

Quantitative Ethnobotany of *Gnetum africanum* Welw. (Gnetaceae) in Massoumboum, Littoral Region of Cameroon

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Abstract

Gnetum africanum Welw. is a plant specie of Central and West Africa, a Non Timber Forest Product (NTFP) with high nutritional, medicinal and economic value. In Cameroon, its leaves are recognized by the forestry administration as a special product. Strong demand combined with destructive harvesting techniques has resulted in its rarity in its distribution area. The objective of this work is to characterize the harvesting and trade of *G. africanum*, and to assess its abundance (density and structure) in order to appreciate the economic value of the Lehman agroforest system (ALM) based in Massoumboum, a village located at 30 Km of Douala town, the economical capital of Cameroon. An ethnobotanical survey was conducted among harvesters and sellers of *G. africanum* in the ALM and in adjacent markets. An inventory of *G. africanum* stems and leaves was carried out at an overall sampling rate of 9.52%. The study revealed that, harvesting of *G. africanum* is freely done by women, youngers and elders. They start their activity early in the morning and convey their products to markets located in the periphery and inside the city of Douala. The price of the gramme is too high in the periphery than in the city, averaging 0.58 CFA franc. This price is high in the dry season due to the scarcity of other agricultural vegetables. The inventories conducted revealed densities of 6 191 stems/ha and 119 548 leaves/ha, with the high density of leaves obtained in less perturbed plots. The combination of field data (forest inventories) with those obtained in the markets (trade data), what we call «quantitative ethnobotany », allowed us to appreciate the temporal economic value (EV) of the ALM. This EV ranges from 500 000 - 700 000 CFA franc, for an average value of 37 059.9 CFA franc /ha. If well managed, *G. africanum* can contribute not only to the economy of the women-harvesters, but also to the economy of the ALM. The glaring development challenge of the background of what precedes is the development of non-detriment findings (NDF) for *G. africanum* in Cameroon. These consist of setting tools which aims to sustain the resource and trade such as the delimitation of *Gnetum* Allocation Units (GAU), as well as the development and implementation of simple management plans (SMPs).

Keywords: NTFP, *Gnetum africanum*, Lehman agroforest system of Massoumboum (ALM), quantitative ethnobotany, economic value, non-detriment findings (NDF).

1. Introduction

Forests provide goods and services which are important for more than 1.2 billions of people all over the world. In Africa, the life of more than 80% of poor people depends on natural resources, composed mainly of non timber forest products (NTFP). The contribution of NTFP in the national economy is often less appreciated due to the lack of statistical data (Awono et al., 2013; Betti, 2007). *Gnetum africanum* and *Gnetum buchholzianum* are two NTFP of the Gnetaceae family group, found in Cameroon. The first and the most appreciated by people is *G. africanum* that is largely harvested in the regions of Centre (Obala, Sa'a, Bot makak, Boumnyébel, Awaï) and South (Meyomessala). The second specie, *G. buchholzianum* is less appreciated and is mostly found at Souza in the Littoral region and at Takamanda forest reserve in the South west region (Mbolu, 2002).

G. africanum and *G. buchholzianum* are lianas, which leaves are used by several peoples of the Central Africa. In Cameroon, the name of the plant varies according to the region. Hence, the plant is called Kok by the Beti;

Eru by people from the North West and South West, Hikok for the Bassa ; Ikiokio for the Yambassa ; Kiwa for the Bafia ; Koko at Batouri, Bissom at Yokadouma ; Ekoke among the Douala ; Kege for the Bankon ; Ekok for the Bakaka ; and Mbiare in households and public areas found in cities/towns (FAO, 2002). *G. africanum* and *G. buchholzianum* are mostly used as medicinal and food plants. Ethnobotanical inquiries conducted in Kinshasa revealed that about 80% of the population eat leaves of *G. africanum* at least once per week (Toirambe, 2002).

In Cameroon, *G. africanum* leaves are exported from the Yaoundé Nsimalen airport and the Idenau port. Products are largely destined to America, Europe, and Nigeria (Mbolo, 2002). In 1998, Cameroon exported a total of 50 tons of *G. africanum* leaves to Europe (Tabuna, 1999). About 4 180 tons of *G. africanum* leaves is harvested each year in the Centre, Littoral and South West regions of Cameroon. The trade is evaluated at 13.8 millions of American dollars per year in the South West region of Cameroon (Tabuna, 1999). The high demand coupled with the bad harvesting techniques used have conducted to the scarcity of the resource in its range areas. This led the International Union for the Nature Conservation (IUCN) to insert *G. africanum* in the red list. In Cameroon, *G. africanum* is classified together with *Prunus africana* and other forest products, by the forest administration as a special product of particular interest. But several difficulties link mostly to the less knowledge of the resource do not allow to settle suitable schemes for sustaining the trade. Except for *P. africana* (Betti et al., 2011), no management inventories have been conducted for other special product of particular interest in Cameroon.

This paper aims to characterize the harvesting and trade of *G. africanaum*, and to assess its abundance (density and structure) in order to appreciate the economic value (EV) of the Lehman agroforest system at Massoumboum (ALM), Littoral region of Cameroon. The specific objectives are : (1) to characterize the harvesting and the trade of *G. africanum*, (2) to assess the abundance and structural characteristics of *G. africanum* in the ALM, and (3) based on results obtained in (1) and (2), appreciate the economic value of the ALM.

2. Materials and Methods

2.1 Study Site

Massoumboum is a village situated in the Council of Yabassi II, Nkam division, in the Littoral region of Cameroon. It is located between 4°06' latitude North and 9°31' longitude East. The population of Massoumboum is mainly composed of Bassa (80%) and Bakoko (20%) ethnic groups, spread in 441 inhabitants. The climate is humid, with rainfall ranging from 2 900 to 3 000 mm ; the temperature varies between 23 °C and 29 °C, with February being the most warm month. Soils are lateritic, characterized by the presence of stons and termite mounds (Anonyme, 2011). The Lehman agroforest system of Massoumboum (ALM) is vast of 18.27 ha and is composed of many fruit plants including palm oil (*Elaeis guineensis*), goyava (*Psidium guajava*), Safou (*Dacryodes edulis*), and many citrus plants such as lemon (*Citrus limon*), orange tree (*C. sinensis*), grapefruit tree (*C. grandis*) and mandarin tree (*C. reticulata*).

The ALM is composed of three blocs including Campement, Ngock mpoo, and Papass.

The bloc Campement is composed of ananas (*Ananas comosus*), bananas (*Musa paradisiaca* and *Musa sapientum*), palm oil and goyava. The spontaneous vegetation is quite diversified and composed mostly of *Chromolaena odorata*, *Musanga cecropioides* and *G. africanum*. Its surface area is 7.09 hectares (ha).

The bloc Ngock mpoo is composed only of palm oil and goyava. The spontaneous vegetation is less abundant due to the clearing activities that occurred between the months of January and March 2017. Its surface area is 6.66 ha.

In addition to the palm oil and goyava, the bloc Papass is composed of *Citrus* trees. The vegetation is well developed and diversified. This bloc has been less cleared. Its surface area is 4.52 ha.

People of Massoumboum village belong to the Bassa and Bassow ethnic groups. They use to harvest freely *Gnetum africanum* in the ALM.

2.2 Biological Material

The genus *Gnetum* belongs to the Gnetaceae family group. It has 30 species, composed mainly of lianas spread in Asia, America and Africa. Two species are found in Africa : *Gnetum africanum* Welw. and *Gnetum buchholzianum* (Mialoundama, 1993). The two lianas are dioecious, vines, ramified with nodes. The stem can attend 10 m in length. Leaves are opposite, with a large limb, oval and elliptic. Fruits are small red cherries. The two species are not easily differentiated through their vegetative organs. In *G. africanum*, internode of male is spike of the same diameter throughout its length, slender in dried (or old) specimens. Staminal column exerted

from the mouth of the envelope. Leaves ovate-oblong or elliptic-oblong, more rarely lanceolate, attenuate at base, abruptly acuminate, 10–13 cm long, and 3.5–5 cm broad. In contrary for *G. buchholzianum*, internode of male is spike in fresh condition much thicker at the base than higher up. Staminal column hardly exerted from the mouth of the envelope. Leaves ovate-elliptic or broadly elliptic, rounded or very slightly cuneate at base, abruptly acuminate, 9–14 cm long, 4–7 cm broad (Hutchinson and Dalziel, 1954, in Clark and Sunderland, 2004 cit. Ingram et al., 2012).

G. africanum tolerates for its development and growth, habitats of medium altitude, mostly the land ecosystems which range from fallows to primary forests, passing through secondary forests and forest galleries. In those habitats, *G. africanum* lianas appear as bushes climbing on trees or shrubs, or spread on soil. *G. africanum* is an evergreen plant, which can adapt even on the most difficult conditions. It uses reserves contained in its tuberized roots (Edissigie, 1991, Shiemo, 1999). This explains the survival of that plant specie during many years in degraded areas, even when the host plants have been destroyed. In tropical Africa, the distribution area of *G. africanum* ranges from Nigeria to Angola passing through Cameroon, the Central African Republic, Gabon, Congo, and Democratic Republic of Congo (Mialoundama, 1993).

In Cameroon, in addition to the forest that can be considered as its original ecological niche *G. africanum* can be found in fallows of *Chromolaena odorata*, long fallows of *Musanga cecropioides*, secondary forests, shrub savannas, farms of *Elaeis guineensis*. The specie is found in the South cameroonian plateau, at 700 m of altitude, in the dense semi-deciduous forest of *Sterculiaceae* and *Ulmaceae*, the low lands of the West region, the atlantic forest of *Caesalpinaceae*, shrub savannas of *Bridelia ferruginea* at about 950 m of altitude. The plant seems to adapt to all forest habitats, except for the flooded forests of the Nyong valley and of the Littoral mangrove swamps (Letouzey, 1985a, b ; Edissigie, 1991; Ndoye et al., 1998).

2.3 Method

The method used in this work includes ethnobotanical inquiries and forest inventories.

Ethnobotanical surveys

Ethnobotanical surveys were conducted among harvesters and sellers of *G. africanum* in Massoumboum and in two markets at the Douala city. In Massoumboum, we interviewed five women involved in the harvesting of *G. africanum* in the ALM. To each harvester we ask questions regarding the harvesting technic, the frequency of the harvesting, the quantity of the product harvested, at which period is done the harvesting, how the product is transported to the markets, at what cost, which markets, what are the financial revenues. In the markets, surveys were conducted in two phases including the rainy season (July-September 2017) and the dry season (November-December 2017). For each seller of *Gnetum*, we asked questions regarding the locality of procurement of the product, the frequency of selling, the quantity of the product sold par month, week, and we bought some bundles (paquet) of leaves. For each bundle, we noted the price in CFA franc (1 euro = 650 CFA franc), we weighted with a balance (mark YEN YEN 2010) having the sensitivity of 50 grammes and a threshold mass of 10 kilogrammes, we noted the mass, and we recorded the number of leaves contained in the bundle.

Forest inventories

The method used to assess the abundance and the potential of *G. africanum* in the ALM is the one call “method for forest management inventories”. This method consists of counting the number of stems of the resource on a representative sampling area and to estimate the stock at the level of the useful forest area. The inventory of *G. africanum* in the ALM was conducted from 5th September to 23rd October 2017. The ALM is vast of 18.27 ha for a useful area (this is the area where the presence of *G. africanum* is evident) of 12.6 ha. Twelve (12) lines of 100 m long each were settled on the total area of the ALM. This gives a total of four lines per bloc, distant each other of 100 m. In each line, we delimited 10 continuous plots of 100 m² (10 m x 10 m), rotating left and right. This gives a sampling area of 1.2 ha and a sampling rate of 9.52% compared to the useful area and 6.57% compared to the total area. In each plot, all stems of *G. africanum* were identified and counted. For each stem, we recorded its diameter in the collar using the calliper rule, we recorded the number of leaves and we measured the length.

Data recorded were introduced in Excel 2013 and following quantitative values were calculated:

- Density (D_i) = N_i / S_s with N_i being the number of stems (or leaves) and S_s being the sampling area (in ha) ; this express the number of individuals or leaves per ha ;
- The potential or stand stock (P) = $D_i \times S_u$ with D_i being the density and S_u being the useful area (in ha). The stand stock express the quantity of the resource (individuals or stems) or products (leaves) in the whole area, the plantation in this case.

Data analysis

Data analysis was performed using the R version 3.5.1 (2018-07-02), R 386 computer packages. This bundle served to make the one way ANOVA and to search correlations. The one way ANOVA was used for example to assess the variance in the price of the product in different markets, procurement areas, and seasons. The method used to explore the correlation between the length of stems and the density is that of Pearson.

3. Results

3.1 Harvesting and Trade of *Gnetum africanum*

Socio-economic profile of harvesters

A total of five women harvesters, belonging to the Bassa ethnic group were met and interviewed. They all use to harvest freely *G. africanum* in the ALM. Their age varies between 24 and 56 years old. The five women can be distinguished in two groups including Youngers and elders. The first group or Youngers are two single girls, 24 and 30 years old respectively. They are specialized in the harvesting and selling of *G. africanum*. The second group (60%) is composed of three elders 45, 48 and 56 years old who are working not only on the harvesting and trade of *G. africanum*, but also involved in many other activities and mostly agriculture.

Harvesting activities

The harvesting of *G. africanum* begins early in the morning, without rain. The time spent per day for harvesting can be 6-8 hours, depending to the topography of the field. The prospection of *Gnetum* can take 2 or 3 days. The harvesting method consists of cutting the stems at 10 cm above the ground (the method which is largely used) or harvesting leaf after leaf from stems.

Trade circuits

Two trade circuits can be observed from the ALM to the final markets in the city of Douala. The first circuit goes from the forest to the stocking area. The product is transported by the harvester herself. The second circuit goes from the stocking area to the markets, and is transported by the bikes or taxis. The bikes transport the products from the stocking area to the Pk 14 or 21 markets, while taxis transport those products from the Pk markets to the city markets. The price of the transport by bike is 1000 CFA franc (1 euros = 650 CFA franc) for a bag of 50 kg and 1500 CFA franc for a bag of 100 kg. For taxis, the harvester has to pay additional price of 500 CFA franc whatever be the quantity, to reach the market of Ndokotti syncatex at Douala city.

*Selling of *G. africanum* in the markets*

A total of 130 bundles of leaves of *G. africanum* were recorded and bought from four sellers settled in four markets including : New bell and Ndokoti syncatex in the Douala city, and Pk 14 and Pouma located respectively at 14 kilometers and 80 km to Douala city. The distribution of bundles in different seasons is as follow: 100 bundles in the rainy season and 30 bundles in the dry season (table 1). Ndokotti syncatex is the market which gets the high number of bundles, 80. Bundles of *Gnetum* found in the markets come from three main areas including Boum-nyebel, Massoumboum and surrounding villages, and Song Pagal. The high quantity of the product (74%) comes from the Boum-nyebel market, based at about 130 km from Douala. Boum-nyebel feeds two markets of Douala city: New-Bell and Ndokotti syncatex.

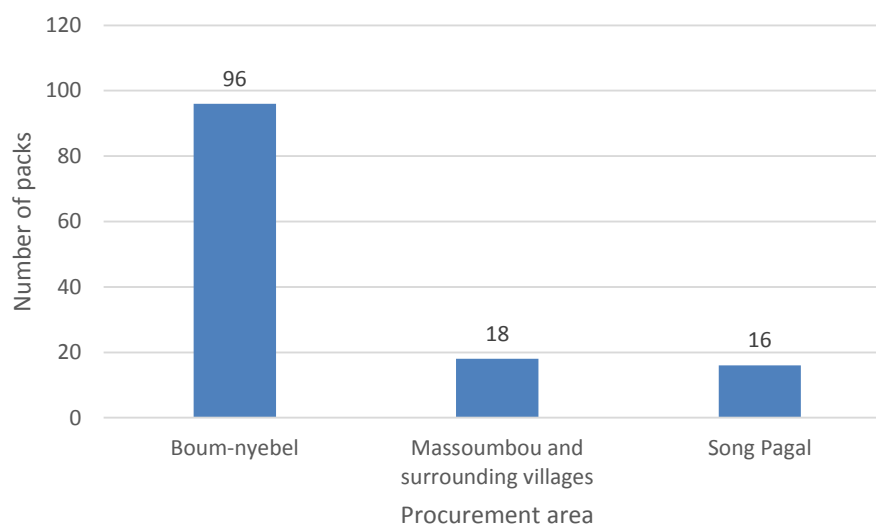


Figure 1. Procurement areas of *Gnetum africanum* in markets

Table 1. Distribution of bundles of *G. africanum* weight and bought in different markets and seasons in Douala and surrounding cities

Procurement area	Market	Code of the seller	Number of bundles per season	
			Rainy season	Dry season
Boum-nyebel	Ndokotti syncatex (Douala)	Se11	50	30
	New-bell (Douala)	Se12	16	
Massoumboum and surrounding villages	Pk14 (14 km to Douala)	Se13	18	
Song Pagal (Pouma)	Pouma (80 km to Douala)	Se14	16	
Total	4	4	100	30

The average price of the gramme is 0.58 CFA franc \pm 0.15. This price varies significantly from one market to another as presented in table 2 ($P < 0.001$). Pk14 and Pouma markets have the highest price of the gramme. The average price of the gramme in the two markets of Douala is 0.51 CFA franc while the average price of the gramme in the periphery of Douala is 0.7 CFA franc. Table 3 compares the average price of gramme of *G. africanum* in different procurement areas. This price varies significantly from one procurement area to another ($P < 0.001$). *G. africanum* coming from Massoumboum and surrounding villages is the most expensive 0.71 \pm 0.18 CFA franc while that coming from the Boum-nyebel market has the cheapest price. The comparison of the price of the gramme between the two seasons is done in table 4. The price of the gramme differs significantly from one season to another ($P < 0.001$). The highest price of the gramme being observed during the dry season, 0.69 \pm 0.09 CFA franc. The second comparison of the price of the gramme in different seasons was limit to the same sellers surveyed in the Ndokotti syncatex market at Douala (table 5). The price of the gramme of *G. africanum* differs significantly for the same sellers between the two seasons ($P < 0.001$). The price of the gramme in the dry season is high 1.4 time that observed in the rainy season.

Table 6 presents the comparison between the number of stems per bundle among different markets. The number of stems per bundle does not really vary from one market to another ($P > 0.05$). The average number of stems per bundle is 580 \pm 139.7. Pk 14, which hosts *G. africanum* coming from ALM has the lowest number of stems per bundle, 519. The number of leaves was counted in the 30 bundles bought during the dry season, in the Ndokotti syncatex market and the correspondance price was calculated (table 7). One bundle of *Gnetum* contains an average number of 2695 leaves and costs 800 CFA franc. Each leaf can cost 0.31 \pm 0.05 CFA franc in Ndokotti syncatex market.

Table 2. Comparison of the price of the gramme of *G. africanum* in different markets surveyed in Douala and surrounding cities

Market	Mean	Sd	n	F value = 13.53	Pr < 0.000000104 ***
Ndokotti syncatex	0.56	0.13	80		
New-bell	0.47	0.10	16		
Pk 14	0.71	0.18	18		
Pouma	0.69	0.08	16		
All markets	0.58	0.15	130		

The F value and Pr are from the comparison between different markets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 3. Comparison of the price of the gramme of *G. africanum* in different procurement areas

Procurement area	Mean	Sd	n	F value = 16.58	Pr < 0.000000399 ***
Boum-nyebel market	0.54	0.13	96		
Massoumboum and surrounding villages	0.71	0.18	18		
Song-pagal Village (Pouma)	0.69	0.08	16		

The F value and Pr are from the comparison between different procurement areas. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 4. Comparison of the price of the gramme of *G. africanum* in different seasons

Season	Mean	Sd	n	F value = 21.9	Pr < 0.0000072 ***
Dry season	0.69	0.09	30		
Rainy season	0.55	0.15	100		

The F value and Pr are from the comparison between different seasons. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 5. Comparison of the price of the gramme of *G. africanum* in different seasons among the same sellers

Season	Mean	Sd	n	F value = 106.6	Pr < 3.01e-16 ***
Dry season	0.69	0.09	30		
Rainy season	0.48	0.08	50		

The F value and Pr are from the comparison between different seasons. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 6. Comparison of the number of stems of *G. africanum* per bundle in different markets

Market	Mean	Sd	n	F value = 1.986	Pr < 0.119
Ndokotti syncatex	588.9	136.6	80		
New-bell	557.0	164.2	16		
Pk 14	519.1	140.7	18		
Pouma	624.8	624.9	16		
All markets	579.7	139.7	130		

The F value and Pr are from the comparison between different markets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 7. Number of leaves of *G. africanum* per bundle

Parameter	Mean	Sd	n
Price of the bundle in all markets	627.70	149.42	130
Number of leaves per bundle	2695.33	503.14	30
Price of the bundle in dry season at Ndokotti syncatex	800		30
Price of the leaf in dry season at Ndokotti syncatex	0.31	0.05	30

Table 8. Characteristics of the inventory of *Gnetum africanum* realized in the ALM

Bloc	Surface area (ha)	Sampling area (ha)	Sampling rate (%)
Campement	7.09	0.4	5.6
Ngock mpoo	4.52	0.4	8.8
Papass	6.662	0.4	6
Total	18.27	1.2	6.6

3.2 Density and Stand Structure of *G. africanum* in the ALM

Characteristics of the sampling/inventory

The global sampling rate is 6.6%. Ngock mpoo is the bloc which was highly sampled (8.8%).

Density of *G. africanum* in the ALM

Globally, *G. africanum* appears as bushes, with voluble stems found on soils or which surround different trees and shrubs including *Chromolaena odorata*, *Elaeis guineensis*, *Dacryodes edulis*, *Psidium guajava*, *Citrus spp.*

Table 9 presents the density of *G. africanum* per bloc in term of number of stems and leaves. A total of 7 429 stems and 14 3457 leaves of *G. africanum* were counted on the 102 plots delimited (1.2 ha), which gives a density of 6 190 stems/ha and 119 547.5 leaves/ha (table 9). The bloc Campement has the highest density of stems (6 525 stems/ha) while Papass has the highest density of leaves (167 705 leaves/ha).

Table 9. Density of stems and leaves of *G. africanum* per bloc in the ALM

Nom du bloc	Sampling area (ha)	Number of stems	Number of leaves	Density of stems	Density of leaves
Campement	0.4	2610	40038	6525	100095
Ngock mpoo	0.4	2405	36337	6012	90842.5
Papass	0.4	2414	67082	6035	167705
Mean/total	1.2	7429	143457	6190	119547.5

Stand structure in length of G. africanum

Lengths of *G. africanum* stems inventoried were distinguished in class of 10 cm (table 10). Papas is the bloc which has many stems long than 400 cm. A total of 22 stems in Papass are long than 400 cm compared to 7 for the bloc Campement and 1 for the bloc Ngock mpoo. The curve showing the distribution of stems of *G. africanum* in length classes is illustrated in figure 2. The figure shows a reverse J shape curve which illustrates a good regeneration. The modal class is 3 (30 cm). Table 11 presents the average lengths of stems in different blocs. The average length of stems is 60.1 cm. There are significance differences between the lengths of stems in different blocs ($P < 0.001$). Papass is the bloc which hosts the high mean of the length, 87.5 cm.

Tableau 10. Distribution stems of *G. africanum* in different classes of length or high in blocs. 1 : 10 cm, 2 :20 cm, 3 :30 cm,, 40 :400 cm

Class of length	Campement	Ngock mpoo	Papass	Total
1	37	24	17	78
2	603	449	272	1324
3	695	688	464	1847
4	294	254	227	775
5	213	194	123	530
6	162	150	102	414
7	143	122	126	391
8	103	78	61	242
9	71	82	91	244
10	45	50	65	160
11	70	78	100	248
12	35	41	95	171
13	20	32	75	127
14	13	21	29	63
15	8	14	34	56
16	45	26	123	194
17	4	22	46	72
18	1	7	24	32
19	4	14	39	57
20	1	5	11	17
21	17	21	84	122
22	2	6	33	41
23	4	1	17	22
24			9	9
25	1	3	11	15
26	3	4	40	47
27	1	2	14	17
28			1	1
29	1	8	10	19
30		1	1	2
31	4	4	24	32
32			5	5
33		1	4	5
34	1			1
35	2	1	3	6

Class of length	Campement	Ngock mpoo	Papass	Total
36			7	7
38		1	1	2
39			4	4
41	6		10	16
42	1		2	3
43			1	1
45			1	1
46		1	3	4
47			2	2
51			3	3
Total g n ral	2610	2405	2414	7429

Table 11. Average length/high of stems of *G. africanum* in ALM

Bloc	Average length (cm)	n	F value = 382.9	Pr <2e-16 ***
Campement	44.4	2610		
Ngock mpoo	49.8	2405		
Papass	87.5	2414		
Total/mean	60.1	7429		

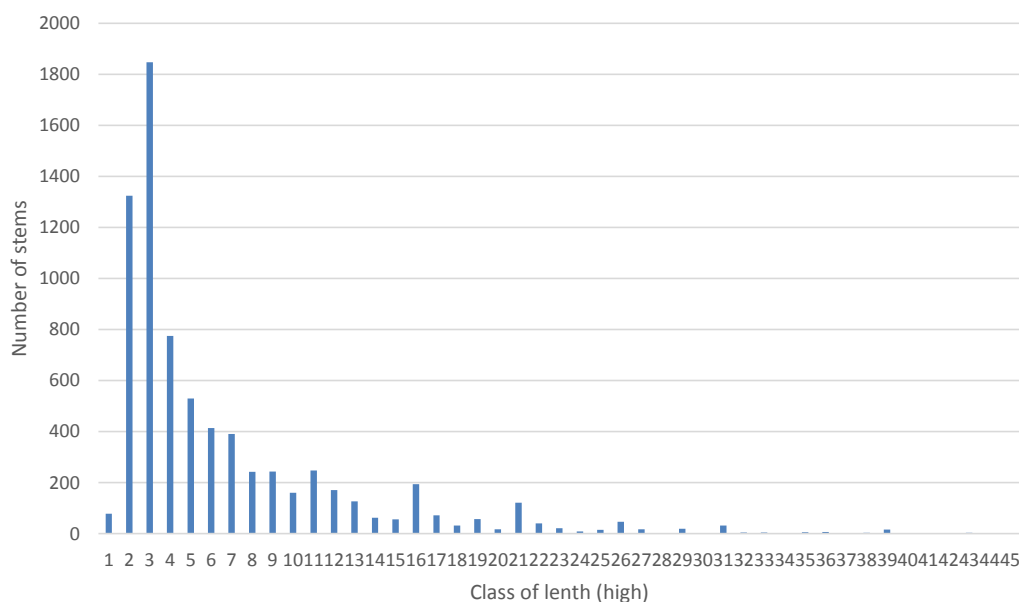


Figure 2. Length structure of stems of *G. africanum* in the ALM

Relation between the length of the stems and the density of G. africanum

The matrix of the relation between the length of stems and the density of *G. africanum* is presented in table 12. The method used for the correlation is that of Pearson. We can see that the length of the stem is positively correlated to the density of leaves and negatively correlated to the density of stems.

Table 12. Correlation between the length of stems and the densities of *G. africanum* in the ALM (Pearson method)

	Density of leaves	Density of stems	Length of stems
Density of leaves	1	-0.36	0.97
Density of stems	-0.364	1	-0.56
Length of stems	0.97	-0.56	1

Temporal potential of the ALM in *G. africanum*

The temporal potential which represents the product of the density and the surface area is shown in table 13. The potential of the ALM in *G. africanum* is estimated at 113 106 stems and 2 184 133 leaves. The high potential of leaves is observed in Bloc Papass with 1 117 251 leaves, which represents 51% of the total.

Table 13. Temporal potential of *G. africanum* in the ALM

Bloc	Total area (ha)	Density of stems (stems/ha)	Density of leaves (leaves/ha)	Potential of stems	Potential of leaves
Campement	7.1	6 525.0	100 095.0	46 262.3	709 673.6
Ngock mpoo	4.5	6 012.0	90 842.5	27 174.2	410 608.1
Papass	6.7	6 035.0	167 705.0	40 205.2	1 117 250.7
Total/moyenne	18.3	6 190.8	119 547.5	113 105.9	2 184 132.8

3.3 Temporal Economic Value of the ALM in *G. africanum*

The Economic value (Ev) of the ALM in *G. africanum* is evaluated here in terms of leaves and bundles (table 14). The temporal Ev of the ALM in *G. africanum* can range from 500 000 CFA franc to 700 000 CFA franc. Knowing that the average price of a leaf is 0.31 CFA franc, the economic value of the ALM in *G. africanum* can be estimated at 37 059.9 FCFA/ha.

Table 14. Economic value of the ALM in *G. africanum*

Bloc	Average number of leaves/bundle	Potential of leaves	Potential of bundles	Average price of a bundle in all markets	Average price of a bundle indry season at Ndokotti	Average price of a leaf in dry season at Ndokotti	Economic value for bundles in all markets	Economic value for bundles in dry season at Ndokotti	Economic value for leaves
Campement	2695.33	709 673.60	263.30	627.7	800	0.31	165271.83	210637.98	219998.82
Ngock mpoo	2695.33	410 608	152.34	627.7	800	0.31	9562 4.17	121872.45	127288.51
Papass	2695.33	1117250.7	414.51	627.7	800	0.31	260190.13	331610.81	346347.72
Total	2695.33	2184132.8	810.34	627.7	800	0.31	508650.21	648271.73	677081.17

4. Discussion

4.1 Harvesting and Trade of *G. africanum*

Harvesters of *G. africanum* of the ALM are essentially composed of women, single and married, youngers (40%) and elders (60%). The youngers are specialized in harvesting and trade of *G. africanum* while the elders practise other activities such as agriculture. The two groups use two technics for harvesting the plant : cutting stems or harvesting leaf after leaf. Same observations were made by Awono et al. (2002) and Nlend (2007) in Monatele and Sa'a, Lékié division, Centre region of Cameroon. In the South West region of Cameroon, retailers were all found to be women, largely local, married. They specialize in *Gnetum* leaves although 31% have parallel trade in other products, mainly agricultural activities (Ingram et al., 2012). Cameroonian woman is in the Centre of harvesting and trade of NTFP in general and of *G. africanum* in particular. Trade of *G. africanum* allows to resolve financial problems of the family (Awono et al., 2002). In contrary, in the Democratic Republic of Congo (DRC), the harvesting and trade of *G. africanum* (Fumbwa) is done by men. Two reasons explain this situation : the harvesting method consists of felling host trees and the economic profit is high compared to other activities (Manirakiza et al., 2009). In Massoumboum, trade circuit of *G. africanum* include two steps done by the harvester herself : from the forest to the storing area in the village, and from the village to the markets using taxis and bikes. In the Centre region, trade of *G. africanum* includes several steps and stakeholders : harvester, storage, wholesaler, seller, leaf-cutter (Mbolo, 2002). In the South-west region, trade of *G. africanum* also involves many stakeholders and steps (Ingram et al., 2012). In Massoumboum, the harvesting of *Gnetum* begins early in the morning, without rain. The time spent per day for harvesting can be 6-8 hours, depending to the topography of the field. In the South-west region, the harvesting time varies from 40 minutes to 9 hours, when harvesters leave in the early morning and return around 4 pm, spending on average 3-4 hrs travelling (Ndumbe et al., 2009).

The price of the gramme of a bundle of *G. africanum* varies from one market to another, from one procurement area to another and from one season to another. The price of the gramme is high in markets located in the periphery of Douala city (0.7 CFA franc/gramme) compared to the price practised in the Douala city markets (0.51 FCFA). This situation can be explained by the fact that Douala is a big city, which receives products coming from different areas compared to the periphery or rural areas. Also, the rural areas and mostly Pk and

Pouma (the littoral region) are not considered to be in the original ecological niche of *G. africanum*. The price of the gramme obtained in different markets in Cameroon are as follow : 2 CFA franc (Betti et al., 2016) and 0.6 CFA franc (Mbolo, 2002) in Yaounde, 0.45 CFA franc in Boum-nyebel, 0.7 CFA franc in Limbe, and 0.15 CFA franc in the periphery of Yaoundé (Mbolo et al., 2012). In the South west region, the average price per gramme is 0.82 CFA franc while that obtained in Nigeria (Calabar and Ikang) average 1.5 CFA franc (Ingram et al., 2012). The low price of the gramme observed in the periphery of the Yaounde city, in the division of Leki é and Mbam to be precised, may be due to the fact that the Centre region is located in the original ecological niche of *G. africanum* in Cameroon, compared to the littoral region where we have many swamp forests and swamp mangroves known as non-suitable habitats for *G. africanum* development and growth (Edissigie, 1991; Ndoye et al., 1998). The price of the gramme is high in dry season compared to the rainy season. This can be explained by the scarcity of other products including agricultural products or vegetables such as cassava leaves and other NTFP during the dry season (Ingram et al., 2012).

4.2 Density and Stand Structure of *G. africanum* in the ALM

The sampling rate obtained in our inventory is 6.5%, which is in conformity with the norms of forest management inventories proposed by the forest administration in Cameroon. According to those norms, the sampling rate to apply for surface areas less or equal to 5 000 ha should be at least equal to 2%. The average density of *G. africanum* in the ALM is 6 191 stems/ha and 119 548 leaves/ha. The density of stems is less compared to the 46 945 stems/ha obtained in the Leki é division, Centre region of Cameroon by Mbolo (2002). This difference between the two densities of stems can be explained by two reasons. The first is related to the location of the Leki é division in the original ecological niche of *G. africanum* ; and the second reason is related to the degree of perturbation of the habitat. Our inventory was conducted in a plantation, which is regularly cleared, while the work of Mbolo (2002) was conducted in fallows and secondary forests. The density of leaves is link to the length of the stems, which explains the high density of leaves obtained in the bloc of Papass compared to the bloc Ngock mpoo. In fact, the bloc Ngock mpoo has been cleared some months before the inventory, while Papass has been not cleared since long time. Stems in Papass had enough time to grow and reach high lengths. The specific structure of *G. africanum* in terms of the length of stems reveals a reversed J shape curve, illustrating a good regeneration of the plant. This means that, the plant may not be treathenned in the ALM, since old stems will be easily replaced by the youngsters. The only problem to solve resides on the application of the fair frequency and the technics of harvesting. This remains the challenge of the work to be done.

4.3 Economic Value, Potential and Sustainability of *G. africanum* in the ALM

The potential of the ALM is estimated at 113 106 stems and 2 184 133 leaves. The economic value estimated for the ALM in *G. africanum* can range from 500 000 - 700 000 CFA franc. Knowing that the average price of a leaf is 0.31 CFA franc, the economic value of the ALM in *G. africanum* can be estimated at 37 059.9 CFA franc/ha. If well managed, *G. africanum* can contribute not only to the economy of the women-harvesters, but also to the economy of the ALM. In the Massoumboum, harvesters have obtained the authorization of the owner of the ALM before entering in the plantation. The growing development challenge to be done is the settlement of tools for sustaining the resource and trade. These are tools which aim to make sure the trade of the product is non-detrimental to the survival of the resource in the forest, known in other word as « non-detriment findings » (NDF). In spite of its important economic value, the trade of *G. africanum* is not yet well regulated in Cameroon (Betti, 2007 ; Ingram et al., 2012). This trade is, in theory, regulated under the 1994 Forest, Wildlife and Fisheries Law (No 94/01). According to the forest law, all forests belong to the Cameroonian State and adjacent communities have user rights for own (not commercial) use of forest resources. But many people however, are unaware of this and/or believe that forests belong to them and can be freely exploited for commercial use (Laird et al., 2010). In 1995, the trade led to *G. africanum* being declared as an endangered species and a ban considered (but never implemented) in 1999 (Fondoun and Tiki Manga cit Ingram et al., 2012). Cameroon government has made many efforts to improve the exploitation and trade of forest products, compared to other many african countries. But many problems still remain in the field of NTFP or specialized products (Betti, 2007 ; Betti et al., 2016 ; Ingram et al., 2012). The quota of harvesting *G. africanum* as many other specialized products is not based on fair forest inventories (Betti, 2007). It would be interesting if Cameroon authorities extends the work conducted on *Prunus africana*, another special product (Betti et al., 2011) of huge interest to other products in general and to *G. africanum* in particular. This includes : the identification of the high production sites, the delimitation of the sites in *Gnetum* Allocation Units (GAU), the realization of forest inventories, the development of simple management plans (SMPs), and the implementation of those SMPs.

5. Conclusion

This study aimed to characterize the harvesting and trade of *G. africanaum*, and to assess its abundance (density and structure) in order to appreciate the economic value of the Lehman agroforest system at Massoumboum (ALM), Littoral region of the study reveals that the harvesting of *G. africanaum* is freely done by women. The inventories conducted revealed densities of 6 191 stems/ha and 119 548 leaves/ha. The combination of field data (forest inventories) with those obtained in the markets (trade data) allowed to appreciate the temporal economic value (EV) of the AKM. If well managed, *G. africanaum* can contribute not only to the economy of the women-harvesters, but also to the economy of the ALM. The growing development challenge of the background of what is discussed in this paper is the development of non-detriment findings (NDF) for *G. africanaum* in Cameroon. These consist of setting tools which aims to sustain the resource and trade.

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