic derivatives, triterpenes, coumarins, quinone derivatives, free anthracenics, C-heterosides, D-heterosides, cardiotonic derivatives are not not represented. With regard to the variety of yellow tiger nut, it is noted that the families represented are the leuco anthocyanins, the reducing compounds, the mucilages and the steroids. This therefore implies the absence of other phytochemical groups such as tannins, leuco anthocyanins flavonoids, alkaloids, saponosides, cyanogenic derivatives, triterpenes, coumarins, quinone derivatives, free anthracenics, C-heterosides, D-glycosides, cardiotonic derivatives. As to in the variety of the brown tiger nut, we find that the leaves contain phytochemical families such as Catechic Tannins Flavonoids Anthocyanins Leuco anthocyanins Reducing compounds Mucilages Steroids Coumarins. Like other strains, the leaves of this strain also lack certain phytochemical groups. Among these groups we have: alkaloids, saponosides, cyanogenic derivatives, triterpenes, coumarins, quinone derivatives, free anthracenics, C-heterosides, D-heterosides, cardiotonic derivatives.

Discussion

The objective of this study was to perform the ethnobotanical and ethnopharmacological characterization of tiger nut tubers grown and marketed in Benin. Ethnobotanical study, a contraction of ethnology and botany, is the study of the relationships between plants and humans (Pelt, 2008) [14]. The results showed that the majority of respondents had no formal education. Thus, of the 100 respondents to the survey, practitioners are mostly men and come ahead of women with 56% against 44%. This same observation was made by UNDPBENIN in 2009 when it carried out an ethnobotanical study of the plants used in the treatment of diabetes in pregnant women in Cotonou and Abomey-Calavi (Benin). are illiterate and these results are close to national data and show that the use of medicinal plants remains the prerogative of poor people (PNUDBENIN, 2009) [15]. The age group represented in the practice of this activity is 45-59 years old. These results confirm those of Klotoé because he asserts through his work that herbalists are mostly female and over fifty (50) years old (Klotoé *et al*., 2013) [16]. Of the respondents, 83% have no formal education. Radiotherapists, herbalists, sellers of medicinal plants in traditional medicine are either married, single or widowed. The proportion who are married is 88% followed by that of single people with 2% and finally widowers who represent 10%. In addition, the virtues of plants are ancestral knowledge that is transmitted from generation to generation (Adjanohoun *et al*., 1989; Klotoé *et al*., 2013) [16, 17]. More than 90% of herbalists in the markets surveyed are illiterate and these results are close to national data and show that the use of medicinal plants remains the prerogative of poor people (PNUDBENIN, 2009) [15]. The sociolinguistic groups that use tiger nut for therapeutic purposes are: Gua or Otamari, Bariba, Idaacha, M'bèrèmè and Ditammari. The proportion of Otamari represents 42% followed by Idaacha with 21%, Ditamaris with 16%, baribas with 12% and M'bèrèmè with 9%. Actors with an experience less than or equal to 5 years represent 65% and come first in front of the slice of 6 to 10 years whose number of years of experience is 10% and finally the last slice whose number of years of experience is greater than 10 years is 25%. According to the respondents, 30% think that the tiger nut comes from Koupagou and 24% believe that this species comes from Koutoyagou, 16% think that the tiger nut comes from the Otamari and 10% from Koutoyagou. As for the rest, which represents 74% of the respondents, they believe that the origin of this species is different. Some reasons are at the origin of density change in this species. Among these reasons, we can retain fertilization, the length of the rainy season. But the main reasons for the change in density are: fertilization with a proportion of 58%. The tiger nut is used for several purposes including food and medicine. Referring to the medicinal aspect of tiger nut, different ailments are likely to be cured by taking potions made from tiger nut. Thus, the respondents believe that the following diseases can be cured: reproduction, the digestive tract; malaria; teething; hockey, vomiting, increased blood, diabetes, stomach pain, cough, lactation and vitamin deficiency. Malaria is a disease that can be cured by the use of tiger nut. This observation is confirmed by Giani. However, many have observed that 87% of people suffer from malaria in Burkina Faso, but in the majority of cases, this disease is treated at home (Giani, 2007) [18]. This can be explained by the low income of the respondents, since the majority (30%) live off odd jobs. 75% of those surveyed claim to treat themselves only with plants, in agreement with (Kirby, 1996) [19] for whom more than 80% of the populations of developing countries resort exclusively to plants for treatment. If 75% of respondents claim to treat themselves by plants, only 51% feel that antimalarial plants are effective. Diabetes is one of the most common non-communicable diseases in the world (Jayakumar *et al*., 2010) [20]. According to the WHO, more than 176 million people are affected worldwide (WHO, 2004) [21]. It is estimated that the prevalence, from 2.8% in 2000, will reach 4.4% of the world population in 2030 (Sarah *et al*., 2004; Etuk *et al*., 2010) [22, 23]. Of all the continents, Africa is the continent most affected by this disease (Erasto *et al*., 2005) [24]. This effect that the use of tiger nut can produce on diabetes could also induce retroactive positive effects on the gestational state because the gestational state is a factor in the exacerbation of diabetes with health consequences for the mother and the child (Bory, 2011) [25]. Indeed, during gestation, insulin secretion is sometimes insufficient to meet the body's needs, especially in the postprandial period. This results in a decrease in the tissue uptake of glucose, an increase in the production of glycogen by the liver, and an increase in blood sugar: this is called gestational diabetes (Jordan *et al*., 2007; Vambergue, 2002) [26, 27]. It should be noted that reproductive problems represent 54% of the causes of tiger nut consumption followed by 18% of problems relating to the digestive tract, increased blood, stomach aches and lactation. Compared to the virtues of *Cyperus esculentus*, *Cyperus rotundus* oil is active against Gram-positive microorganisms (Staphylococcus aureus and Streptococcus species) and moderately active against Sarcina lutea, Bacillus subtilis and Mycobacterium phlei and fast-resistant fungi (acids). The oil is completely inactive against Gram-negative microorganisms (El-Gohary *et al*., 2004) [28]. The ethanolic extract of *Cyperus rotundus* showed potent calming activity in numerous tests according to Singh *et al*.,

(1970) [29]. Furthermore, the phytochemical groups identified are not present in all the plants studied. Thus, alkaloids are not found in any herbal drug. Tigernut tubers contain leuco anthocyanins, reducing compounds and steroids and mucilages. Leuco-anthocyanins are phenolic compounds with powerful antioxidant properties that act as free radical scavengers by preventing and fixing the damage caused by them. Free radicals produced during cellular metabolism can be destroyed by antioxidants synthesized in situ or through dietary intake (Ebrahimzadeh *et al*., 2010) [30]. These antioxidants can thus activate the immune defense and reduce the risk of cancer and degenerative diseases (Mpondo *et al*., 2012) [31]. Steroids derived from terpenoids constitute the largest known set of plant secondary metabolites (Yamunadevi *et al*., 2011) [32]. Steroids are secondary metabolites known for their analgesic and cardiotonic properties. They regulate protein and carbohydrate metabolism, increase muscle and bone synthesis and are also associated with hormonal control in women (Hossain *et al*., 2013) [33]. The hormonal control exerted by steroids in women would be in the direction of the reproductive function of women (Bruneton, 2009) [34]. The mucilages are found in the tubers of the three varieties. These mucilages are soluble fibers and also have several medicinal properties. They are anti-cholesterol, anti-constipation, anti-diabetic and anti-cancer (Lin *et al*., 2005) [35]. Reducing compounds are also found in all three varieties. Reducing compounds are monosaccharides and disaccharides (Bruneton, 2009) [34]. However, the results obtained differ from those obtained by Chukwuma *et al*. (2010) [8] by studying the phytochemical potential of the raw and roasted tuber. Phytochemical screening showed that a higher content of alkaloids, sterols and resins than cyanogenic glycosides, saponins and tannins was detected in raw tigernut tubers. Only alkaloids, sterols and resins were detected in roasted tubers. Alkaloids, saponins and tannins are known to have antimicrobial activity as well as other physiological activities (Trease and Evans, 2009) [36]. These differences can be lodged at the level of the matrix used because it is fresh tubers which were used while Chukwuma used roasted tubers. It can therefore be estimated that newly formed compounds are added to the final product.

Regarding the leaves, the results show that they contain gallic tannins, anthocyanins, leuco anthocyanins, reducing compounds, mucilages and steroids. In addition, phytochemical groups such as flavonoids, alkaloids, saponosides, cyanogenic derivatives, triterpenes, coumarins, quinone derivatives, free anthracenics, C-heterosides, D-heterosides, cardiotonic derivatives are absent. Thus the leaves of the black tiger nut and the brown tiger nut are likely to resolve physiological problems relating to the protection of the skin and healing agents, to precipitate salivary glycoproteins. Internally, the consumption of these leaves can solve antidiarrheal problems; antibacterial, antifungal and antiviral; antioxidants; increase in the resistance of capillaries and decrease in their permeability; hypoglycemic agents, counterpoisons of alkaloids and heavy metals. These leaves can also alleviate edematous problems; oxidizing. Its retinal purple regeneration properties promote night vision and anti-bacterial and antiviral activity. These same leaves can solve symptomatic problems of disorders related to venolymphatic insufficiency and capillary fragility (phlebology, proctology and gynecology) and circulatory ophthalmological disorders at the retinal, choroidal level and for the improvement of corpuscular vision. Their high content in reducing sugars gives them the properties of lubricating skeletal joints, cell recognition, antigenic sites, etc. Consuming these leaves may help regulate protein and carbohydrate metabolism, increase muscle and bone synthesis, and control hormones in women (Hossain *et al*., 2013) [33]. The presence of mucilage in the leaves of black tiger nuts allows us to hypothesize that their consumption will be associated with anti-cholesterol, anti-constipation, anti-diabetic and anti-cancer properties. The leaves of the three varieties of nutsedge are likely to increase the resistance of the capillaries and reduce their permeability. These leaves can also induce anti-edematous activities; antioxidant activity; properties that increase the regeneration of retinal purple (promotes night vision) and anti-bacterial and antiviral activity. Anthocyanoside drugs can be used in nature, in the preparation of galenic forms or the isolation of pure anthocyanosides in several treatments, particularly symptomatic treatment of disorders related to venolymphatic insufficiency and capillary fragility (phlebology, proctology and gynecology) and disorders circulatory ophthalmology at the retinal, choroidal level and for the improvement of corpuscular vision. It is also possible to use anthocyanosides are used in the food industry as natural and non-toxic dyes (drinks, jams, confectionery). Reducing sugars are important in many biological roles. They are the major constituents of food. Insoluble sugars also serve as structural material in the cell wall of plants and bacteria as well as in the connective tissues and cell membranes of animals. Sugar polymers also serve to lubricate skeletal joints, have a cell recognition function, antigenic sites, etc. There are therefore a multitude of different types of sugars, making this family of molecules very complex. The functions or applications of each are intimately linked to their structure and conformation. Steroids derived from terpenoids constitute the largest known set of plant secondary metabolites (Yamunadevi *et al*., 2011) [32]. The steroids are secondary metabolites known for their analgesic and cardiotonic properties. They regulate protein and carbohydrate metabolism, increase muscle and bone synthesis and are also associated with hormonal control in women (Hossain *et al*., 2013) [33]. The hormonal control exerted by steroids in women would be in the direction of the reproductive function of women (Bruneton, 2009) [34]. The mucilages are found in the tubers of the three varieties. These mucilages are soluble fibers and also have several medicinal properties. They are anti-cholesterol, anti-constipation, anti-diabetic and anti-cancer (Lin *et al*., 2005) [35]. Reducing compounds are also found in all three varieties. Reducing compounds are monosaccharides and disaccharides (Bruneton, 2009) [34].

The leaves of the brown tiger nut, by the content of coumarins, they have a vitamin P action which consists of increasing the resistance of the capillaries and reducing their permeability. They are used in this way to treat venous disorders (esculoside and esculetol). Coumarin itself has been used for its anti-oedematous, anti-inflammatory and immunostimulant properties, but the multiplication of cases of hepatitis has led to the withdrawal of the corresponding specialties. Coumarin is used in the manufacture of foodstuffs (caramels, confectionery and chewing gum) and also in perfumery. Furocoumarins are mainly photosensitizing, they are indicated for the treatment of psoriasis and vitiligo. Pyranocoumarins are antispasmodics. Thus the leaves of the tiger nut can induce, through their consumption, treatments for venous disorders, oedemas, inflammations. We can therefore consider the possibility of usade of these leaves in the manufacture of some foodstuffs. Among the many works that indicate that flavonoids have anti-inflammatory

properties (Da silva *et al*., 1994; Galati *et al*., 1994; Read, 1995) [37, 38, 39] and that they are capable of modulating the functioning of the immune system (Middleton *et al*., 1996) [40], it can be said that flavonoids are powerful inhibitors of the proliferation of B and T lymphocytes (Mookerjee *et al*., 1986; Namgoong, 1994) [41, 42]. Flavonoids also inhibit platelet adhesion and aggregation. Hispidulin, a methoxyflavone, decreases platelet aggregation, for example, by increasing intracellular levels of camp following inhibition of phosphodiesterases (Roengsumran *et al*., 2000) [43]. They may also have antiviral and antibacterial properties; anti-carcinogenic; antioxidant properties and impact on peroxidation. In addition to the phytotherapeutic benefits offered by these leaves of the brown nutsedge, they can also be used in medicine in the treatment of wounds etc.

Conclusion

The tiger nut is a plant with multiple virtues. The present work, the objective of which was to investigate the uses of this plant and to evaluate the potential, revealed that the different organs of tiger nut (leaves and tubers) have therapeutic virtues. The idea of consuming tiger nut leaves could induce health risks. As for tubers, their consumption presents no risk. In addition, black nutsedge tubers in particular have better benefits such as the ability to eliminate free radicals in addition to those common to different varieties. As a result, these tubers can activate the immune defense and reduce the risk of cancer and degenerative diseases.

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