Impacts of the use of *Chrysophyllum albidum* G. Don on its vulnerability and its conservation in Benin.

ABSTRAT

Aims / Objectives: *Chrysophyllum albidum* is a fruit tree of great socio-economic importance in West Africa. In several localities in Benin, despite the species over-exploitation of the species, few data relating to its viability and the conservation of its genetic diversity exist. The objective of this study is to determine the values and forms of uses, of various organs of the species by the populations, in order to identify their impacts on the vulnerability of the species and its sustainable use.

Methodology: A semi-structured survey has collected from 877 an (eight hundred and seventy-seven) person's taken at random, ethnobotanical data on the species. The frequencies of use of the different organs, the index vulnerability of the species, as well as the dendrometric parameters were evaluated. In addition, Cramer's V test was used to analyze the influence of sex and socio-cultural groups on the different uses made of the species.

Results: It appears that the species is more and more essential, because it is better known and has priority used in human and animal food, the cure of certain bodily and spiritual diseases but also serves as energy wood and lumber. The frequency of use organs varies from 2.28% (flower) to 99.54% (fruits), passing through 25.88% (root), 35.23% (bark), 49.82% (leaves) and 82.78% (wood). The degree of stress on the various organs of *C. albidum* makes the species very vulnerable in Benin with a high vulnerability index (VI = 2.50).

Conclusion: These different data reveal the need to design strategies for the sustainable management of the plant genetic resources of this species useful in Benin.

Keywords: *Chrysophyllum albidum*, Anthropogenic activity, Sustainable use, Uses traditional, Vulnerability, Benin.

1. INTRODUCTION

Apart from agriculture and breeding Non-Timber Forest Products (NTFP) constitute a major source of medicine, food and income for the rural populations [1]. NTFPs are resources plant genetics that effectively contribute to the food self-sufficiency of our local populations and communities [2].

Chrysophyllum albidum is one of the forest tree species that provide NTFP of great importance to the inhabitants of rural and urban areas of West Africa with great export potential [3]. Fruit tree growing as a wild plant, *C. albidum* belongs to the family Sapotaceae and to the order Ericales. Its fruit, widely used in food, is sold in local markets. Their fruit pulp contains 8.8% protein, 15.1% fat, 3.4% ash, 4% crude fiber and 68.7% carbohydrate [4]. The species is used in the traditional pharmacopoeia where its leaves, its roots and its bark intervene in the treatment of many diseases or symptoms such as malaria, sexual weakness, asthma, jaundice. Its wood is used both as firewood and lumber for local populations [5].

Ranked among the ten priority woody food species in Benin [6], *C. albidum* is therefore a species on which action should be taken aimed at better understanding the socio-economic importance, uses and pressures that threaten its preservation and conservation, especially since it does not yet benefit until day, of a real research program for its sustainable development. Among others factors causing the disappearance of *C. albidum* in Benin, we note aging, urbanization and the sacred nature of the species [7], the systematic collection of fruits of the species for marketing [8]. However, in Benin, the favorable habitats of *C. albidum*, are not sufficiently threatened by the climate changes [9]. So the probability of survival of the species in the face of climate change is high. Furthermore, previous ethnobotanical studies carried out on the species have shown that it provides multiple goods and services to local populations, because it presents several categories of use [5, 8] which vary according to time and socio-cultural groups holding knowledge diversified endogenous species transmitted from generation to generation [10]. Certainly, this dynamic in the forms of use makes the species more essential to the rural populations but also increases their vulnerability [7]. Consequently, the anthropogenic actions remain one of the greatest factors causing the disappearance of the species in Benin. However, such losses have a negative and long-term impact on the endogenous knowledge of several plant species [11]. Clearly, the taking into account the endogenous perceptions of local populations are essential to the design

of adequate strategies that can allow the sustainable exploitation of resources plant genetics [12]. Use values determine the interest of the rural populations towards plant species [13], while the frequency of use of the organs and the number of categories of use of the species, and provide information on the vulnerability index [14].

The demographic and economic growth experienced by the localities of Benin, increases the anthropogenic actions exerted on the populations of the species, due to the ever-increasing demand for his organs. Hence the relevance of this study which has general objective of assessing the level of vulnerability of the species in a context where its different organs are used daily. Specifically, this study aims to: (i): identify the different forms of use of the organs of *Chrysophyllum albidum* trees and (ii) determine the frequencies of use of plant organs and the value of its index of vulnerability.

2. MATERIAL AND METHODS

2.1. Study zone

This study took place in Benin in different localities located in the six phytogeographical districts where *C. albidum* individuals are present (figure 1). It's about localities in the Coastal, Pobè, Ouémé Valley and Plateau districts of the Guineo-Congolese located between $6^0$25'N and $7^0$30'N; and the Zou and Bassila districts of the zone of Sudano-Guinean transition Iocated between $7^0$30'N and $9^0$45'N. These areas vary depending on the nature of the ground, the climate and the type of activity carried out by the inhabitants. Groups plants that host the species are those of concessions, the edge of lowlands, forests relics of fallows then fields and plantations [15].

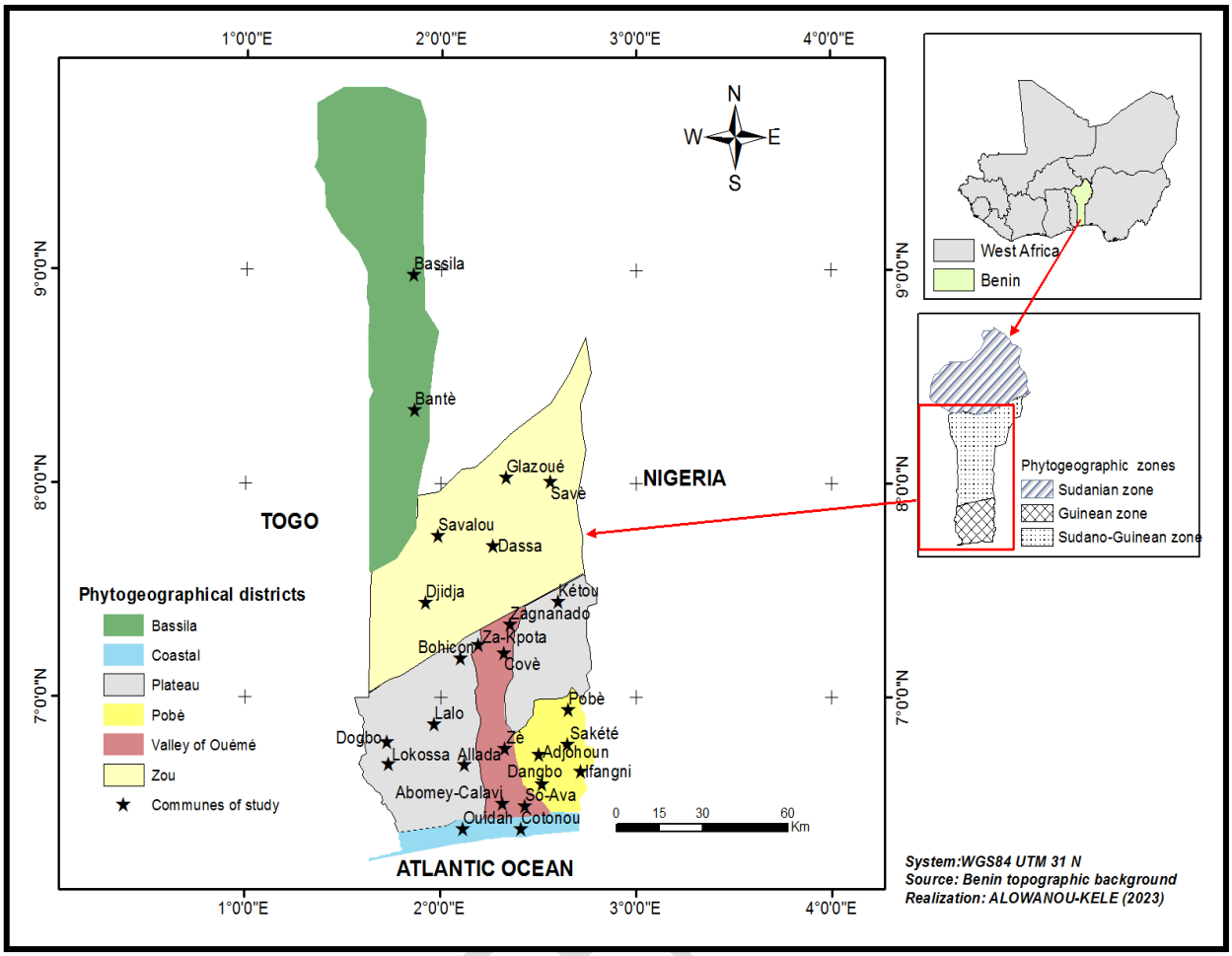

Figure 1 : Prospected localities.

2.2. Sampling and ethnobotanical surveys

A preliminary survey made it possible to interview 34 people chosen in a way randomly by phytodistrict, i.e. 204 people in all six phytodistricts constituting the study area. The data collected made it possible to identify the localities where the species is present and to calculate the size of the sample in each of the phytodistricts, from the formula of [16] presented below:

$$n = \frac{U^2_{1-\alpha/2}\, Pi\,(1-Pi)}{d^2}$$; with

n, the size of the sample to be considered by phytodistrict in this study;

$U_{1-\alpha/2}$, the value of the normal random variable for a risk $\alpha = 0.05$ ($U_{1-\alpha/2} = 1.96$ for $\alpha = 0.05$);

Pi, the proportion of people who know and use *Chrysophyllum albidum*;

d, the allowable margin of error. It is 0.05.

Table 1: Sample size by phytodistrict.

Phytodistricts	**Number of people knowing *C. albidum* among the 34 presurveyed per phyto-district**	**Proportion (Pi)**	**Size of the sample considered in the phytodistrict (n)**
Bassila	25	0,735	300
Pobè	31	0,911	125
Plateau	32	0,941	86
Coastal	32	0,941	86
Valley of Ouémé	32	0,941	86
Zou	29	0,852	194
Total	**-**	**-**	**877**

2.3. Collection of data

877 people, made up of 256 women and 621 men, were interviewed with success, based on a semi-structured questionnaire [17] and a clear picture of the species. These respondents were chosen at random from all the localities, and interviewed individually (figure 2). 'The established questionnaire concerned the categories of use of the species, the parts of the plant that are exploited, the method of harvesting the organs of the plant, the opinion of the respondent on the abundance of the species in the localities of the study area, the probable reasons for the scarcity of *C. albidum* trees and the strategies to adopt for the sustainable development of the species. Moreover, in the localities where the actual presence of feet of the species, it was measured the dendrometric data such as the total height of the plants of the species and the diameter at chest height (figure 3).

Figure 2 : Ethnobotanic survey interview.

Figure 3 : Diameter measurement.

2.4. Data analysis

The information collected made it possible to identify the different categories of uses and uses made of the various organs of *C. albidum*, and to calculate the following parameters explained:

- **Frequency of use (FUO)**

The frequency of use made it possible to know the level of use of each of the organs of the plant by the target populations. Its formula is as follows: FUO = $\frac{N \times 100}{Nt}$; with:

N, the number of people who cited this body;

N_t, the total number of respondents.

- **Average Value of Use (AVU)**

According to [18], the average value of use makes it possible to evaluate the local knowledge of the populations on a species. It is the total number of reported uses by an interviewee, and is calculated in this study according to socio-cultural groups and sex, through the following formula:

$$AVU = \frac{NUt}{N}$$; with :

NUt, the total number of uses reported by all respondents in a category data;

N, the total number of respondents considered.

- **Vulnerability index (VI)**

The vulnerability index was calculated to assess the impact of the forms of use of the species on its viability. The formula used is as follows: $VI = \frac{\sum Nx}{N}$; with :

Nx, the value given to x according to its degree of vulnerability;

N, the number of parameters serving as major indicators of pressure and threat on the species.

By parameter, the vulnerability scale considered varies from 1 to 3 [14]. For interpretation of our vulnerability scale, it was taken as reference values, the interpretation thresholds of [11]. For [11], a species is said to be weakly vulnerable when its vulnerability index is strictly less than 2; a species is said moderately vulnerable when its vulnerability index VI [2; 2.5[; a species is said very vulnerable when its vulnerability index is greater than or equal to 2.5.

Table 2: Adapted parameters measuring the vulnerability of *Chrysophyllum albidum*; [11], [19] and [20].

Parameters (Pi)	**Types of vulnerability**		
	Weak (Scale = 1)	**Average** (Scale = 2)	**Full** (Scale = 3)
P_1 : Frequency of use (FUO)	FUO < 20%	20 % ≤ FUO ≤ 60%	FUO ≥ 60%
P_2 : Number of categories of use (NCU)	NCU < 2	2≤ NCU ≤4	NCU ≥ 5
P_3 : Plant organ used	Latex ; leaf	Branch ; fruit	Wood ; seed ; flower ; bark ; root
P_4 : Presence in the environment	Abundant	Less abundant	Rare
P_5 : Collection mode	Collection	-	Picking ; cutting
P_6 : Stage of development	Old/ senescent	Adult	Young

Statistical analyzes were performed with R version 4.2.0 software. To do this, field data underwent Cramer's V test and Correspondence Analysis Multiples (CAM), to identify the possible influence of gender and socio-cultural groups investigated on the forms of use of the species.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. *Chrysophyllum albidum*, multi-purpose species

In Benin, local people use *Chrysophyllum albidum* for several purposes. Thus six (6) categories of use of the species have been identified. The ripe fruits of the species constitute for men, food (human food) very well appreciated; its wood is intensively used as primary fuel (wood energy) and timber; its bark, leaves and roots are used as fodder and very phytomedicine very effective. The flowers and leaves contribute to the fight against evil spirits (uses medico-magic). 99.54% of informants exploit the species as food while 75.25% and 46.18% use it respectively as energy wood and phytomedicine. By against, 35.68% of respondents say they rather exploit the species for its wood used as wood work. In addition, 18.47% and 2.73% of the interviewees declare using the species respectively as fodder and medico-magical species (figure 4).

Several uses are made of plant organs (table 3). The fruits and wood are the most exploited organs with respectively 99.54% and 82.78% of frequencies. Follow after, the leaves, the bark and the root which have respectively for frequencies 49.82%, 35.23% and 25.88%. On the other hand, the flower is little used because; it has a more or less low frequency of use (2.28%) more or less weak. Better, the fruits of this species are more sought after by the Gouns and the Fons; its leaves are mainly exploited by Kotafons and Nagots; the wood of the species is more used by the Gouns and the Nagots; the roots and barks are used more by the Nagots and the Kotafons (figure 5).

Table 3: Categories of use and frequencies of use of *Chrysophyllum albidum* organs.

Organs	Categories of use	Frequencies of use (%)	Uses
Fruit	Human food	99,54	Directly consume at ripeness
Wood	Firewood	82,78	Wood bundles / Wood coal
	Lumber		Woodwork / Woodart and craft
Leaf	Animal feeding	49,82	Provender
	Phytomedicine		Treat diseases
	Medical and magical uses		Fight against evil spirits
Bark	Phytomedicine	35,23	Treat diseases
Root	Phytomedicine	25,88	Treat diseases
Flower	Medical and magical uses	2,28	Fight against evil spirits

The average use values of *Chrysophyllum albidum* organs (figure 6) reveal that men (AVU = 6.75) have almost the same knowledge as women (AVU = 6.42), in the use of the species. Within socio-cultural groups, average use values vary, from 3 to 8.42 and show that the Kotafons (AVU = 8.42), the Aïzos (AVU = 7.90), Nagots and Adjas (AVU = 7) respectively hold more than knowledge in the use of the species, that the Fons (AVU = 6.34), the Gouns (AVU = 5.55), the Mahi (AVU = 5.39) and the Ouatchis (AVU = 3).

The results of Cramer's V test (table 4) reveal that the link between gender and categories of use of *C. albidum* is low (P-value = 0.024; value very close to O), so that the link between socio-cultural groups and these categories of use is strong (P-value = 0.83 ; value close to 1). Multiple Correspondence Analysis (MCA) indicates that the link between sex and certain forms of use of the plant genetic resources of the species (human food, fodder, phytomedicine, timber and fuelwood) is low; on the other hand, medico-magical uses are significantly influenced by gender (figure 7). Furthermore, the socio-cultural groups identified influence the forms of use of the different organs of *C. albidum*.

Table 4: Links between the categories of use of *Chrysophyllum albidum* and the parameters socio-demographic (gender and socio-cultural group).

Cramer's V test	
Socio-demographic parameters	**P-value**
Gender	0,024
Socio-cultural groups	0,83

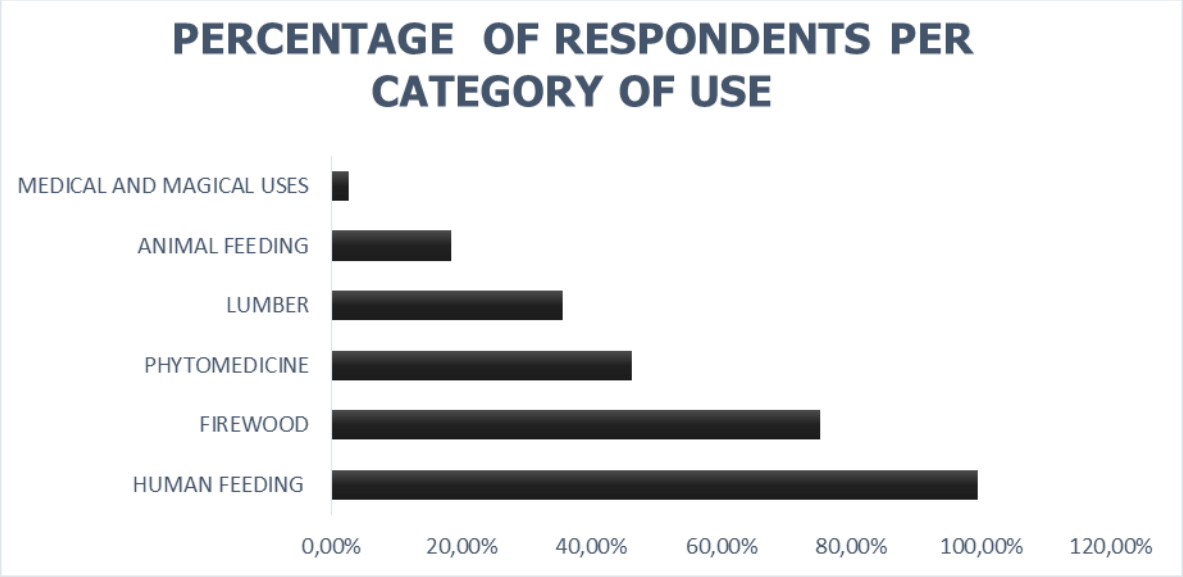

Figure 4 : Frequencies of *Chrysophyllum albidum* use categories in Benin.

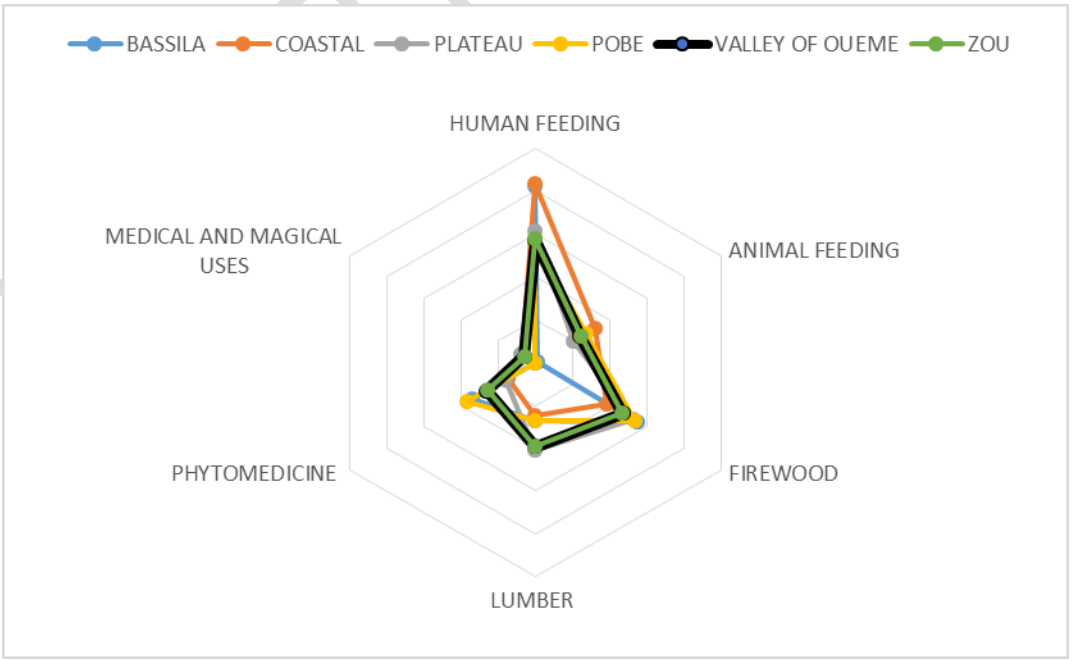

Figure 5 : Use of *Chrysophyllum albidum* organs by socio-cultural groups investigated.

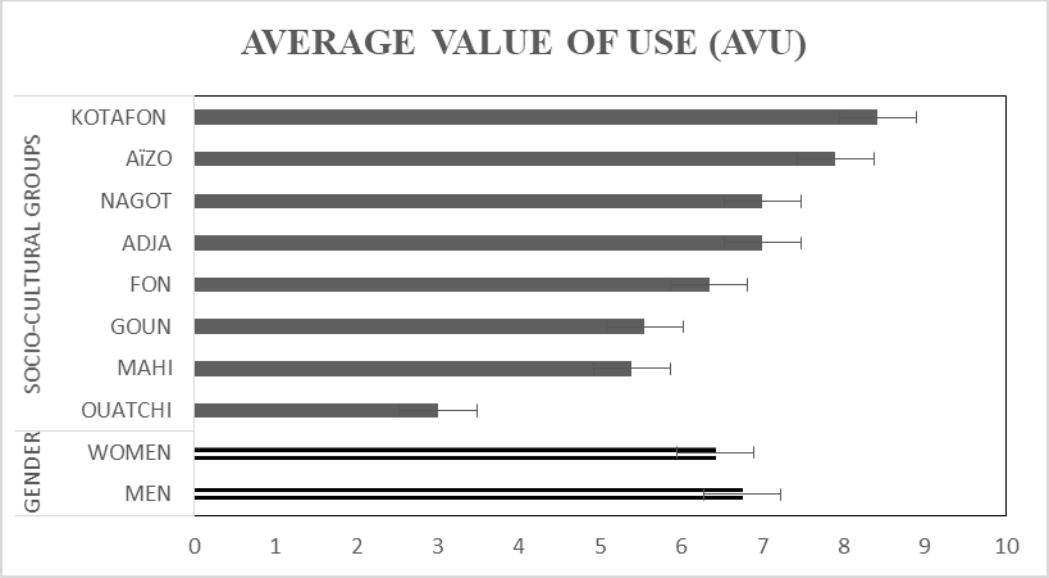

Figure 6: Variation in the Average Value of Use (AVU) according to gender and sociocultural groups.

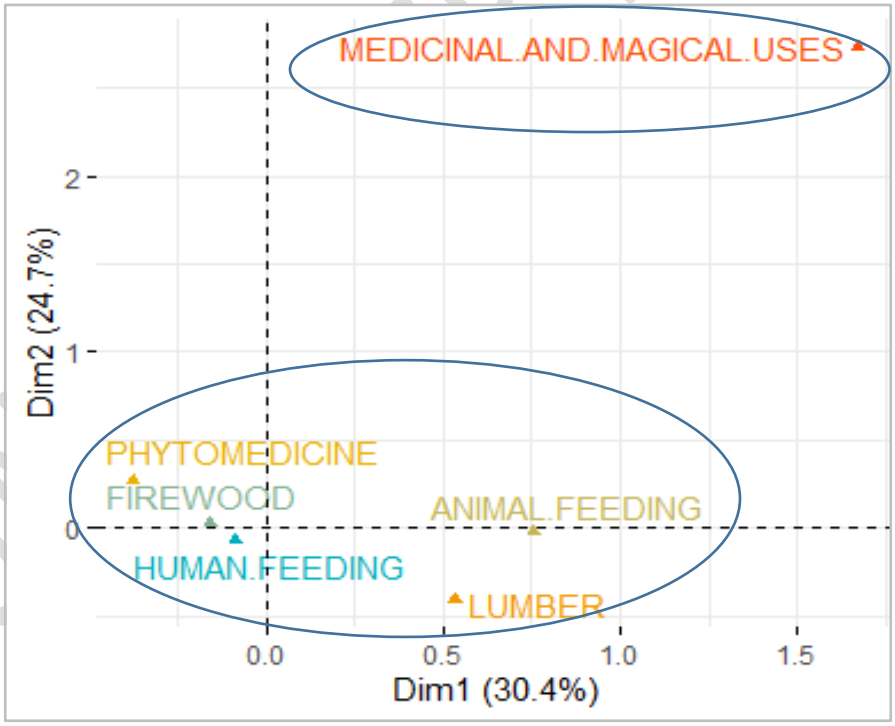

Figure 7: Correspondence Analysis Graph Multiples (CAM) on the categories of use of the species in sex function.

3.1.2. Vulnerability of *Chrysophyllum albidum* in Benin

Due to the high number of usage categories (NCU = 6), the frequency of use (FUO = 49.25%), mode of collection (picking and cutting), types of organ exploited (wood, fruit, bark, leaf, flower and root), the presence in the study environment of feet of the tree (less abundant), and of the stage of development (adult), *Chrysophyllum albidum* has a vulnerability index of 2.50. Therefore the species is very vulnerable (VI ≥ 2.50) in Benin (table 5).

Table 5: Scale of vulnerability by considered parameter.

Considered parameters	Results obtained and comments	Affected vulnerability scales
Frequency of use	49,25%	N1 = 2
Number of categories	NCU = 6	N2 = 3
Exploited plant organs	Wood, fruit, bark, leaf, flower and root	N3 = 3
Presence in the medium	Less abundant	N4 = 2
Mode of collection	Picking and cutting	N5 = 3
Stage of development	Mainly adult	N6 = 2

3.1.3. Conservation statuts of C*hrysophyllum albidum* in Benin

Nowadays, *Chrysophyllum albidum* is mainly present in certain houses. However, many people cut off the feet of the species that were in their homes, because of the lack of space that these trees often create, when the environment life is favorable to them. Similarly, some people have testified to having cut the old trees of *C. albidum*, because for them, the old age of these plants decreases the quality and quantity of fruit produced. The plants of *C. albidum*, identified in Pobè phytodistrict, are more large (TrCir = 202.40 cm) and taller (Hpl = 23.86 m) for the most part (figure 8). Furthermore, people familiar with the plants of *C. albidum*, as a plant strongly medicinal, overexploit some of its organs such as roots, bark and leaves, to treat many bodily and/or spiritual illnesses (Figure 9).

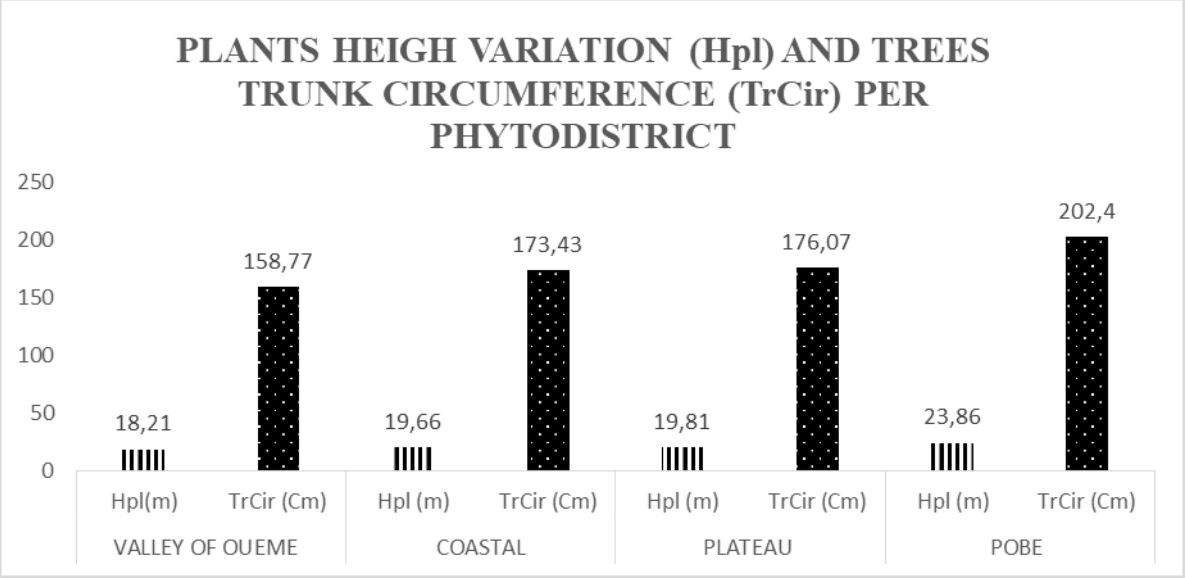

Figure 8: Diagram showing the height of the plants and the circumferences of the trunks of *Chrysophyllum albidum* by phytodistrict of effective presence of the species.

Figure 9: Rised debarking of the trunk of *Chrysophyllum albidum*.

3.2. Discussion

3.2.1. Links between the use of *Chrysophyllum albidum*, its vulnerability and its availability

To live, the local populations are involved in agriculture whose production is complemented by non-timber forest products [21]. *Chrysophyllum albidum* with its multiple uses (NCU = 6), is a plant widely used by rural populations. However, the populations judge a plant important, when they can take its wood, its bark, roots, fruits and leaves for useful purposes [11]. It is therefore because the different organs of *C. albidum* have not escaped this mesh. From where anthropic action contributes a lot to the destruction of the vegetation cover through the world. This pressure on the plant genetic resources of trees is even more increased with the increase in population size. As a result, plants become more vulnerable day by day. This is the case of *C. albidum*, whose index of vulnerability VI calculated at 2.50 ($VI \geq 2.50$) clearly reveals that the species is very vulnerable in Benin, according to the interpretation thresholds defined by [11]. The parameters that used to calculate this vulnerability are the high number of use categories (NCU = 6), the frequency of use (FUO = 49.25%), the mode of collection (picking and cutting), the types of organ exploited (wood, fruit, bark, leaf, flower and root), the presence in the environment study of the feet of the tree (less abundant), and the stage of development (adult). *Detarium microcarpum* with an index of 2.67 was also considered a very vulnerable species in the Zou phytodistrict of Benin, by [19]. The average usage values vary between 8.42 (Kotafons) and 7.90 (Aïzos), indicate that according to socio-cultural groups, there is an uneven distribution of knowledge about the uses of the species. So the socio-cultural groups hold a diversity of endogenous knowledge on the use of the species [10].

Unlike the work of [8] who state that men have significantly more knowledge in the use of the species (ID = 5.44 bits) than women (ID = 2.10 bits), the present study reveals after eight (8) years that the knowledge are almost the same in kind. This difference in results can be justified by several reasons, including the size of the sample considered, which is fixed by phytodistrict, the increase in the interest that the fairer sex increasingly grants to knowledge related to the use of plants [22, 23], the presence of more in addition marked plants of the species in the houses to the detriment of its other habitats [8], etc. Apart from the medico-magical uses of the species which remain the well-guarded hunting ground of men, perhaps

for reasons of culture, men and women have almost the same knowledge in the use of *C. albidum*. In clear, women have made great progress in the knowledge and use of the species.

The very high frequency of fruit use (FUO = 99.54%) of trees of the species shows that apart from the systematic collection of the fruits of the species for their commercialization [8], the populations also engage in harvesting and the cutting of the branches bearing them. However, according to the testimonies collected on the ground, the cutting the branches of these trees, profoundly reduces its yield. The wood is used for a frequency of 83.78% due to the aging of certain trees of the species and urbanization [7]. The felling of *C. albidum* trees is also linked to the fact that the wood would be a good wood for the manufacture of vegetable toothbrushes and for the manufacture economical coal. For some people, the older the tree, the less the fruits are numerous and of good quality. The irrational exploitation of the bark and roots of plants of the species for medicinal purposes, stunts their growth and fruiting, when well even the disproportionate use of the leaves does not impact the development of the trees [24]. Ultimately, the ever-increasing reduction in density in trees of *C. albidum* in natural habitats is mainly due to poor management of resources of this very useful plant.

3.2.2. Prospects for the conservation of *Chrysophyllum albidum*

Rural populations are mostly poor, so they are greatly affected by the vulnerability of the income plants they exploit. In order to come to their aid, the State must take measures promoting the influence of agricultural activities, such as financial subsidies, technical supervision, access to water for all, and the fight against transhumance through the sensitization of breeders and farmers for the strict respect of animal circulation corridors. Thus, the local populations deliver more to fields and livestock, so that their unhealthy uses of resources phytogenetics of forest trees are limited. Likewise, political leaders must make available land reserved for plantations of woody species whose that of *Chrysophyllum albidum* to prevent their felling for lack of space. In this framework, we can also experiment with these plantations in forests and other sacred places for solve the problem of poaching and premature killing. The scientific community must not only develop strategies for making juice from the ripe fruits of the species to avoid the massive loss of fruits due to lack of storage over a long period; but also work for the construction of seed banks of the good fruits of the species for promote the sowing of seeds likely to produce good quality fruit later.

4. CONCLUSION

This research has made it possible to identify the links between perceptions, uses and vulnerability or even the availability of *Chrysophyllum albidum* in Benin. Results inventoried, it appears that the species under study is used for its fruits which are used as food for humans; its wood exploited as energy wood and lumber; its leaves, bark and its roots prized for their medicinal and spiritual virtues. Unfortunately, the rural populations have daily access to the various organs of trees of the species through use of very unsavory practices, thus making this species very vulnerable. This vulnerability contributes dangerously to the loss of the species. Hence the need to design conservation strategies for this species, very useful in Benin.

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