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Article

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Ethnobotanical survey of Garcinia kola Heckel (Clusiaceae) traditionally used in Gbado-Lite City (Nord Ubangi, Democratic Republic of Congo) as Phytomedicine.

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Article History

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Résumé

L'objectif de cette étude était de mener une enquête ethnobotanique afin d'identifier les différents usages de Garcinia kola (Clusiaceae) à Gbado-Lite. L'enquête a été réalisée conformément aux principes de la Déclaration d'Helsinki. De plus, la collecte des données a été effectuée selon la méthode d'échantillonnage probabiliste stratifié. Les résultats obtenus révèlent que la majorité des répondants (94 %) sont des hommes, la tranche d'âge la plus représentée est celle des 36-50 ans (71 %) et le groupe socioculturel le plus abondant est celui des Ngbandi (44 %). Par ailleurs, la plupart des répondants sont mariés (88 %), 68 % ont un niveau d'études secondaires et 34 % sont sans emploi. La graine est l'organe le plus fréquemment utilisé (39,7 %) de G. kola, suivi par l'écorce (34,5 %), les feuilles (15,1 %) et les racines (10,8 %). La majorité des répondants (94 %) utilisent la plante à des fins médicinales. La mastication est la méthode de préparation des phytomédicaments la plus courante (43,5 %) dans la zone d'étude, suivie de la décoction (32,6 %) et de l'infusion (23,9 %). De plus, le mode d'administration thérapeutique utilisé pour tous les organes (100 %) de cette plante est la voie orale. Par ailleurs, le G. kola est principalement utilisé comme stimulant (39 %) et comme médicament pour traiter les maux de dos (16 %), le paludisme (9 %), le diabète (9 %), les vers intestinaux (8 %), les hernies (6 %), la varicelle (5 %), les intoxications (5 %) et la dysménorrhée (3 %). La majorité des personnes interrogées (85 %) ont indiqué que le G. kola n'est pas abondant dans son habitat naturel. Il est donc souhaitable que des études phytochimiques et pharmacobiologiques soient menées sur cette plante afin de valider scientifiquement ses propriétés ethnopharmacologiques, qui restent à élucider. Il est également souhaitable que cet arbre soit intégré au projet agroforestier afin de créer un écosystème productif pour un approvisionnement durable en matières premières. Par ailleurs, la plantation et la protection de l'espèce et de son habitat naturel dans le cadre d'un projet de séquestration naturelle du dioxyde de carbone permettraient aux bénéficiaires de percevoir des crédits carbone.

Keywords:
Biodiversité, Pharmacopée traditionnelle, Garcinia kola, Ethnomédecine, Écorégion d'Oubangui

Abstract

The aim of this study was to conduct an ethnobotanical survey to identify the different uses of Garcinia kola (Clusiaceae) in Gbado-Lite. The survey was carried out according to the principles of the Helsinki Declaration. In addition, the data collection was carried out according to the stratified probability sampling method. The results obtained in this study reveal that the majority of respondents (94%) are male, the most representative age group is between 36-50 years (71%) and the most abun dant socio-cultural group is the Ngbandi (44%). In addition, most of the respondents are married (88%), 68% have secondary education and 34% are unemployed. The seed is the most commonly used organ (39.7%) of G. kola, followed respectively by the stem bark (34.5%), the leaves (15.1%) and the roots (10.8%). The majority of respondents (94%) use the plant as a medi cine. Chewing is the most common method of preparing phytomedicines (43.5%) in the study area, followed by decoction (32.6%) and infusion (23.9%). Moreover, the therapeutic mode of administration used for all organs (100%) of this plant is oral. In addition, G. kola is used more as a stimulant (39%) and also as a medicine to treat backache (16%), malaria (9%), diabetes (9%), intestinal worms (8%), hernia (6%), and varicella (5%) and also to treat poisoning (5%) and dysmenorrhea (3%). The majority of respondents (85%) reported that G. kola is not abundant in its natural habitat. It is therefore desirable that phyto chemical and pharmaco-biological studies be carried out on this plant with a view to the scientific validation of its eth nopharmacological properties, which have not yet been elucidated. It is also desirable that this tree be integrated into the agroforestry project in order to create a productive ecosystem for a sustainable supply of raw materials. On the other hand, the planting and protection of the species and its natural habitat within the framework of a natural carbon dioxide sequestration project would enable the beneficiaries to benefit from carbon credits.

Keywords:
Biodiversity, Traditional pharmacopoeia, Garcinia kola, Ethnomedicine, Ubangi ecoregion

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1. Introduction

According to the World Health Organization (WHO), more than 80% of the populations in developing countries rely on Traditional Medicine for health care (WHO, 2002 and Ngbolua *et al*., 2011a, b). Knowledge of this so-called alternative or complementary medicine is usually acquired through long experience and passed on from one generation to another (Klotoé *et al*., 2013). However, the transmission of ethnomedical knowledge is not always assured for the new, more extroverted generation, particularly among young peo- ple who tend not to believe in Traditional Medicine (Anyinam, 1995). Hence, it is essential to ensure the trans- mission of knowledge through scientific publications.

It is therefore urgent to identify ethno-medical knowledge through field surveys in order to develop a "community bio-cultural protocol" for better management of biodiversity and associated knowledge. In addition, the results of such a survey can help identify medicinal plants with high pharmaceutical potential for cultivation or domestication, or even conservation in the natural environment to prevent their extinction. This is the case of Garcinia kola or Nzale (Ngbandi); Kusu (Ngbaka); Ngadiadia (Lingala) (Figure 1), a plant to be developed in the perspective of sustainable management of plant genetic resources through the creation of a productive ecosystem. According to DIAF (2017), its minimum working diameter (MWD) is 60 cm and its average annual increment (AAM) is 0.5 cm.

The present study was initiated with the aim of identifying the different uses of *Garcinia kola* (Clusiaceae) in Gbado-Lite. The specific objectives of this study are to (1) To describe the Socio-demographic profile of the respondents; (2) To identify the organs of the plant used by the different ethnic groups and (3) To identify the modes of preparation of the recipes and to evaluate the perception of the population on the frequency of the plant for the last 10 years. The interest of this work is obvious because the valorization and sustainable management of biological resources through the creation of a productive ecosystem in the city of Gbado-Lite will allow the achievement of sus- tainable development goals such as good health and well-being (MDG3), the fight against climate change (MDG13) and the protection of life on earth (MDG15).

Figure 1. *Garcinia kola*, (A) Whole plant, (B) Seeds

2. Materials and Methods

2.1. Description of the study area

The present study was carried out in the town of Gbado-Lite (Latitude: 4° 16′ 41″ North; Longitude: 21° 00′ 18″ East; Altitude: 300-500 m above sea level). The town of Gbado-Lite (Figure 2) is located in the Umbangian ecoregion, a subset of the Northeastern Congolian lowland forests. This ecoregion is one of the 200 global priority terrestrial ecoregions referred to as the « G200 » (Ngbolua *et al*., 2018; Ngbolua *et al*., 2019 a-c; Ngbolua *et al*., 2020 b, c).

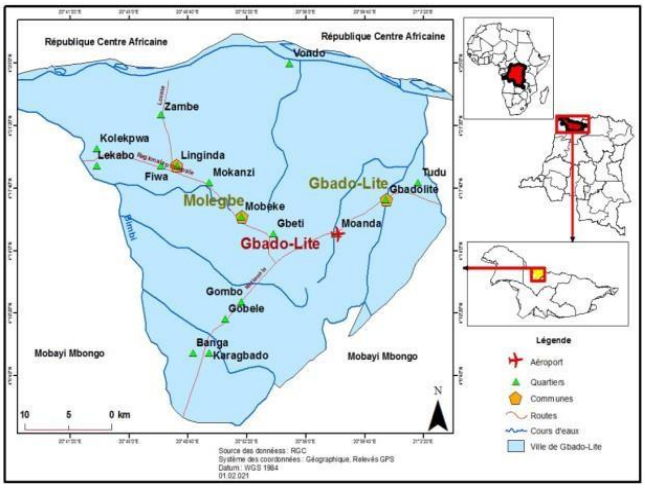

Figure 2. Geographical location of the town of Gbado-Lite

From a bioclimatic point of view, the town of Gbado-Lite belongs to the AW_2 climatic type according to the Köppen classification (Ngbolua *et al*., 2018; Ngbolua *et al*., 2019 a-c; Ngbolua *et al*., 2020 b, c); Rainfall is rela- tively abundant with an average of more than 1600 mm, insolation is low, i.e., 45% of total radiation of tropical energy.

Administratively, the town of Gbado-Lite is subdivided into three (3) communes including the urban commune of Gbado-Lite and the urban-rural communes of Nganza and Molegbe. The urban commune of Gbado-Lite is sub-divided into five

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districts (Mowanda, Pangoma, Mbanza, Lite and Kaya).

2.2. Methods

The survey was carried out in the commune of Gbado-Lite according to the principles of the Declaration of Helsinki. The stratified probability sampling method was used as described above (Ngbolua *et al*., 2016; Ngbolua, 2020a; Masengo *et al*., 2021 a, b). It consists of dividing the study area (Gbado-Lite commune) into different strata, represented here by the five neighborhoods (Kaya, Lite, Mbanza, Moanda and Pangoma) and associating the same number of respondents, twenty people. The survey ques- tionnaire administered to the respondents consisted of two parts: (1) Socio-demographic data: gender, age, so- cio-cultural group, level of education, occupation and mari- tal status; (2) ethnobotanical data (vernacular name, part(s) used, diseases treated, category of use, methods of prepara- tion and administration of medicinal recipes, etc.). The interview was conducted in the local language, Lingala. Microsoft Excel version 2010, SPSS version 20 and Origin version 8.5 Pro were used for data processing and analysis.

3. Results and Discussion

3.1. Socio-demographic characteristic of respondents

Figure 2 shows the distribution of respondents by gen- der.

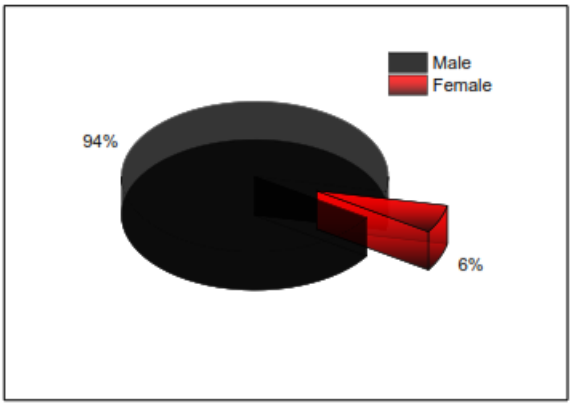

Figure 3: Distribution of respondents by gender

Figure 3 shows that men predominate (94%) over women (6%).

Figure 4 shows the distribution of respondents by age.

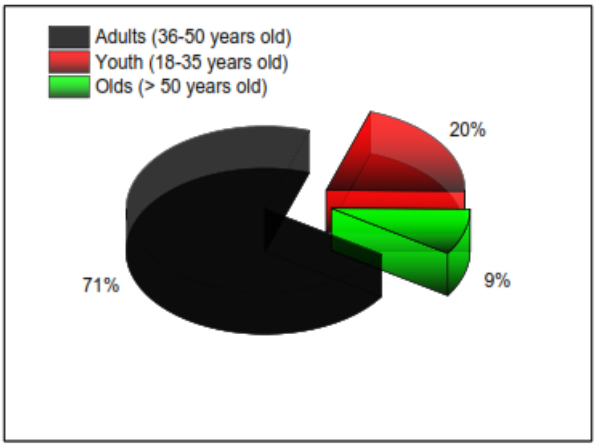

Figure 4: Distribution of respondents by age

Figure 4 shows that the majority of respondents (71%) are between 36-50 years old. 20% of respondents are be- tween 18-35 years old and 9% of informants are at least 50 years old. The fact that all three age groups (old, adult and young) within the local population hold this endogenous knowledge of the therapeutic use of *G. kola* proves that there has been transmission and preservation of the practice and this would help to sustain it for a long time.

Figure 5 shows the distribution of respondents accord- ing to their socio-cultural group.

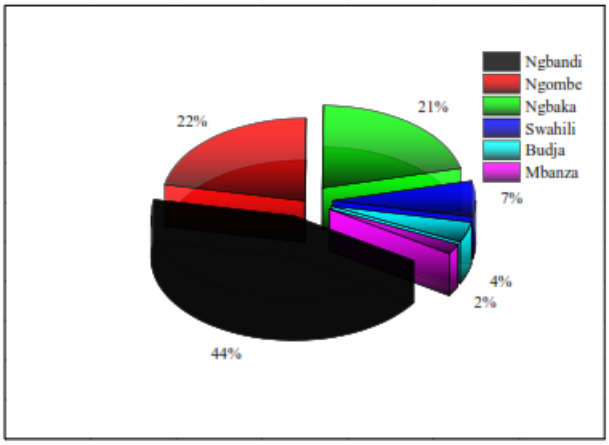

Figure 5: Distribution of respondents by socio-cultural group

Figure 5 shows that the majority of respondents (44%) belong to the Ngbandi socio-cultural group, followed re- spectively by Ngombe (22%), Ngbaka (21%), Swahili (7%), Budja (4%) and Mbanza (2%).

The results of this study show that the various indige- nous peoples of sub-Saharan Africa, and in particular those of the DRC, are holders of traditional knowledge, particu- larly which related to the therapeutic use of plants.

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Figure 6 shows the distribution of respondents accord- ing to their level of education.

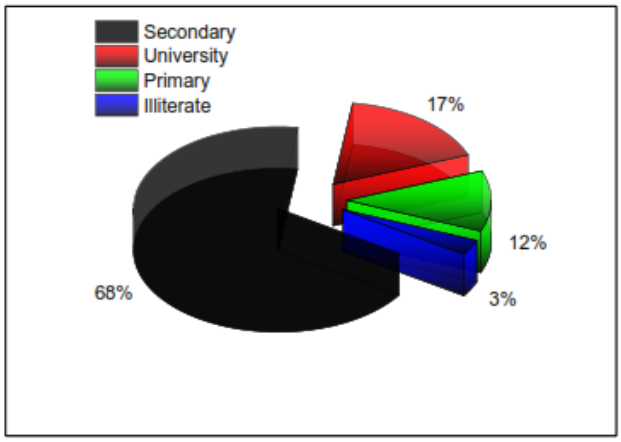

Figure 6 Distribution of respondents by education level

Figure 6 show that the majority of respondents (68%) had secondary education. In addition, 17% of the respond- ents had a university education, while 12% had barely com- pleted primary education. Finally, 3% of respondents are illiterate. The fact that the vast majority (97%) of the re- spondents in this study are literate may help to transmit this endogenous knowledge in writing to future generations and to share it with other people living in other regions of the plant world.

Figure 7 shows the distribution of respondents by occupation.

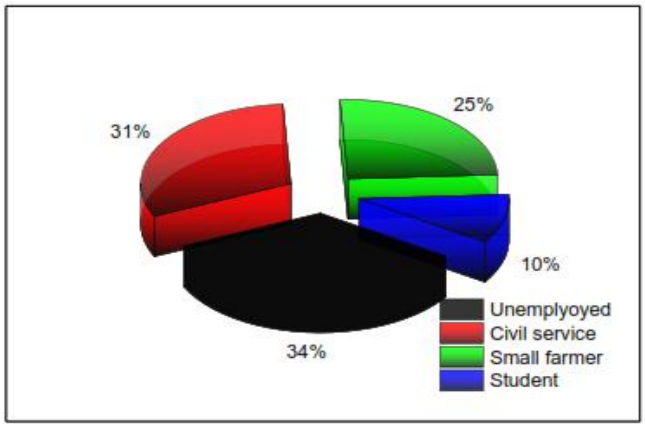

Figure 7: Distribution of respondents by occupation

Figure 7 shows that the majority of respondents (34%) are unemployed. Of the respondents with an activity, 31% are civil servants, 25% are farmers and 10% are students. The use of alternative medicine is a reality for all so- cio-economic groups: civil servants, students, farmers and unemployed.

Figure 7 shows the distribution of respondents accord- ing to their family situation.

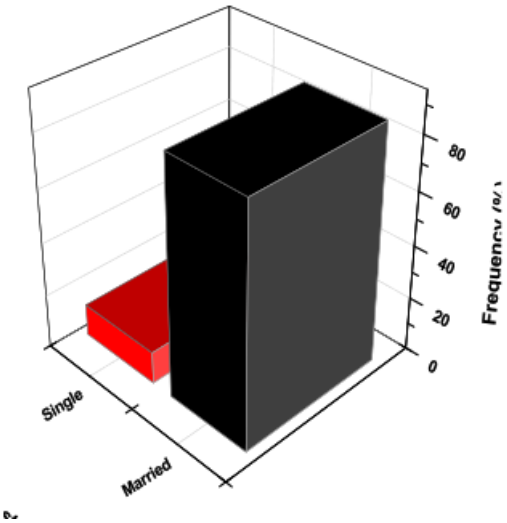

Figure 7: Distribution of respondents by marital status

Figure 7 shows that married people are in the majority (88%) compared to single people (12%).

3.2. Ethnobotanical information on the use of G. kola

Figure 8 shows the frequency of citations for the parts of the G. kola plant used

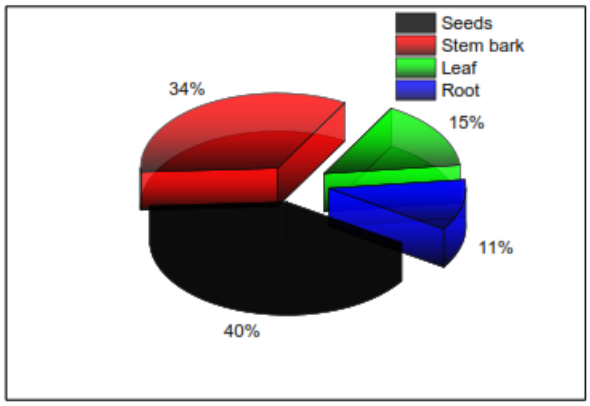

Figure 8: Citation frequency used plant parts

Figure 8 shows that the seed is the most used part of the plant (39.7%), followed by stem bark (34.5%), leaves (15.1%) and roots (10.8%).

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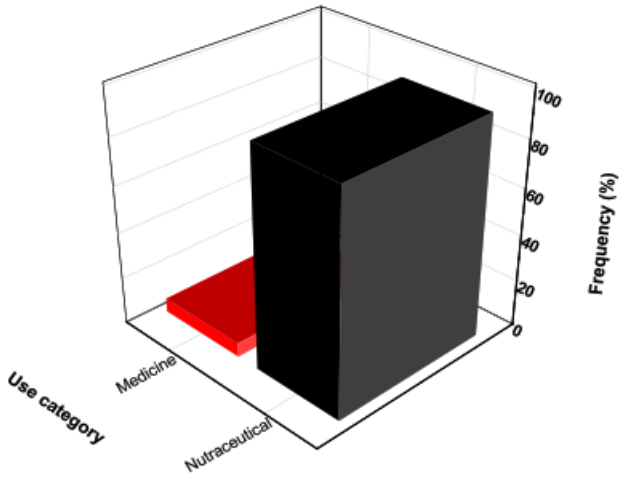

Figure 9: Use category

Figure 9 shows that the majority of respondents (94%) use *G. kola* organs as a Nutraceutical and only 6% use it as a medicine.

Figure 10 shows the frequency of citing the different ways of preparing therapeutic recipes based on *G. kola*.

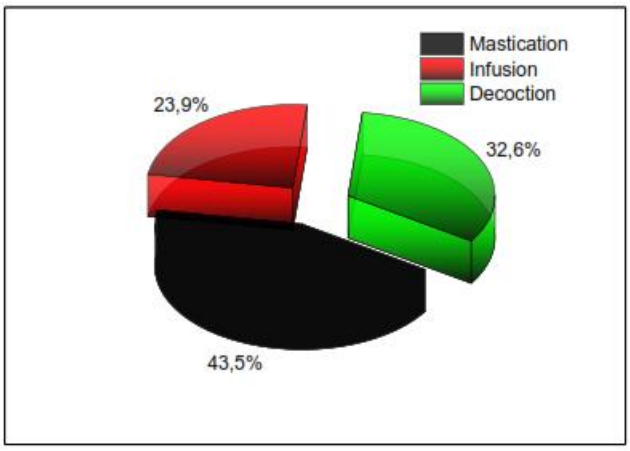

Figure 10: Frequency of recipe preparation methods

Figure 10 shows that chewing is the most common method of preparation (43.5%) in the preparation of tradi- tional therapeutic recipes using *G. kola* organs. This is fol- lowed by decoction (32.6%) and infusion (23.9%). In con- trast, authors like, Rusaati *et al*. (2021), Junsongduang *et al*. (2020), Ngbolua *et al*. (2019), Lautenschläger *et al*. (2018) and Salhi *et al*. (2010) have reported that decoction is the main method of preparation of traditional therapeutic reci- pes. According to Umair *et al*. (2019) decoction is widely used as it is easy to prepare by mixing the herbs with water, tea or soup.

3.3. Diseases treated with G. kola

Figure 11 shows the frequency with which the different diseases treated with *G. kola* are cited.

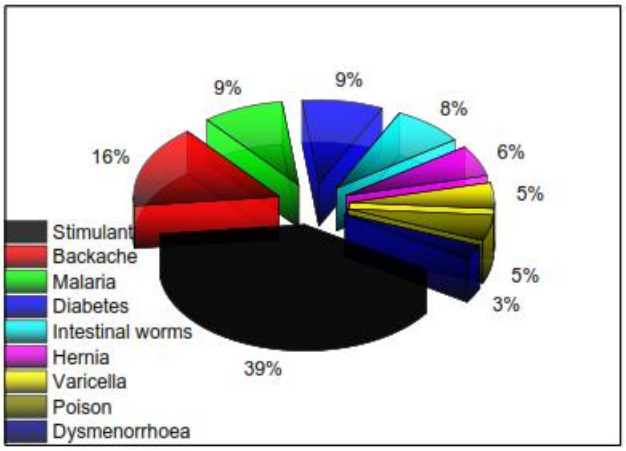

Figure 11: Diseases treated with *G. kola*

Figure 11 shows that the *G. kola* plant is used more as an aphrodisiac (39%). Also, it is used to treat back pain (16%), malaria (9%), diabetes (9%), intestinal worms (8%), hernia (6%), varicella (5%) as well as the treatment of poi- soning (5%) and painful menstruation (3%). According to Latham *et al*. (2021), the flesh around the seeds is eaten, although it is very sour. The crushed seeds are used, often with those of *Cola acuminata*, to aid digestion. One seed is enough to expel the roundworms. The bark and seeds are taken as a tonic. They are also used to treat excessive crying in infants, heart palpitations, epilepsy and diarrhoea. It is the most widely used medicinal plant in the Kisantu and Mbanza Ngungu territories to treat laryngitis.

Throughout West Africa, the main use is to make chew- ing sticks from the stems (and also the roots) of the young trees, which are divided into pencil-sized pieces; these sticks are said to whiten teeth. Lautenschläger et al. (2018) showed that G. kola is used to treat several ailments, in- cluding infection legs, intestine pain, malaria, skin disease, snake bile, snake repellent, stomach pains, typhus and yel- low fever.

G. kola is a multi-purpose plant used in food and phar- macopoeia. In African pharmacopoeia, the *G. kola* seed is consumed fresh for its stimulating and aphrodisiac properties and also chewed to fight bad breath (Alaje *et al*., 2014). The seed also has a blood pressure regulating effect, an anti- diabetic effect and aids in the treatment of abdominal and ulcer pain. The wood of the *G. kola* stem is used for oral hygiene and as a toothpick (Ballet *et al*., 2012). In addition, in human nutrition, *G. kola* seed is most often consumed fresh because

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of its high content of micronutrients including copper and selenium (Aké, 2015). In the craft industry, the trunk of this tree is used as timber (Ballet *et al*., 2012). In addition, the stem of *G. kola* is also used to make charcoal, which is widely used as an energy source in households for cooking (Aké, 2015). However, the present study indicates that this unsustainable practice is a threat to the species in its natural habitat. Indeed, the plant becomes scarce and there- fore vulnerable. Phytochemically and ethnopharmacologi- cally, it is shown that the solvent mixture chloroform/ethyl acetate/formic acid is the best system to separate the anti- bacterial active compounds. These compounds are linoleic acid, 1,2-benzenedicarboxylic acid and 2,3-dihydro-3,5-dihydroxy-6-methyl ester. The presence of these secondary metabolites justifies the use of this plant in traditional medicine as a source of new potent antimicrobial agents (Seanego and Ndip, 2012).

Table 1 gives the dosage for the use of *G. kola* organs.

Table 1: Diseases treated with *G. kola* and dosage of use.

Treated diseases	Part(s) used	Posology
Poison	Seeds	1 to 2 times a day (morning and/or evening)
Diabetes	Seeds, stem bark	2 times a day (morn- ing & evening)
Hernia	Seeds	2 times a day (morn- ing & evening)
Malaria	Stem bark, leaf, Seeds	1 drink/day
Back pain	Stem bark, leaf, Seeds, root	1 purged in the evening
Dysmenorrhea	Stem bark, Seeds	2 times a day (morn- ing & evening)
Sexual weakness	Seeds	Once in the evening
Varicella	Stem bark, Seeds	2 times a day (morn- ing & evening)
Intestinal worms	Leaf, Seeds	3 times a day (morn- ing, noon & evening)

The seeds of *G. kola* have a wider therapeutic spectrum (diabetes, hernia, malaria, backache, painful menstruation, sexual impotence, chickenpox and poisoning) than the rest of the organs of this plant. Also, the bark of the stem is used to treat diabetes, malaria, backache, painful periods and chickenpox. The leaves are also used to treat malaria and back pain. Finally, the root is hardly the treatment of back pain.

Table 2 shows the relationship between socio-cultural groups and treated diseases.

Table 2: Socio-cultural groups and diseases treated with G. kola

Socio-cultural group	Treated diseases	Frequency of citations
Mbanza	Sexual weakness	1
	Back pain	2
	Malaria	1
	Varicella	1
Budja	Malaria	1
	Hernia	1
	Dysmenorrhea	1
	Back pain	2
Ngbaka	Sexual weakness	15
	Hernia	9
	Back pain	2
	Poison	3
	Malaria	6
	Intestinal worms	4
	Dysmenorrhea	2
	Varicella	2
	Diabetes	10
Ngbandi	Sexual weakness	45
	Malaria	10
	Dysmenorrhea	2
	Back pain	17
	Intestinal worms	8
	Varicella	6
	Diabetes	6
	Hernia	3
	Poison	4
Ngombe	Sexual weakness	19
	Hernia	1
	Back pain	10
	Intestinal worms	2
	Malaria	7
	Poison	1

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	Varicella	2
	Diabetes	5
Swahili	Sexual weakness	5
	Hernia	1
	Back pain	2
	Intestinal worms	6
	Malaria	2

The results in Table 2 show that *G. kola* is a medicinal plant used in the treatment of several symptoms and diseases which are sexual weakness, backache, malaria, chicken pox, hernia, painful menstruation, anti-poison, intestinal worms and diabetes. Furthermore, the frequency of therapeutic use of *G. kola* by the inhabitants of Gbodo-Lite town depends on the socio-cultural groups (Table 2). For example, the most frequent diseases treated with *G. kola* use among the Ngbaka are sexual impotence, hernia, diabetes and malaria; among the Ngbandi are sexual impotence, malaria, backache and intestinal worms and among the Swahili are intestinal worms and impotence.

Table 3 shows the use of *G. kola* organs by so- cio-cultural group.

Table 3: Socio-cultural groups and part (s) used of *G. kola*

Socio-cultural groups	Frequency	Parts used	Frequency
Mbanza	2	Seeds	2
		Stem bark	2
		Leaf	1
Budja	4	Seeds	4
		Stem bark	2
		Leaf	1
Ngbaka	21	Seeds	19
		Stem bark	21
		Leaf	5
		Root	16
Ngbandi	44	Seeds	40
		Stem bark	31
		Leaf	23
		Root	9
Ngombe	22	Seeds	20
		Stem bark	13
		Leaf	5
Swahili	7	Seeds	7
		Stem bark	7

Only the Ngbaka and Ngbandi treat the nine diseases cited in this study and use all parts of *G. kola* (seeds, stem bark, leaves and roots) for this purpose (Table 3). The Ngombe, Mbanza and Budja use three organs of *G. kola* (seeds, stem bark and leaves) to traditionally treat diseases in Gbado-Lite. And finally, Swahili uses barely two *G. kola* organs (seeds and stem bark) in traditional therapy. The results in Table 3 show that the therapeutic use of a plant depends on the endogenous knowledge of the socio-cultural groups.

Figure 10 shows the population's perception of the spe- cies' frequency over the last 10 years.

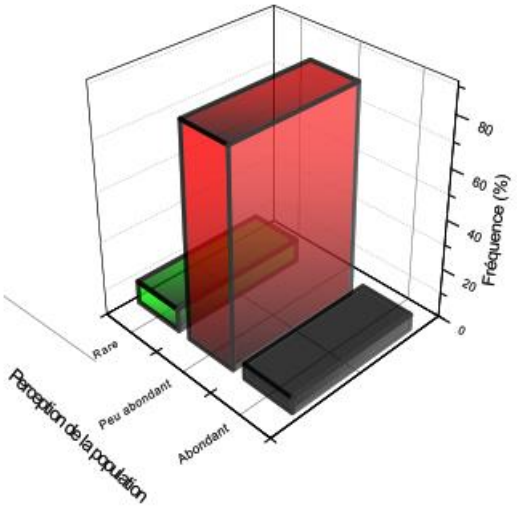

Figure 12: Population's perception of the frequency of use of the species

With regard to the population's perception of the fre- quency of the species, the majority of respondents (85%) stated that the species is not very abundant. In addition, 9% of respondents thought that the *G. kola* plant was becoming rare and 6% of respondents thought that the species was still abundant. Taking into account statements provided by respondents in Figure 12 showing a decline in the number of the species in its natural habitat. It is imperative that sustainable solutions be taken to preserve this plant through in situ and in vitro cultivation.

3.4. Market information of G. kola

G. kola seeds are one of the non-timber forest products sold in the markets of Gbodo-lite town (Figure 13). *G. kola* seeds are sold on the stalls in piles or by the piece.

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Figure 13 a, b: Interview and sale of G. kola seeds at Gbado-Lite central market

The money from the sale of *G. kola* seeds is used to solve several specific household problems, including the reinforcement of food security, the purchase of basic necessities, the purchase of school materials, weddings, etc.). The results of this study partially corroborate the studies of Mawunu *et al*. (2021), Mawunu *et al*. (2020), Ngbolua *et al*. (2020b), and Monizi *et al*. (2019; 2018), who reported that the income from the sale of non-mandated forest products (food and non-food) contributes towards strengthening food security and the acquisition of goods and services (purchase of school materials, health care, basic needs, contributions in deaths and weddings, etc.).

4. Conclusions and Recommendations

The aim of this study was to conduct an ethnobotanical study to identify the different therapeutic uses of *Garcinia kola* (Clusiaceae) in Gbado-Lite (North Ubangi) in the DRC. The results of this study show that:

- The majority of respondents are male (94%), aged be- tween 36-50 years (71%) and belong to the Ngbandi so- cio-cultural group (44%);
- In addition, the majority of respondents had secondary education (68%);
- The seed is the most used organ (39.7%), followed re- spectively by the bark of the stem (34.5%), the leaves (15.1%) and the roots (10.8%);
- The majority of respondents use the plant as an alicament (94%);
- Chewing is the most common method of preparing a therapeutic recipe (43.5%), followed respectively by de- coction (32.6%) and infusion (23.9%);
- The plant is most commonly used as an aphrodisiac (39%) but also to treat other illnesses such as back pain (16%), malaria (9%), diabetes (9%), intestinal worms (8%) and
- hernia (6%);
- The majority of respondents stated that the species is not very abundant (85%) in its natural habitat.

It is therefore desirable that phytochemical and pharmaco-biological studies be carried out on this plant with a view to the scientific validation of its ethnopharmacological properties, which have not yet been elucidated.

It is also desirable that this tree be integrated into the ag-roforestry project with a view to creating a productive eco-system for a sustainable supply of raw materials, and also that the planting or protection of the species and its habitat within the framework of a natural carbon dioxide sequestration project would allow the beneficiaries to benefit from carbon credits.

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Author Contributions (CRediT Taxonomy)

Ruphin Djolu Djolu (Conceptualization, Investigation, Methodology, Writing – original draft), **Koto-Te-Nyiwa Jean-Paul Ngbolua** (Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review), **Colette Masengo Ashanda** (Data curation, Formal Analysis, Software), **Emmanuel Kitete** (Validation, Visualization, Writing – review), **Monizi Mawunu** (Validation, Visualization, Writing – review), **Jeff Iteku Bekomo** (Validation, Visualization, Writing – review), **Dorothée Tshilanda Dinangayi** (Validation, Visualization, Writing – review), **Damien Tshibangu Sha-Tshibey** (Validation, Visualization, Writing – review), **Pius Mpiana Tshimankinda** (Project administration, Software, Supervision, Validation, Visualization, draft, Writing – review)

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

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Conflicts of Interest

The authors declare no conflicts of interest.

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