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Garcinia Kola (Guttiferae) in Tropical Rain Forests: Exploitation, Income Generation and Traditional Uses, in the East and Central Regions of Cameroon

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ABSTRACT

The present study was aimed to characterize the *Garcinia kola* populations in the eastern and central regions of Cameroon. To achieve this, 39 plots of 40m x 40m (1600 m²) were established in *G. kola* formations in order to identify and count the unexploited, exploited and dead individuals. An ethnobotanical survey was conducted using pre-established interview forms in different locations where the study was carried out. The percentage of unexploited individuals in Makénéné-Ndikinimeki zones was higher (90.25%) than that of different locations in the eastern region. Moreover, the percentage of exploited and devitalized individuals (62 % and 18% respectively) is high in this region as compared to that of the locations in the centre region. The high rate of death individuals in eastern region is due to the pressure on population, which is linked to the harvesting method (felling and uprooting) observed in this location. This variation of the intensity of the anthropogenic influence can be explained by the accessibility to the growing sites of the species and the closeness or not of these sites to the inhabited areas. Stems, bark, seeds and roots of *G. kola* are indeed organs used by populations of the East and Centre regions of Cameroon for many purposes (fight against indigestion, impotence, as anti-inflammatory and treatment of stomach ache. This result also shows that, the commercialization of these products in the local markets provides income that contributes to the livelihood of those involved in its trading activities mainly in the centre region.

KEYWORDS: NTFP; exploitation; vulnerability; incomes; sustainable management

INTRODUCTION

The forests of central Africa cover a surface area of approximately 241 million hectares [1, 2]. The Congo Basin represents more than half of this central African forest and constitutes the second largest cover of the dense rain forests of the world after Amazonia, with 12 % of the tropical forest covers. To this dimensional importance, is

added an exceptional biological diversity. As an example, Gabon, Cameroun and the Democratic Republic of Congo respectively count 6 551, 8 260 and 11 000 species of different plants, characterized by a high level of endemism [3]. The tropical rain forests of Africa are indeed terrestrial ecosystems concealing one of the highest biological diversities of the planet [4, 5].

They play an important role in the process of maintenance of biological diversity, stabilization of the watersheds and conservation of soils. These forests also play a significant role, in the survival of the local human populations, providing them with drinking water, wood for heating and construction, honey, medicinal plants, food and also belong to the spiritual and cultural inheritance of the country [6, 7].

Among the exploited products of these forests, Non Timbers Forest Products (NTFP) are thus sources of income or food for subsistence and has become more attractive for several unemployed people in Central Africa. According to [8], the exploitation and sale of these products provide considerable incomes, particularly for the most vulnerable rural and urban populations. Most of the NTFP are harvested "free" in their natural state from their environment. The multiple functions mentioned above have aroused within the international community a renewed of interest for these ecosystems [9, 10].

Despite the richness of these forests, they are threatened today by overexploitation. Moreover, the discovery and the exploitation of new mining layers (gold, uranium, diamond, cobalt etc.), coupled with poor agricultural practices such as slash-and-burn agriculture, industrial agriculture (soybean, oil palm) and global changes favour the deterioration of these forest ecosystems. In addition, these exploitations remain a major ecological concern, because they threaten ecosystem services and could contribute to the disappearance of unidentified species [11]. Indeed, the economic slump and poverty prevailing in most tropical countries like Cameroon have resulted in increasing pressure on forest resources.

This pressure generates an intense deforestation that deprives the local populations of important sources of subsistence and incomes. These exploitations thus threaten the existence of thousands of animal and plant species [12]. Oldfield [13] indicated that 9000 woody species, subjected to intense exploitation, are currently threatened of extinction throughout the world. Among the most exploited species in Cameroon, *Prunus africana* that was very widespread on the African mountain habitats is now threatened because of its healing virtues for prostatic adenoma; *Ricinodendron heudelotii*, *Irvingia gabonensis* and various species of *Garcinia spp* etc...are also largely endangered. Therefore, the

exploitation on the natural populations is done by peeling of bark of the whole trunk [14]. Cunningham [15] estimated that 35 000 individuals of *Prunus africana* have been cut down in six years in the world (1986-1991) for the exploitation of their barks. The exploitation of woody forest products such as wood has always been the subject of controversies particularly in the framework of its short-term profitability and the conceptualization of the socially bearable development. However, beside these woody forest products, non timber forest products which constitute the "raison d'être", the reason for living of the forest communities are also intensively exploited by some populations. Thus, the legislations and policies are favourable tools for the valorisation but do not put a concrete means (financial means, capacities building of the forest communities, studies of the markets for these products) to follow the decisions. The NTFP include bush meat, foodstuffs, medicinal plants, edible plants, canes, exudates, etc. Despite the importance of NTFPs, there is very little information on the ecological impact of their exploitation and their contribution to the gross domestic product on the local population. Unlike wood and agricultural products, few studies have been carried out on the follow-up and evaluation of resources and their socio-economic contribution at the local scale. This is why today, information is limited to the selection of NTFP of local or national importance. Even for these major NTFPs, data are often incomplete, unavailable or based on case studies that cannot be extrapolated at the national level.

The implementation of conservation, management and sustainable use strategies is not possible nowadays, due to the lack or insufficient scientific data on their biology. This general lack of information is in particular related to lack in Sub-Saharan zone of expertise and infrastructures to carry out inventories of biodiversity, and mainly the characterization of the species with Non timber forest products. This work aimed to characterize the current state of *Garcinia kola* populations in the rain forests of Cameroon, identify its various uses and evaluating income generated by its exploitation.

the income generated as well as the intensity and frequency of harvests using previously established interview forms. The sample size (81) was mostly made of aged persons (63 men and 18 women), distributed into 3 age classes: 18 people (≥ 50 years old), 56 people of intermediate ages (25-50 years old) and seven people of less than 25 years old. The criterion for selection of the 81 persons was regular or seasonal exercise of the exploitation and/or marketing activities of bark or seeds of *G. kola*.

Characterization of the populations of *Garcinia kola* in different sites

The populations around forest traditionally use various plants or animals' species for their foods, treatment of the diseases and many others. These populations instituted from generation to generation, practices relating to the use and management of the resources from their environment. The mechanisms of regulation or functioning of these practices can deeply modify the forest environment; by their positive or negative effects on the populations of exploited species. The quadrats method (1600m²) was used in order to characterize the populations of *G. kola* in the various areas. A total of 39 plots of 40 m x 40 m were established in different locations of both regions. In each plot we identified and counted the unexploited, exploited and dead individuals.

Data analysis

Data recorded for different variables (exploited and dead individuals) were analysed using the statistical software package XLSTAT 2017 for windows. Analysis of variances (ANOVA) was used to determine variability among means and the DUNCAN multiple range test was used ($p < 0.05$) to determine significant differences between means.

RESULTS

The local population has a good knowledge of non-timber forest products that surround them and their uses as food and medicinal plants. This knowledge constitutes an essential prerequisite to a sustainable management of the resources. Preserving the species producing the NTFP with respect to their commercial exploitation, or improving their production particularly with silvicultural methods and progressive

enrichment of the forest can ensure the long term availability of the resources.

Current practices of exploiting *Garcinia kola* in their natural environment in the Centre and East regions of Cameroon

In the different locations studied, the natural formations with *G. kola* are free access and of common use for villages around or relatively far. To reach these formations, harvest the bark and return to the village, farmers need to walk for 5 to 12 hours in the eastern region and 2 to 3 hours 30 minutes in the Centre region. Few farmers whose villages are very far from the formations in the Centre region conduct this activity as a full day of regulatory work, usually set as 8 hours per days. These harvest trips can be carried out in groups (collective trips) or individually. In the case of collective trips, the manpower is mainly family or friendly. The quantities of harvested bark, seeds and/or roots per harvest tripper person vary between a half of the bag and a whole bag weighing 25-40 kg fresh weight. The quantity of product carried per person depends also on the distance from the village to the forest.

The exploitation of the bark is considered by the local populations as a hard activity because of long walking distance (5 to 10 km), with 40 kg of fresh bark to be carried on the back. For these reasons, the exploitation and the commercialisation of the bark and seeds of *G. kola* are considered as secondary activities. The accessibility to the formations with *G. kola* is not very easy in the localities of the East region because they are far away from inhabited areas. The exploitation of the bark of *G. kola* varies from one region to the other in Cameroon, and with respect to the needs of the local population; it is carried out both in dry and rainy seasons.

The choice of the places of harvests is based mainly on the presence of the species and the user's needs. The material used during the processes of harvest included only the cutlass. Bark harvesting occurs on a daily basis in the eastern region, whereas in the central region, it occurs periodically. The exploitation of the bark is generally carried out by young and vigorous people (Figure 2), especially people in charge of families. Older people (more than 70 years) mostly avoid this activity. The quantities of harvested bark mainly in the eastern region, as

well as the time devoted to this activity, depend therefore on the age and the physical condition of the harvester. The younger and more vigorous the harvester, the more important are the quantities of harvested products in the different locations. In the eastern region as well as in the Central region, it was found that people involved in the collection of these between 25-60 years old. However, it should be noted that whatever

the region, people of the second age group (25-40 years) are most concerned, followed by the third age group (40-60 years) and finally the first age group (10-25 years). Nevertheless, the proportion of young people involved in the harvesting or commercialisation system is higher in the central region (13%) than in the eastern region (5%) (Figure 2).

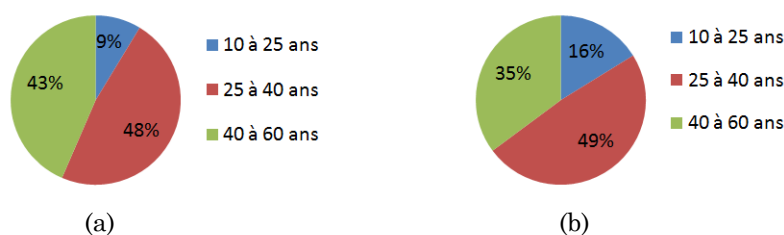


Fig.2: Proportions of the surveyed people implicated in the exploitation and marketing of the products resulting from *G. kola* according to the areas: (a) East region ;(b)

Centre region

Once the site of harvest is reached, the criteria of selection of the trees to be exploited vary according to the regions: In the eastern region, all trees of different diameter are barked, whereas in the central region, the criteria of selection of trees to be exploited are the size of the tree and the thickness of the bark. Bark collection is done mainly by the native's population and takes place *in situ* on the plant, usually by peeling the bark with the cutlass. The intensity of bark collection per tree depends on the locations. More than 50%, 75% or 100% of circular ringing of the bark on the bole of the tree, from the base up to the median was observed in the locations of the eastern region. In the Centre region in contrary, only small surfaces of bark (less than 50% of circular ringing of the stem) of irregular size are taken on the bole of the tree. The felling of the tree followed by the removal of the bark both along the entire length of the stem and on the branches is a common practice in the area of the eastern region (about 7% of the exploited individuals). This practice remains not applied in the centre region of Cameroon. It should be

noted that the ringing of the circumference of the stem as well as the collection of the roots of *G. kola* are the modes of exploitation which generally cause the devitalisation of the plant. These modes of exploitation are common on trees growing in cultivated areas.

Uses of the products of *G. Kola* in the different localities

Uses of the products of *G. kola* in the different localities Different parts of *G. kola* are exploited by the local populations for various reasons. Figure 3 shows categories of utilisations by the population in the different regions. It arises from the analysis of this figure that the use is variable in the different locations in the eastern region of Cameroon, 35% of the people surveyed use Bitter kola's products to treat diseases, 23% is for commercialisation, 19% for wine fermentation; seeds are used locally as appellatives (5%). Meanwhile, in the Centre region, 75% of the people surveyed said that products harvested are mainly for sale. However, seeds and/or barks are less used for the fermentation of the wine in this area.

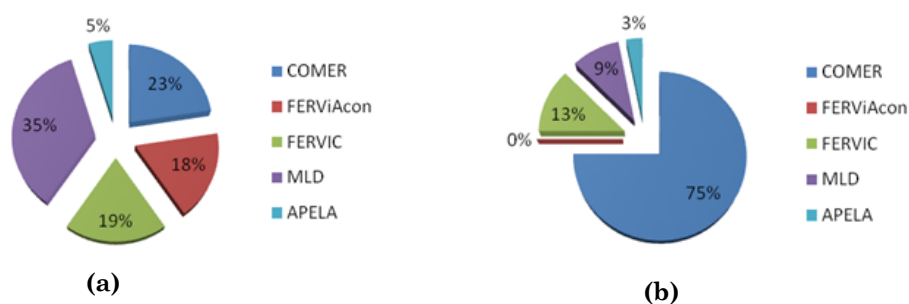


Fig.3: Utilisations of *G. kola* according to the areas: (a) East, (b) Centre; COMER (Commercialization), FERViAcon (Fermentation of the wine for Self-consumption), FERVIC (Fermentation of the wine and Commercialization), MLD (Disease), APELA (Appellatives).

Organs used, harvest site and persons involved *G. kola* exploitation

Stems, sheets, bark and roots are the *G. kola* organs used by populations of the eastern and central regions of Cameroon for many purposes. Figure 4 shows that at least three parts of the

species that are used. The proportion of population using at least three of the organs represents 63% in the eastern region and 0 % in the Centre region. In this region, seeds or barks are the most used organs by 87% of the population; roots are not exploited in the region.

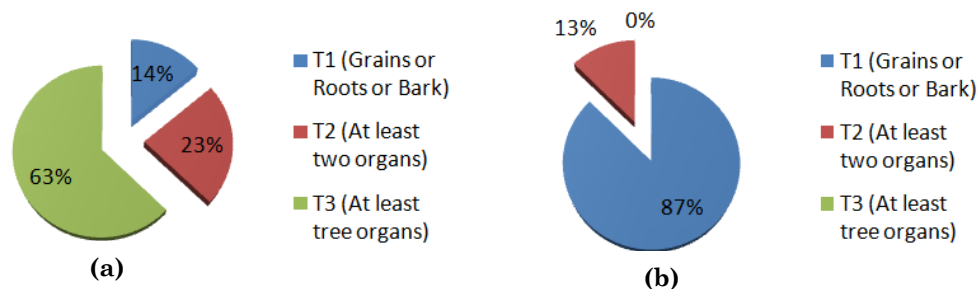


Fig. 4: Proportions related to the use of the leaves, stem, bark and roots of *G. kola* by the populations according to regions: (a) East, (b) Centre

Characterization of the exploitation state of individuals

Figure 5 shows that the percentage of the unexploited individuals in the centre region (90.25%) is higher than in the areas of the eastern region (20.51 %). Moreover higher proportions of exploited and death individuals (62% and 18% respectively) were observed in the eastern region as compared to the 9.02 % and 0.75 % observed in the centre region. However, statistical

analysis (test of Duncan) does not show any significant difference between the percentages of exploited in both regions at 5% level of probability ($p < 0.3432$; Table 1). Meanwhile, a significant difference was observed between unexploited and death individuals in these regions (Figure 5). The rate of unexploited and dead individuals varies with respect to the sites (Table 1).

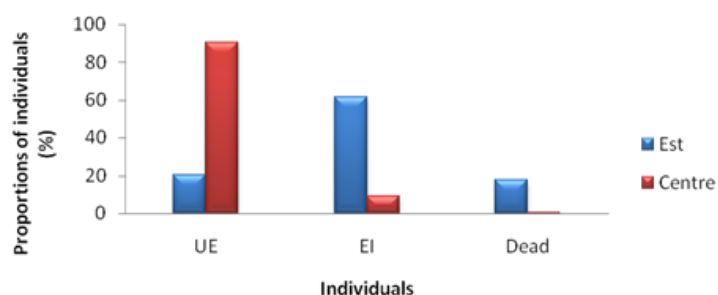


Fig. 5: Proportions of dead (DI), unexploited (UE) and exploited (EI) individuals according to the sites.

Table 1: Average proportions of the individuals exploited, unexploited and dead in the various samplings sites. EI: exploited individuals, UE: Unexploited individuals, DI: death individuals

	EI	UE	DI
East	1.2±0.5a	0.4±0.64a	0.35±0.45a
Centre	0.84±1.01a	7.5±4.33b	0.06±0.1b

In the column, means with same letter(s) attached to them are not significantly different at 5% probability level.

Level of populations involved in the exploitation and commercialization of *G. kola* products

In the villages studied, four main categories of users of *G. kola* bark and seeds were distinguished: sellers of bark and/or seeds, palm wine producers, farmers and hunters; within each of these four categories there are three subcategories related to the regularity on the exercise of these activities. These subcategories are: people (responsible for household) which exerts in a regular way, those which carry out in a periodic way and finally those which exert in a punctual way. This categorization is not partitioned; the same person can belong to two or three categories at the same time (Figure 6). In this context, the regularity of the activity constitutes an indicator of the intensity and the frequency of exploitation of the *G. kola* bark in the forest.

Bark exploitation made by the palm wine producers is generally considered as periodic or punctual activity. It is thus a random type of activity which can be exerted at anytime in the year. Generally, palm wine producers prefer to harvest by themselves the bark necessary for wine fermentation. On the other hand, bark exploitation, carried out by sellers, is considered as either a more or less regular activity or generally in a periodic activity, especially during periods when the agricultural activities are suspended (dry seasons), the collection of seeds is done mainly at maturity of the fruits (July-November). In this case, it can be observed that commercialization of *G. kola* bark or seeds is one of the most important activities for some actors who also have many others activities such as clearing, plowing, hunting, gathering, fishing, basketry, crafts, constructing or repairing huts, etc. However, *G. kola* exploitation always comes after the agricultural activities.

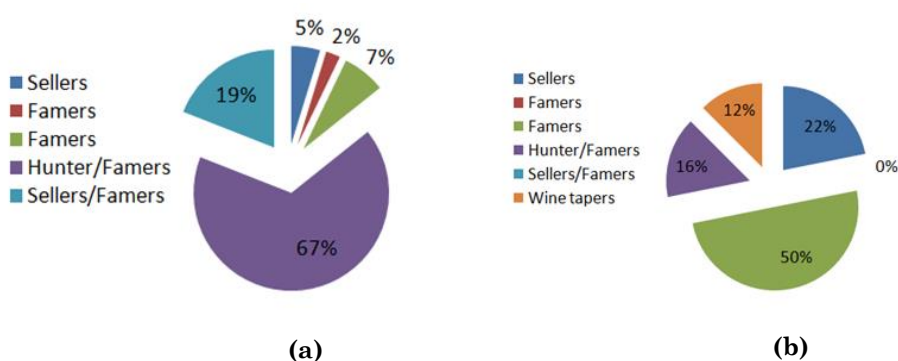


Fig. 6: Proportions of the populations involved in *G. kola* exploitation according to their principal activities in the two studied regions: (a) Centre region; (b) Eastern region.

The free access to the resource allows exploitation and commercialization of *G. kola* bark as well as palm wine commercialisation by any member of the community. However, only a low proportion of the rural population in the eastern region are involved more or less regularly in the commercialization of the bark, which is considered by other members of the

community as too laborious. Yet, the exploitation of the bark remains almost not practiced in the central region.

Tractor and agents of exploitation and marketing of the bark and seeds of Bitter kola in the villages of the Eastern and Central regions of Cameroon

The harvested bark is either sold locally in the village or transported and sold in the city by the farmers. Their clients are healers and palm wine producers living in the villages. Fermented palm wine, on the other hand, is generally sold in the village or in neighbouring villages. The seeds collected either is sold on the spot at the village, or transported and sold downtown by the harvesters. In the case of the sales at the villages, they are the wholesalers who go to the site to supply themselves, then returned and sell to retailers in cities. The retailers on the urban markets are primarily women in the centre region compared to the eastern. Contrarily, in eastern region, they are primarily men. These products, mainly nuts of Bitter kola collected out in forest (77%) in the localities of the east, and mainly collected in plantation in the Ndikilimeki-Makénéné zone that was probably a forest many years ago. It is appropriate to note that individuals exploited in this locality in the plantations are not planted by the local population but have been kept during farm preparation.

Techniques and intensities of bark and seeds harvesting at the level of individuals in locations

In a technical point of view, the collection of the bark by the local populations takes place *in-situ* on the trees generally by striking the stem with a mace in order to facilitate the detachment of the bark of sapwood, or by peeling the bark using a cutlass. Another standard technique consists in cutting down the tree at approximately 1 m above ground-level (or foot height) before taking the bark on the higher part of the cut down tree, using a cutlass. The intensity of harvest on each tree by these local populations varies extremely. Small surfaces of the bark of irregular sizes are taken at various places on the length of the stem; the ringing of the bark more than 50 % of the bole of the tree at the base up to the middle; the felling of the tree followed by the collection on the bark as well over the entire length of the stem as on the branches. These practices (ringing, felling etc..) are highly observed in the East region where about 63 % of the people surveyed proceed by felling of the tree to remove the bark, 33% use to harvest by ringing of the bark (Figure 7). This practice is not observed in the locations of Ndikinimeki-Makénéné (Centre). In these zones the felling or ringing of *G. kola* trees before collecting the bark is not practiced. It can also be noted that the harvesting of nuts in this area is done mainly by collecting and gathering/ pick-up and picking (Figure 7). This technique of harvesting is also used by the populations of the East Cameroun.

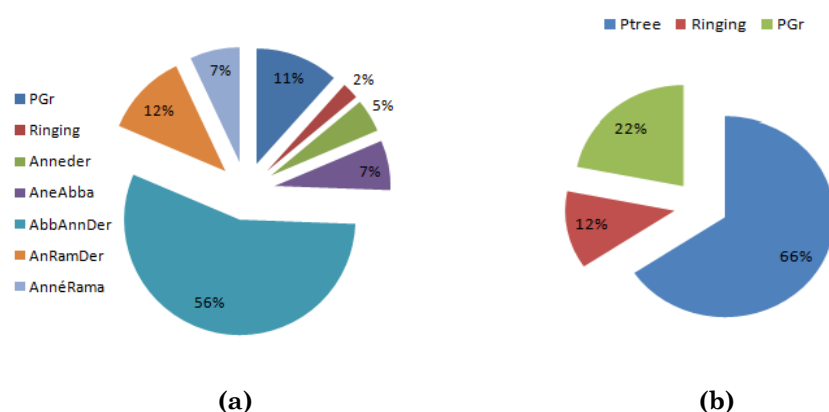


Fig. 7: Proportion of the methods used to collected the products resulting from *G. Kola* (Seeds, barks or Roots) according to the areas: (a) East; (b) Centre, with PGr (Picking from the ground), Ptree (Picking from the tree), Anneder (Ringing-Uprooting), AneAbba (Ringing-Felling), AnRamDer (Ringing- Ptree-Uprooting), AbbAnnDer (Felling-Ringing-Uprooting), AnneRama (Ringing-Ptree).

The figure 8 presents the quantity of seeds collected *in-situ* on the plant according to the locations. This quantity varies extremely from one site to another: in the Eastern region, about 58% of surveyed affirms to collect an average of one basin/tree and 25% harvest an average 1.5

basin (a basin of 20 L). In the Centre region, the collected quantity depends on the abundance of individuals in the plantations. It is noted that 54% of the population harvest an average of 1 to 5 basins, 23% harvest 1 basin, 14% harvest 15 to 20 basins and 9 % harvest 10 to 15 basins.

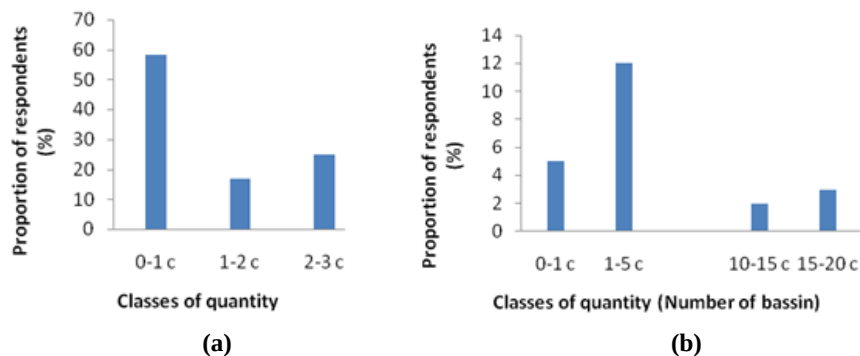


Fig.8: Quantity of seeds collected per tree in the various areas: (a) East; (b) Centre

Involvement of resellers in the commercialization of Bitter kola seeds

During the investigation, it was noted that this trade of Bitter kola seeds is 100% dominated in the zone by women. They are the second link in the chain. Their activity is to buy Bitter kola seeds from hunters, planters and resell them either in villages or in urban centers. This activity has several components as follows:

- Some women do only "bayam-salam", i.e buy the Bitter kola seeds from hunters and/or farmers to resell them either at Ndikinimeki or Makénéné, or in others big towns (Bafoussam, Douala, Yaoundé etc.).

- Others buy from hunters and/or farmers; store it to resell progressively when the seeds will become rare in the market as noted above. This activity is practiced by a non-negligible fringe of the female population of the area. It helps these practitioners to earn their life. Several categories of person are involved in the commercialization circuit of Bitter kola (harvesters, wholesalers and resellers). The harvesters include mainly the men in the various localities, but in the East, approximately 3 % of women are involved in harvest the of *G. kola* nuts, whereas in the Central area about 15% are involved. The resellers are mainly the women (80%) in the Makénéné-Ndikilimeki locality; about 57% of these resellers sell between 1-5 basins of Bitter kola per market day and about 43% between 5-10 basins. "This variation in the number of basins depends highly on the availability of the product in the

market day. Between June and August there is much of it but from September the quantity drops considerably on the market "Justine said. Buyers (in high stock) come mainly from Yaoundé and West region of Cameroon. However, in the east region, men are those mainly involved. In this region the availability in the market has highly reduced with time, said a retailer.

The use of *G. kola* products to cure diseases in the different locations

The bark or the seed of Bitter kola is widely used for its medicinal properties in the different locations. The seeds are consumed to treat sexual weakness, stomach ache in all localities (69% and 53% respectively in the Centre and East regions) (Figure 9). The bark or seed is consumed to fight against indigestion, impotence in both regions, but also as anti-inflammatory agent in the eastern Region (5% of surveyed). Some others in the same region use it to treat stomach ache (7%) or stomach and indigestion (12%) at the same time. However, some others say that they eat it just for pleasure as "cola". Contrarily to seeds, that are eaten raw, the bark is boiled with water before consumption. The quantity of water depends on the quantity of bark to boil. After boiling, it is advised to consume two glasses per days until the cure of stomach ache or indigestion. It should be noted also that, in the eastern region, the local populations use mainly the bark (100% of surveyed) for medicinal preparations.



Fig.9: Proportion of *G. Kola* organs used to treat the diseases in the different regions: (a) East; (b) Centre. With MalgIndiges (Stomach ache-Indigestion), MalgFaisex (Stomach ache-Strengthening sexual virility), Malgmalven (Stomach ache-belly ache).

At the level of the prices commonly practiced by Bitter kola owners, a basin of 20 L costs 35,000 to 65,000 FCFA in the market of Makénéné and is resold for 40,000 to 70,000 FCFA in the same market by the retailers (wholesalers). In the villages, these prices fall considerably. When the producers move to bigger markets of the zone, the prices increase by 5000 to 7000 FCFA per basin depending on the demand in the market and also to the distance from the village to the market. Concerning the retail, about 4 to 5 grains cost 100 FCFA in Lomié or Makénéné markets. The determination of profit margin remains a gross estimation and could be overestimated. However, it does not take into account neither the various taxes involve in the urban market, nor the losses encountered in the unsold stocks. A piece of *G. kola* bark of about 35-50 cm² costs 500 francs FCFA, a "basket" of barks of about 50 kg is sold in the East region between 7000 and 13000 FCFA by local population (e.g. the Pygmies) and is resold for at least 40 000 FCFA while retailing. Despite the scarcity of *G. kola* trees in the eastern region, the bark remains highly marketed, whereas in the location of Ndikilimeki-, it is not commercialized. The selling price of seeds and the bark is variable and depends on the seasons

of production. The prices are generally higher during the rainy season, when the tracks are in very bad condition, thus vehicles have enough difficulties to circulate through the villages.

Incomes resulting from the sale of Bitter kola products per weekly market day

The income resulting from the sale of *G. kola* products especially the *G. kola* seeds varies according to the localities, but also according to the various categories of people involved in the distribution chain. Generally, seeds are free in the farms or forest; hence, harvesters benefit 100% of their products cost if the time taken to harvest and proceed the fruits to nuts is not considered. On the contrary, the resellers gain according to the market behaviour of each market day. In the centre region, where it was observed a great quantity of Bitter kola seeds in the markets, about 43% of respondents gain between 20000 to 30000 FCFA/weekly market, 29% between 5000 to 10000 FCFA and finally of 28% between 10000 to 20000 FCFA (Figure 10b). However, in the East region of Cameroon, about 46% of the retailers gain between 20000 to 30000 FCFA/season of production, and the rest between 5000 to 10000 FCFA (27%) or 10000 to 20000 FCFA (27%) per season (figure 10a).

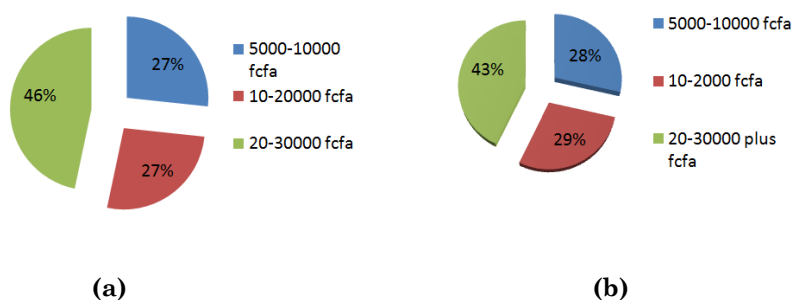


Fig.10: Income resulting from the sale of grains of *G. kola* per season in the eastern (a) and per market day in the centre (b)

Expenditure item from the income obtained from the sale of Bitter kola nuts or stem bark

The sales of *G.kola* stem barks seeds help the local population to meet up with many of their needs for subsistence (oil, soap, kerosene, salt, etc.). Figure 11 shows the expenditures range noted during the survey in the different localities. The responses are very variable from one locality to other. This figure shows that in the East, the incomes is mainly for subsistence (46%), followed by health (drugs 21%), for

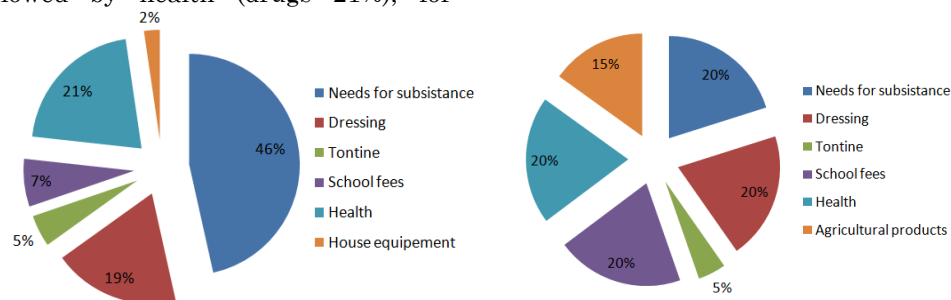


Fig.11: Expenditures range noted during the survey in the different localities

DISCUSSION

Impact of exploitation on the survival of *G. kola* populations

*Variation of the anthropic pressure on *G. kola* in different regions*

The exploitation of seeds and stem back of Bitter cola is usually done by individuals or groups of individuals. In the case of groups, the labour force is provided by the family in most cases. Harvesting of the fruits and bark is either for domestic use or for commercial use. Access to Bitter kola trees for harvesting of its fruits and bark is free in natural forests. The fruits are mostly hand-picked under the crown of trees and bark harvesting is done traditionally on individual trees. The variation observed on the group of dead, unexploited and exploited individuals, also reflects a variability of the anthropic pressure with respect to the region. This variation can be explained by the conditions of accessibility to the resources and the remoteness of its sites from the residential areas. The more the sites are near to the villages, the easier their access and the more their vulnerability to the exploitation of their barks, stems or seeds.

dressing of the different family members (19%) and sometimes for savings and meeting contribution (5%). In the localities of the Centre region, a zone strongly dominated by agriculture, it is noted that the expenditures are almost equally distributed. The income enable the local population to provide many needs for subsistence (20%), clothing of family members (20%), school fees of the children (20%), to purchase drugs for health (20%) and purchase agricultural inputs (15 %).

Survival of populations of exploited trees in different locations

The death rate is higher in the eastern region (18%) and could be due to over exploitation. This high rate can also be due to the methods used for collecting back or roots in this location. The debarked and de-rooted trees are supposedly those that are highly productive. This could lead to a significant reduction in the population over time. It is thus necessary to research on low impact exploitation techniques of this species in order to ensure the sustainability of harvesting and the durability of the species. The small proportion of the dead individuals in the Centre region can be explained by the fact that they are far from the highly inhabited area. The percentage of dead individuals obtained in eastern region was higher (18 %) than the 15% reported by Guedje [17] for *G. lucida* population in the southern region of Cameroon. The rate of dead individuals (0.75 %) is lower in the Centre region than that observed in the East region or that reported by Guedje [17] in the South region of Cameroon for *G. lucida* population. Compared to *G. kola*, *G. lucida* under-goes high local population pressure due to the high demand of its barks in the local or regional market. The bark is highly used and commercialized in Cameroon. The high demand of bark and the

method of exploitation, mainly in the East region could explain the high mortality rate observed in this locality. Within the studied populations of *G. kola*, the average death rate observed in both regions was about 9.35%. This value is much lower than the 22.11% obtained by Tasse [18] in a *Prunus africana* population at mount Cameroon. Guedje [17] reported that, a species with a death rate value lower than 15% is not vulnerable. However, this relatively low percentage of average death population should not encourage the overexploitation of the resource, because in this case, it is based on a small size sampling compared to *Prunus africana* whose data cover the entire Cameroon territory. We suppose that others areas over the Cameroon territory or the Congo basin might have higher rate of exploitation as it is shown in the case of the eastern region. Moreover, other factors might contribute to the increase of rate of exploitation as shown in the case of *P. africana*, among others, the illicit exploitation and the demand of regional and international markets [19]. In this study *Garcinia kola* is more vulnerable in the eastern region than in Makénéné-Ndikilimeki locations. Mortality contributes to the reduction of the population and is consequently one of the significant parameters which influence the dynamics of the population.

The exploitation of *G. kola* bark like that of most vegetative organs may have impacts on the plant and on the ecosystem; the severity of this impact varies depending on the sampling technique and the amount/surface of bark harvested [20]. The techniques that consist in continuously removing the bark around the tree constitute methods of non-sustainable harvest because they generate enormous wounds on the bark; recovery becomes difficult, or even impossible under these conditions. The use of this method exposes the cambium of the tree to enemies such as stems borers and diverse cryptogamic diseases which lead to considerable dryness or death of the crown [21]. The techniques of harvest observed during this work, mainly in the East constitute thus a threat for the population's future. The principal methods used, are debarking (90% of the trunk), the anhelation, the demolition and uprooting. These destructive methods are also observed in other species such as *Anonidium mannii*, *Altonia bonei*, *Pausinystalia johimbe*, *Prunus africana*, *Scorodophleus zenkeri*,

Garcinia lucida, *Xylopia aethiopica*, *Aucoumea klaineana* [17, 22]

The exploitation of the leaves, stems, roots, seeds and barks could be an indicator of the degree of anthropization. The levy on foot is a method that does not affect survival or regeneration of a species, which depend on the frequency of removing and the number of barked individuals [10]. However, the removal of bark causes a strong reduction of growth in thickness of the stem to the profit of the surface of the removed bark. According to Guedje [17], the survival of the exploited individuals depends on the physiological state of the species, probably related to the anatomical character. The collection of seeds, does not affect the survival of the tree. However, Tasse [18] reported that all types of forest resource exploitation have an ecological impact. The magnitude of this impact depends on the nature and intensity of the harvest, the type of organ exploited and the ecological characteristics of the species being exploited (abundance, density, diametric structure). The sporadic harvest of some fruit may have little effect on the long-term stability of the tree population that produces these fruits. For Peters [23, 24], the nature, the intensity and the frequency of exploitation depend on the demand and accessibility of the product (in the forest and on the markets) and the household's vital needs or income. This pressure usually results in the immediate or long-term mortality or drastic reduction in the number of individuals [19]. Low-density resources produce low yield per hectare and are more vulnerable to intense exploitation [17].

Importance of Bitter cola compared to other species exploited by local populations in different localities

The market is dominated by the women who represent about 82% of actors in the area of NdiKinimeki-Makénéné. Conversely, in the East, it was observed that the seeds of several species are mainly marketed by the men (hunters). This can be explained by the fact that the scarcity of Bitter kola pushed the women to towards other species of NTFP that are abundant in the area and are marketed in the zones like *Afrostryas lepidophyllus*, *Pentaclethra macrophylla*, *Ricinidendron heudelotii*, *Carapa procera*, *Monodora miristica* etc. However, in the Centre region, the position of products particularly the

seeds or the stem bark *G. kola* is certainly not the same as that of the other plants or animal products collected by the local population, but these forest products constitute for them a considerable financial supplement. The commercialization of Bitter cola seeds is in fact only a periodic activity for most farmers, wholesalers or the resellers. Other products as Pholidotes including Pangolin with tricuspid scales (*Manis tricuspis*), Pangolin with long tail (*Manis tetradactyla*), harnessed Guib (*Tragelaphus scriptus*), duiker with yellow back (*Cephalophus sylvicultor*) and some species of monkeys are also commercialized in the location of NdiKinimeki-Makenéné. Some cultivated species in the plantations play a significant role for this population. Fruits of *Dacryodes edulis*, *Mangifera indica* and various species of *Citrus* are highly marketed in this location. The commercialization of its products provides them additional work and income. Compared to agriculture, these generated incomes remain modest, but essential for those populations. On market days the intermediaries called "Bayam salam" directly buy the products from the villagers and resell. Their profit margin is about 30-40%, but can reach 60% in hollow period. Sometimes these "Bayam salam" buy and stored to resell in hollow periods. If at the village level, the villagers were organized in cooperatives or trade unions, and if they had a certain level of education for the most part, they could get ride of these intermediaries and sell their products directly to the city market. This would enable them to have incomes that are more substantial. The prices charged on the rural market remain generally low. The prices fluctuate according to the availability of the resource on the market, which are influenced by the seasonal period and alterability of the product.

Economic importance of *G. kola* in different regions

Bitter cola is an important source of income generated from the sale of the seeds and bark of this species and so constitute a substantial monetary resource for the local population involved in its trade. The seeds and bark of *G. kola* are widely sold in various markets in Cameroon. A pile of about four to five nuts costs 100 FCFA. This price is different from that observed by Ndoeye [25] who reported that, about 10 seeds of *G. kola* cost 100 FCFA in the humid

forest zone of Cameroon in some markets (Kribi, Ebolowa, Bafia, Yokadouma, Bertoua, Obala etc...), and a kilogram of Bitter cola seeds during this period was about 500 FCFA. The high price today could be explained mainly by the increasing market demand. About 40 to 50 kg of *G. kola* bark costs more than 40 000 FCFA in the eastern region of Cameroon. The same quantities were being sold in 28 markets of the South region of Cameroon where a kg was estimated at 250 FCFA [21]. There is a high demand for Bitter cola seeds at the international market where a kilogram is sold for about 15-25 US Dollars depending on the negotiations of the exporter [25]. The exploitation of the bark remains more important in the eastern region than in the centre region of Cameroon.

CONCLUSION

The present study showed thus that Bitter kola holds an important place in rural communities involved in this trade in order to raise alternative income. This work shows that it is urgent to ensure a sustainable management of the species and stop its the possible extinction given its already dwindling population. The percentage of unexploited individuals in the centre region zones is higher (90.25%) than that of the eastern region. Similarly, the percentage of exploited or devitalized individuals (62 % and 18% respectively) is high in the eastern region than in the centre region. This high rate, mainly the death individuals in eastern region is due to the pressure on the *G. kola* population linked to the method of harvesting observed in this location of Cameroon (felling, uprooting). This result also showed that, the incomes from commercialization of the bark and seeds in different locations are very important for these local populations. The commercialization of these products in local markets however provides incomes that contribute to the livelihood of those involved in its trading activities mainly in locations of the centre region. The poverty rate increased since the years 1990 in the countries of the basin of Congo, coupled with the raising of prices of imported goods (drugs, food), following the devaluation of the CFA franc which resulted in a strong anthropogenic pressure on the tropical area resources. This pressure unceasingly growing risks to compromise in the future, the activity of the people who depends on these

products. For species having high values like, *G. lucida*, *R. heudelotii* and mainly *Garcinia kola*, a biological study, a test on their propagation must be continued and encouraged to maintain balance between supply and demand.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest in this research article.

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