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Journal of Botanical Research

Volume 3 | Issue 4 | October 2021 | ISSN 2630-5054（Online）

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Volume 3 Issue 4 • October 2021 • ISSN 2630-5054 (Online)

Journal of Botanical Research

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Journal of Botanical Research
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ARTICLE

Phytochemical Study and Anti-nutritional Factors in Stems of *Dioscorea praehensilis* Benth (*Dioscoreaceae*)

Patience Mpia Ngelinkoto[1] André-Marie Kassia Lokassa[1] Bernadin Bulumuka[1] Jeff Kawaya Maliani[1] Myriam Mukadi Ngondo[2] Ruth Luntadila Mbuli[3] Johnny Bopopi Mukoko[2] Florent Biduaya Mukeba[2*]

1. Department of chemistry and environment, Faculty of Sciences, National Pedagogic University, Kinshasa, Democratic Republic of Congo
2. Department of Biology, Faculty of Sciences, National Pedagogic University, Kinshasa, Democratic Republic of Congo
3. Catholic University of the Congo, Kinshasa, Democratic Republic of Congo

ARTICLE INFO

Article history
Received: 13 July 2021
Accepted: 24 August 2021
Published Online: 7 September 2021

Keywords:
Oxalate
Total cyanide
Anti-nutritional factors
D. praehensilis
Anthocyanes dosage

ABSTRACT

The aim of this research was to find and assay phytochemical compounds and various biological macromolecules of the tender stems of *Dioscorea praehensilis* benth and evaluate their antioxidant activity and to compare the content of oxalates and cyanogenetic glucosides between raw and cooked tender stems. The plant collection and identification, phytochemical evaluation: phytochemical screening, preliminary (qualitative) analyses and *in vitro* assays. Phytochemical screening was performed by qualitative methods. The estimation of the content of secondary metabolites was evaluated by spectrophotometry-UV. Antioxidant activity was evaluated using the ABTS and DPPH assays and preliminary composition by the gravimetric method. The results obtained show that the stems of *Dioscorea praehensilis* are devoid of certain important chemical groups, the flavonoids were not detected and they were rich in total polyphenols (17.22 ± 0.16), tannins (19.32 ± 0.52) and anthocyanins (25.22 ± 0.04). Our extracts showed a lower antioxidant activity than that of positive controls. The samples are rich in carbohydrates and fiber, with low levels of proteins, lipids and ash. *Dioscorea praehensilis* has a high toxicity in HCN, but after a good cooking of about 1 hour, 99.97% of the cyanide are eliminated and does not have many oxalates. The results obtained show that *Dioscorea praehensilis* has a high dietary value and can therefore be used as a nutritive food.

1. Introduction

Agricultural innovation in Sub-Saharan Africa strongly focused on food security [1]. According to the FAO [2], vegetable crops play an important role in improving food security in urban and peri-urban areas. Its identity today makes it an essential part of the city landscape and an economic and cultural heritage [3].

Dioscorea spp. is a major nutrient plant in West Africa where it actively contributes to food security and poverty reduction [4,5]. Among the food species, the most

**Corresponding Author:*
Florent Mukeba Biduaya,
Department of Biology, Faculty of Sciences, National Pedagogic University, Kinshasa, Democratic Republic of Congo;
Email: florent.mukeba@upn.ac.cd; florent_mukeba@yahoo.fr

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consumed are those of the *Dioscorea cayenensis* Lam-*D. rotundata* Poir complex, which represent more than 95% of the world production of this genus [6,7]. These species are the result of a long process of domestication of wild yams, especially *Dioscorea praehensilis* Benth. [8-12]. Face to rapid global population growth and accelerating climate change, this Wild Crop-Allied Species (WACS) constitutes a huge reservoir of genetic variability that can be used in plant breeding programs and is essential to improve food security, boost agricultural production and maintain productivity [13-15].

In recent time, considerable attention has been focused on the use of *Dioscorea praehensilis* benth (*Dioscoreaceae*) in human food and food components. However, the nourishment of monogastric animals with certain protein-rich plants is hampered by the existence of anti-nutritional factors. These factors, which are regularly present in phytonutrients, such as saponins, tannins and phytates, have been shown to reduce nutrient availability and cause growth inhibition. Among them, some contribute to the production of flatulence in consumers. Others like lectins and alkaloids can be toxic to the plants themselves and to consumers [16].

The present research aims to provide an overview and evaluation of the content of phytochemicals and their antioxidant activity, to identify and evaluate anti-nutritional factors (cyanogenetic glycosides, tannins and oxalate) in tender stems of *Dioscorea praehensilis* benth (*Dioscoreaceae*).

2. Material and Methods

2.1 Plant Material

The plant material consists of tender stems (aerial part of the growing plant) of *Dioscorea praehensilis* benth (*Dioscoreaceae*), harvested in October 2020 in Kingantoko, in the township of Mont-Ngafula, City Province of Kinshasa where the plant is called Kisadi and in Kikwit in the Province of Kwilu (the province of where we find a great number of consumers of this plant species), where it is called Bandindi in vernacular tongue (Figure 1).

The plant was identified and confirmed by the herbarium of the Institut National d'Etudes et de Recherches Agronomiques (INERA/UNIKIN) of the Faculty of Sciences at the University of Kinshasa.

The harvested tender stems were cut into pieces of between two and three cm and dried in the shade and in the ambient air [25-27 °C] until a constant weight was obtained. The dry samples were ground to powder using the MOULINEX mill and stored in a 500 mL glass bottle in a dark place.

(a)

(b)

Figure 1. (a) and (b) Stems of *Dioscorea praehensilis* benth (*Dioscoreaceae*).

2.2 Methods

2.2.1 Phytochemical Analysis

Phytochemical screening

We used standard qualitative methods as decreed by Bruneton [17], Harborne and Baxter [18] and Kokate *et al*. [19] in order to study the characteristic phytochemicals.

Total polyphenols content

The total phenol content of the tender stem extract was determined according to the Folin-Ciocalteu method [20]. Briefly, the reaction mixture consisted of 0.5 mL of methanolic extract of each of the plant extracts at 1 mg / mL in 5 mL of distilled water and 0.5 mL of Folin-Ciocalteu reagent. Then, 1 mL of a 20% saturated Na_2CO_3 solution is added three minutes later. Homogenize the mixture then incubate at laboratory temperature protected from light for one hour. The absorbances were taken at 725 nm. Each assay was performed in triplicate. For the seven different dilutions of gallic acid standard (5 to 150 µg / mL), the same procedure was followed to obtain a straight line standard

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curve. For the blank, the same procedure was also followed but the extract was replaced by 80% methanol. The results were expressed as mg GAE / g of dry plant material using the following equation y = 0.0098x - 0.0195 (R^2 = 0.967).

Flavonoids content

The flavonoid content of *D. praehensilis* benth extracts was determined by UV-Vis spectrophotometry [21]. The mixture contained 1 mL of methanolic extract from each yam extract at 1 mg / mL concentration and 1 mL of 2% $AlCl_3$ dissolved in 80% methanol. Then, the mixture is stirred well and incubated for one hour at room temperature and protected from light. The absorbances are taken at 425 nm. Quercetin solution (50-200 µg / mL) was used as a standard. 80% methanol was used as a control (blank). The results are expressed in mg QE/g of dry plant matter according to the following equation y = 0.0232x + 0.1535 (R^2 = 0.945).

Tannins dosage

The tannin content was carried out according to the modified method [22]. 2.5 g of powder were extracted from 50 mL of acetone / distilled water (35/15, v / v) at room temperature for three days. The solution was filtered and then evaporated at 40 ° C. in a water bath to remove the acetone, then the aqueous phase was rinsed with dichloromethane (15 mL) in order to remove the pigments and the lipids. Then it was extracted with ethyl acetate (2 x 15 ml). The organic phase is evaporated to dryness at 40 °C. and the extract is weighed and taken up in 3 ml of methanol.

Condensed tannins have been quantified by the vanillin method in acidic medium [23]. 50 L of the crude extract was added to 1500 L of 4% vanillin solution (methanol) and subsequently mixed. Then 750 L of concentrated hydrochloric acid was added. The mixture obtained is incubated at room temperature for 20 mins. Compared to a blank, the absorbance was measured at 550 nm using the UV-Vis spectrophotometer. The results are expressed in mg catechin equivalent per gram of dry plant material (mg EC / g) using the following equation y = 0.006x - 0.0032 (R^2 = 0.857).

Anthocyanes dosage

0.5 mL of the 1 mg/mL solution of extract prepared in MeOH/H_2O (80%) was mixed with 3 mL of methanolic vanillin solution (4%) and 1.5 mL of concentrated hydrochloric acid. The mixture was then incubated for one hour at room temperature and the absorbance is read at 540 nm [24].

The anthocyanin content of the extracts is expressed as mg of D-catechin equivalent (EC/g) of the corresponding dry matter using the equation from the calibration curve: y= 0.0728x + 0.0171 and R2 = 0.944 where x is the absorbance and y is the catechin equivalent (mg/g).

2.2.2 Radical Scavenging Activity

The extracts were dissolved in a DMSO-Water mixture (1: 1), then their effect was compared to a control test carried out with the mixture alone. The antioxidant activity was assayed by ABTS and DPPH spectrophotometry which were carried out according to the method described by [25].

2.2.3 Qualitative Composition

a) Bromatological analyses of Dioscorea praehensilis benth

Determination of moisture, total lipids, total ash, fibers, total proteins and total carbohydrates was performed according to the methods described by Mbemba and Remacle [26], Degroote [27], Vervack [28], AOAC [29], Sadasivam [30], Mbemba [31] and Makengo *et al.* [32]. Each experiment was carried out in triplicate.

b) Anti-nutritional factors

The following treatments were applied separately to the tender stems in triplicate: raw and cooked samples. Portions of the tender stems were cooked in a 1 liter conical flask equipped with a condenser. Tap water was added (stem / water ratio, 1: 3 w/v), and the tender stems were cooked on a heat cap until soft when squeezed with the stems. fingers. The cooking juices and tender stems were separated using a sieve; and the tender stems were air dried and then stored in an oven at 60 °C for complete drying. Cooked samples were stored in airtight bottles and stored at 4 °C for later analysis.

Determination of Total Cyanide contents

The cyanide contents were obtained according to the method (n ° 26.151) described by the AOAC [33]. The crude and dried samples were placed in two Kjeldhal glass vials (autolysis) with vapor distillate collected in NaOH solution and titrated against standard $AgNO_3$ solution in the presence of NH4OH and KI. The concentration of HCN was calculated from the amount of $AgNO_3$ used for the titration.

Oxalate determination

The oxalate assay was carried out using the method

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described by Oke [34]. 2 g of the raw and dried samples were dissolved in 10 ml of HCl (6 M) for one hour and completed at 250 ml in a volumetric flask. The pH of the filtrate was adjusted with a concentrated NH_4OH solution until the solution color changed from salmon pink to pale yellow. Then, the filtrate was treated with 10 ml of a 5% $CaCl_2$ solution to precipitate insoluble oxalate. The suspension was centrifuged at 2500 rpm. Then the supernatant was decanted and precipitated completely dissolved in 10 ml of H_2SO_4 at 20 % (v/v). The total filtrate resulting from dissolution in H_2SO_4 was increased to 300 mL. A 125 ml aliquot of the filtrate was heated to near the boiling point and then titrated against 0.05 M of standardized $KMnO_4$ solution to a pale pink color that persisted for about 30 s after which the burette reading was taken. The oxalate content was assessed from the value of the security. The overall oxidation reaction is:

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$$

2.2.4 Statistical Analysis

All the data were reported as mean ± standard deviation of three replicates. The IC_{50} values were calculated using Graph Pad Prism version 6.0 Software (Graph Pad Software, San Diego California, USA), The analysis of variance Diego California, USA). Statistical analysis was performed using Microsoft Excel.

3. Results and Discussion

3.1 Moisture Content

The measures of moisture are shown below (Figure 2). Our results show that *D. praehensilis* tender stems have a very high moisture content (86.7%).

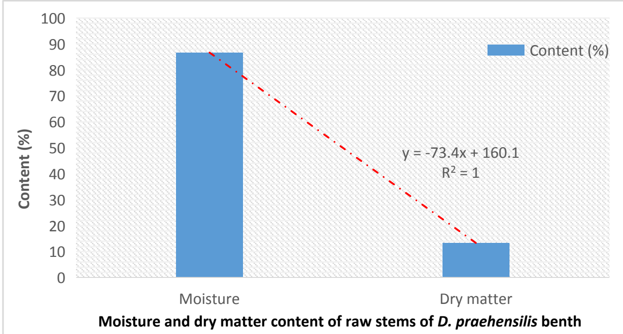

Figure 2. Moisture and dry matter content of raw stems of *D. praehensilis* benth

The variation of moisture between fresh and dried matters is very significant at P>5% (R^2 = 1).

We can notice that *D. praehensilis* tender stems have a very high moisture content compared to *D. praehensilis* yams and *D. alata* liana and D. dumetorum yams, whose moisture turn around 10% [35].

3.2 Phytochemical Screening

The results in Table 1 show that the tender stems of

Table 1. Phytochemical screening of *bark of Dioscorea praehensilis* benth

a. Results of chemical screening on the aqueous phase			**Results**
Chemical Groups Sought	***Reagents used***	***Observations***	**Bark**
1. Phenolic compounds			
Anthocyanins	HCl et NH_4OH	Red (Acid) and blue or greenish (Alca) colouring	+
Catechetical	Stiasny	Pink precipitate	+
Flavonoids	Cyanidine of Shinona	Colouring orange, red, violet	-
Gallic	Stiasny+$FeCl_3$ + CH_3COONa	Blue or black tint	+
Linked Quinones	Bornträger	Pink to purplish-red colouring	+++
Tannins	$FeCl_3$ 1%	Dark blue to black green colouring	-
Total polyphenols	Burton	Blue coloration with blue precipitate	+
2. ***Alkaloids***	Mayer	Precipitation	-
3. ***Saponines***	Foam test	Persistent foam of more than 1 cm after 15 min.	+++
4. Cardiotonic Heterosides	Killer - Killiani	Brownish-red ring at the interface of 2 solutions	+++
b. Results of chemical screening on the organic phase (Methanol)			
Chemical Groups Sought	***Reagents used***	***Observations***	**Bark**
1. Triterpenoids	Liebermann	Purple colouring	+
2. Steroids	Liebermann	Purple colouring	+
3. Free quinones	Bornträger and NaOH 10%	Blackish red coloration with precipitate	+
4. Anthocyanosids	HCl 20% + Diethyl ether + NaOH	No fluorescence under UV light	+

Legend: +++: Very abundant of the desired substance +: Presence of the desired substance; - : Absence of the desired substance

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Dioscorea praehensilis benth although having many phytoconstituents, are devoid of the main compounds as indicated in Table 1. The tender stems were found to be a rich source of polyphenols, anthocyanins and saponins. The same phytochemical compounds such as polyphenols [36] and tannins [37] have been reported in *Dioscorea* yams by Bukatuka *et al*. [35], Sherman [36] and Bray and Taylor [37]. The secondary metabolites generated in the plant systems act as major sources of dietary supplements and medicinal components for human body.

Phytochemical compounds are known to be biologically active constituents and are responsible for various activities such as antioxidants, antimicrobials, antifungi and anticancer [39-40]. Phenolic compounds have various activities including antioxidant, antidiabetic, antimicrobial, antiallergic, antimutagenic and anti-inflammatory activities.

Phytochemical compounds are known to be biologically active constituents and are responsible for various activities such as antioxidants, antimicrobials, antifungi and anticancer [39-40]. Phenolic compounds have various activities including antioxidant, antidiabetic, anticancer, antimicrobial, antiallergic, antimutagenic and anti-inflammatory activities [41-42].

The qualitative results of the content of secondary metabolites shown in Table 2 indicated that gallic tannins were present in the methanolic extract; their presence was confirmed by a positive reaction with a solution of ferric chloride and that flavonoids were not detected. These results confirm those of obtained by Bukatuka *et al*. [35]. In the table above, the samples were rich in total polyphenols (17.22 ± 0.16), tannins (19.32 ± 0.52) and anthocyanins (25.22 ± 0.04). Previous studies carried out on yams species of the same family have shown similar results [35,43,44]. The fact that this species has a high content of polyphenols could confer it considerable antioxidant properties.

Table 3 presents the antioxidant activity of *D. praehensilis*, as determined by ABTS and DPPH, expressed in IC_{50} values. Radical scavenging activity, as an indicator of antioxidant capacity, the antioxidant response of extracts does not appear to correlate with total phenolic content.

In addition, it should be noted that the IC_{50} values obtained by the ATBS test are lower than those of the DPPH test. This difference in activity could be attributed to their reaction mechanism. ABTS reacts simultaneously with both hydrophilic and lipophilic compounds while DPPH reacts only with hydrophilic compounds [45]. In an order of hundredths, our extracts showed a lower antioxidant activity than that of ascorbic acid (vitamin C), gallic acid and Quercetin used as positive controls. Nevertheless, this extract showed an interesting antioxidant activity compared to other plants [35,46-49].

3.3 Biochemical Analyses

3.3.1 Bromatological Analyses

The biochemical composition of ecotypes of *Dioscorea praehensilis* benth consumed in Kinshasa and Kwilu provinces (Democratic Republic of the Congo) is shown in the Figure 3.

As shown in this figure, the tender stems of *Dioscorea praehensilis* benth are rich in carbohydrates (67.16 g/100 g), with low levels of protein (8.4 g/100 g), fiber (14.25 g/100 g), lipid (2.88 g/100 g) and ash (7.31 g/100 g). These results corroborate with those obtained by several other studies [35,42-44]. As about the results obtained on dry matter, it can be stated that for all nutrients, the values we obtained are not in the range of the values given by Mbemba and Remacle [26] because they worked on fresh yam matter.

Table 2. Secondary metabolites content of methanolic extracts from *D. praehensilis*

Tender stems	Total polyphenols (mg GAE/g)	Flavonoids (mg QE/g)	Tannins (mg CE/g)	Anthocyanins (mg CE/g)
D. praehensilis	17.22 ± 0.16	nf	19.32 ± 0.52	25.22 ± 0.04

(nf: not found), GAE: gallic acid equivalent, QE: quercetine equivalent, CE: cathechine equivalent

Table 3. IC_{50} (μg/mL) values of *D. praehensilis* extracts (Means ± SD, n=6)

Tender stems extract	IC_{50} (μg/mL)	
	ABTS	DPPH
D. praehensilis	97.26 ± 7.52	142.53 ± 11.61
Vitamin C	2.36 ± 0.60	3.24 ± 0.96
Acide gallique	0,71 ± 0,08	1,07 ± 0,10
Quercétine	1,42 ± 0,04	3,21 ± 0,99

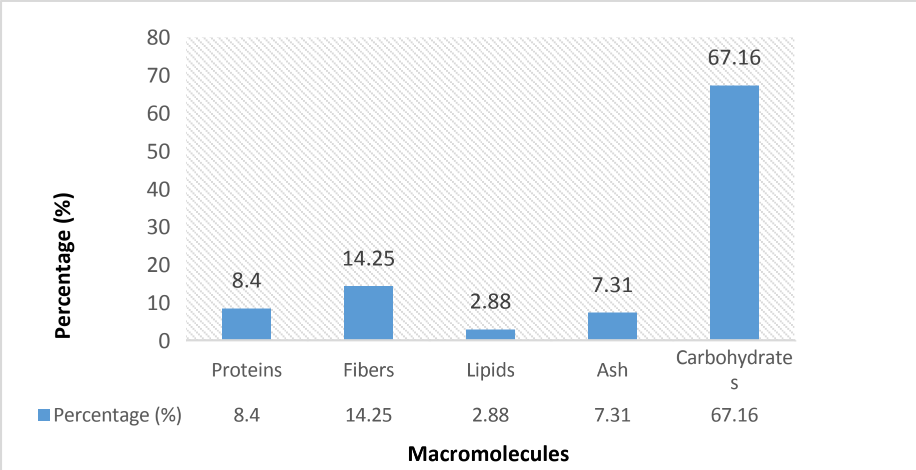

Figure 3. Macronutrient content in *Dioscorea praehensilis* benth stems

3.3.2 Anti-nutritional Factors

Cyanide content before and after cooking

The physico-chemical tests of our samples showed that *Dioscorea praehensilis* benth contains a significant amount of hydrocyanic acid in fresh tender stems. Hence 30 g of sample contains 30 mL of hydrocyanic acid. At this quantity, crude *Dioscorea praehensilis* benth used as food has a high toxicity in hydrocyanic acid. But after a good cooking, about 1 hour, the cyanide is eliminated in 99.97%. According to the procedure, after cooking we obtained 0.03 mL of hydrocyanic acid. Which gives us 0.011 mg/Kg. So after cooking, the Cyanide content is three times less than the no observed effect level (NOEL). NOEL in international way = 0.3 mg/Kg.

Oxalate content before and after firing

The tender stems of *Dioscorea praehensilis* benth do not contain a high quantity of oxalates, according to the result of our study. 10g of our sample gave a result of 0.025 mol/L in oxalate. So *Dioscorea praehensilis* benth as food has a low concentration of oxalic acid.

An excessive amount of soluble oxalate in the body prevents the absorption of soluble calcium ions, as oxalate binds to calcium ions to form an insoluble calcium oxalate complex. Therefore, people with a tendency to form kidney stones are advised to avoid foods rich in oxalate. On the other hand, people suffering from coronary heart disease are encouraged to consume rich foods that are moderately oxalic because this contributes to the reduction of blood cholesterol [50].

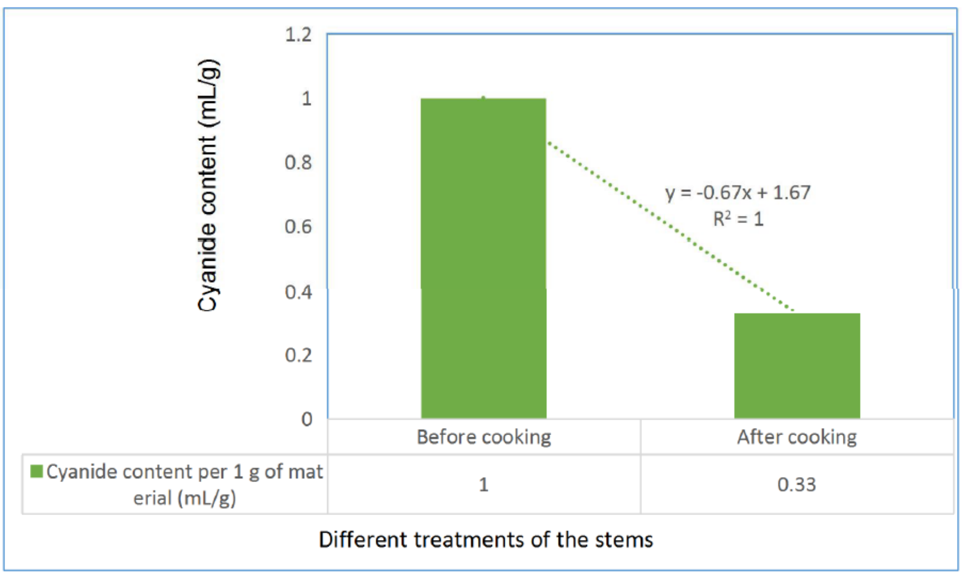

Figure 4. Cyanide content in the stems of *Dioscorea praehensilis* benth before and after cooking

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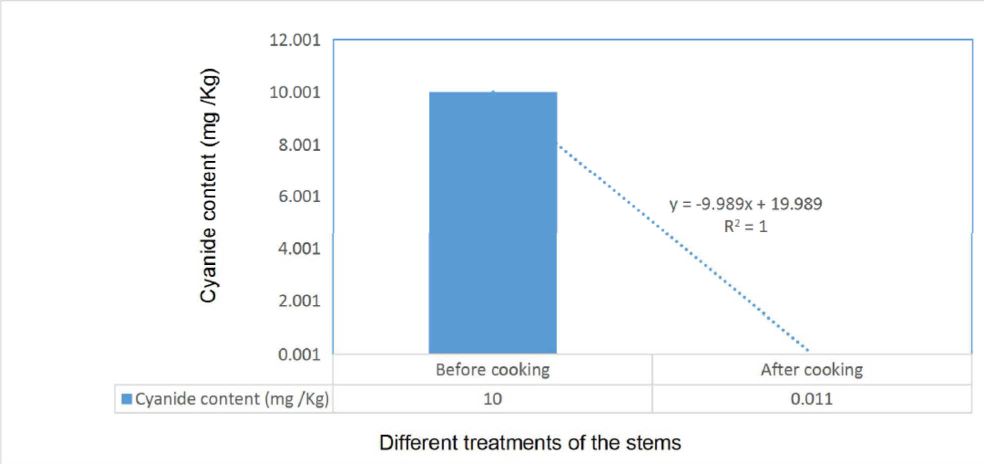

Figure 5. Cyanide content in the stems of *Dioscorea praehensilis* benth before and after cooking

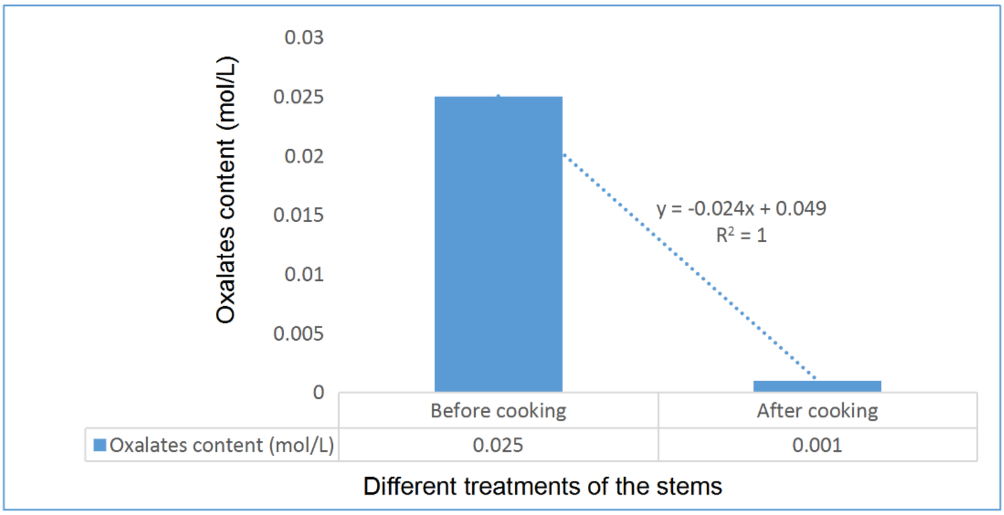

Figure 6. Oxalate content in the stems of *Dioscorea praehensilis* benth before and after firing

4. Conclusions

Nutrient rich plants are very important for a growing world population. Biodiversity is at the center of countless of these foods, but we only use a few of them. Among these plants, Dioscorea species play a vital role in supplementing food and medicine needs of rural populations. The results of the present study revealed various phytochemical compounds in this species and that the tender stems of *Dioscorea praehensilis* benth (Dioscoreaceae) were rich in carbohydrates, proteins and ash.

The results of the oxalates and cyanides measures in cooked food show an average value that does not present a significant risk to public health. Tubers and cereals contain a small amount of oxalate and can therefore be eaten moderately on a regular basis, while legumes are rich in oxalate and should be reduced in the diet to avoid the formation of kidney stones. The public should also be informed of the danger of excessive consumption of oxalate-rich foods.

The ethno-medical practices of traditional healers use *Dioscorea praehensilis* benth in the treatment of various diseases; in particular, the tuber is used against diarrhea, dysentery, stomachaches, dyspepsia, leukoderma, bronchitis and applied on ulcer; it is also used as a tonic, aphrodisiac and improves appetite.

Funding

This study was not funded.

Availability of data and materials

All data and materials are presented in the manuscript.

Authors' contributions

Authors Patience M. Ngelinkoto, André-Marie K.

Lokassa, Bernadin Bulumuka, Johnny B. Mukoko, Myriam M. Ngondo and Florent B. Mukeba. Bernadin Bulumuka, Dorcas M. Kabasele, Ruth L. Mbuli and Florent B. Mukeba collected, dried and reduced in powder and perfomed the extractions. Patience M. Ngelinkoto, André-Marie K. Lokassa, Bernadin Bulumuka, Jeff K. Maliani, Johnny B. Mukoko and Florent B. Mukeba did the literature study, participated in experimental works. Johnny B. Mukoko, Patience M. Ngelinkoto, André-Marie K. Lokassa and Florent B. Mukeba interpreted the data, performed statistical analysis and prepared the manuscript. Patience M. Ngelinkoto, André-Marie K. Lokassa and Florent B. Mukeba designed the study. Patience M. Ngelinkoto, Myriam M. Ngondo and Florent B. Mukeba approved the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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ARTICLE

Floristic Inventory and Evaluation of Carbon Sequestration Potential of the Misomuni Forest Massif, Kikwit City (Democratic Republic of the Congo)

Masens Da-Musa Y.B.[1*] Briki K. Cyril[2] Masens Mandung[3] Koto-Te-Nyiwa Ngbolua[1]

1. Department of Biology, Faculty of Science, University of Kinshasa, Kinshasa, Democratic Republic of Congo
2. University of Kikwit, Kikwit, Democratic Republic of Congo
3. Lumbi Higher Institute of Medical Techniques, Lumbi, Democratic Republic of Congo

ARTICLE INFO

Article history
Received: 2 August 2021
Accepted: 25 August 2021
Published Online: 7 September 2021

Keywords:
Forest ecosystem
Plant biodiversity
Carbon sequestration
Reducing Emissions from Deforestation and Forest Degradation project
Democratic Republic of the Congo

ABSTRACT

The aim of this study was to inventory plant biodiversity and to evaluate the carbon sequestration potential of the Misomuni forest massif. An inventory of all trees with diameter at breast height (dbh) ≥ 10 cm measured at 1.30 m height was performed. The aerial biomass (AGB) was used for estimating the stored CO_2 and its carbon equivalent. 88 plant species belonging to 71 genera and 32 families were inventoried. Fabaceae family displayed the highest number of species and genera. The highest basal area values were displayed by *Scorodophloeus zenkeri* (7.34 ± 2.45 m^2/ha), *Brachystegia laurentii* (5.82 ± 1.94 m^2/ha), *Entandrophragma utile* (5.28 ± 1.94 m^2/ha), *Pentadesma butyracea* (4.53 ± 1.51 m^2/ha). The highest values of stored carbon and their carbon equivalent were observed in *Pentadesma butyracea* (15.13 ± 5.00 and 50.55 ± 16.85 t/ha), *Picralima nitida* (7.02 ± 2.34 and 23.66 ± 7.88 t/ha), *Strombosia tetandra* (6.56 ± 2.18 and 22.10 ± 7.36 t/ha). The Misomuni forest massif is thus much floristically diversified and plays a significant role in the sequestration of CO_2. The total AGB of the inventoried trees is 183.78 ± 61.26 t/ha corresponding to stored carbon and carbon equivalent of 96.63 ± 32.21 t/ha and 289.92 ± 96.64 t/ha respectively. The protection of this ecosystem is highly needed for combatting climatic changes at local, national and regional scales and for the conservation biodiversity habitat.

1. Introduction

The Democratic Republic of the Congo (DRC) is a reservoir (hotspot) of biodiversity in the world [1]. Preserving the DRC's plant biodiversity and forest ecosystems is an imperative that can help mitigate climate change at local and regional scales reducing thus emissions from deforestation and other land-use changes, and enhancing carbon sinks.

The Misomuni forest massif is located in the south of Kikwit city (Kwilu province) in the West part of DRC. Actually, the observed loss of biological diversity in this region is essentially linked to human activity. Indeed, the above-mentioned massif is currently fragmented into several forest islands because of the numerous excessive anthropic activities undertaken in this phytocenosis. Although, three forest islands still retain certain homogeneity due to their particular status as "farms"; so

**Corresponding Author:*
Masens Da-Musa Y.B.,
Department of Biology, Faculty of Science, University of Kinshasa, Kinshasa, Democratic Republic of Congo;
Email: jpngbolua@unikin.ac.cd

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providing service such as microclimate regulation and supporting service like photosynthesis, soils formation and nutrient cycling [2]. The geographical coordinates of these patches are practically the same, although the Mbala Ding portion is located ± 3 km from two other patches and separated from them by an anthropogenic savanna. These coordinates are: 05°08' south latitude, 18°58' East longitude, and 140 to 458 m of elevation [3]. It will be necessary to evaluate the quantity of carbon stored by this phytocenosis and that released following the destruction of the trees which compose this forest massif from the manufacture of charcoal. This would allow in the near future evaluating the impact of the degradation of this plant formation on the climate change currently observed in this region of the country. Indeed, in recent years, there has been an increased demand for traditional bioenergy from the populations of the region concerned, because there is no or little electricity in many areas of our country [4]. To confirm this situation, it is necessary to travel along the National Highway 1 from Kinshasa to km 622 after the town of Kikwit to realize this. Many thousands of bags of embers are spread out along this main road beyond view. These products are the result of the destruction or indiscriminate deforestation of both forest and savannah ecosystems (shrubby savannahs, woodlands, etc.). The combustion of this traditional bioenergy releases tons and tons of CO_2, a greenhouse gas, into the atmosphere [5]. The aim of this study was to inventory plant biodiversity and to evaluate the carbon sequestration potential of the Misomuni forest massif. Indeed, assessing carbon sequestration in such forest ecosystem is required to supply information to monitor, report and verify for reducing deforestation and forest degradation (REDD) program as well as for biodiversity conservation in order to ensure ecosystem functioning.

2. Material and Methods

The Misomuni forest massif, currently divided into several forest islands including Kisalangundu, Mbala Ding and Mambala, is located at least 30 km south of the town of Kikwit on the Batsamba and/or Mukulu road (Figure 1).

It is located geographically between 5°08' south latitude and 18°58' west longitude and an altitude varying between 140 and 458 m. Floristic inventory and dendrometric measurements were conducted within these islands (one-hectare plot by island/site i.e. 3 ha in total). The inventory was based on rectangular plots measuring 100 m in length and 20 m in width (i.e. an area of 0.2 ha), joined together, and laid out along parallel inventory paths. For this purpose, a network of five plots was set up along the paths. Only trees with dbh measured at 1.30 m from the ground and ≥ 10 cm were considered. All specimens of inventoried trees and shrubs were identified according to APG versions II, III, and IV. The ecological spectra (biological type, diaspora type and foliar type)

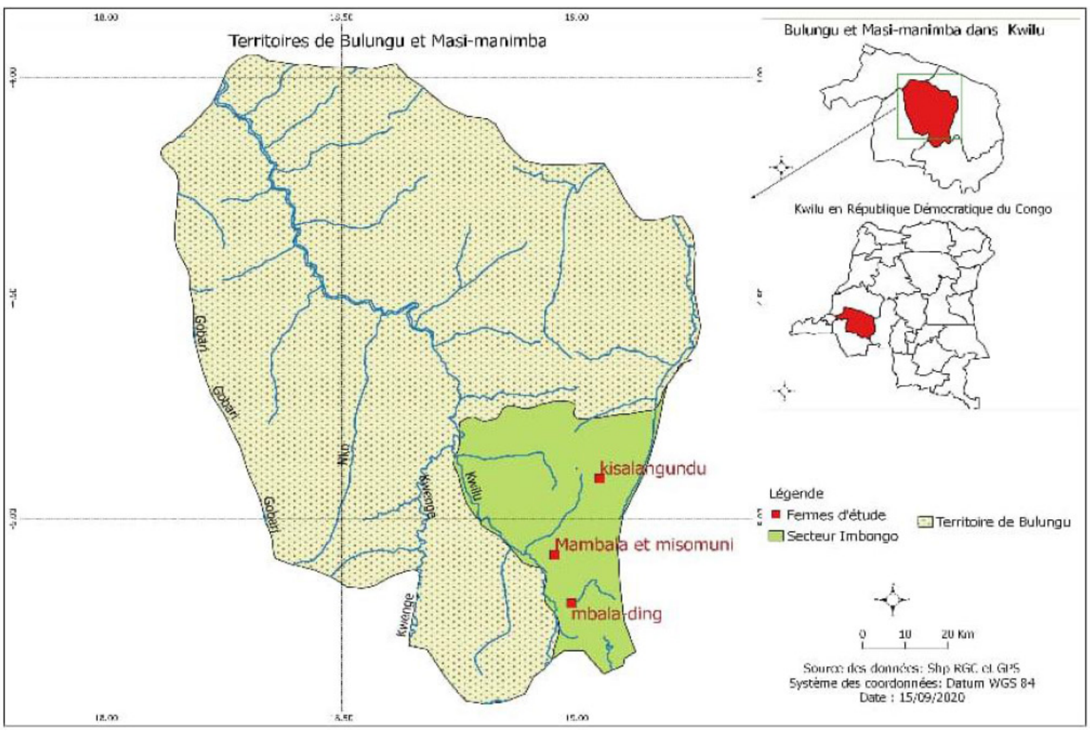

Figure 1. Location of the study sites

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were determined using the Raunkiaer classification as previously reported [6-10]. The Raunkiaer system was used to determine the types of leaf size [11-15]. The morphological classification of Dansereau & Lems and the ecomorphological classification of Molinier & Mùller were used to determine the types of dissemination [16-18]. The phytogeographical distribution types defined in this study were established according to Lebrun as reported by several authors for tropical Africa region [17,19-22]. The determination of ecosociological groups was carried out according to the research of Lubini [23]. The calculations of (AGB), stored carbon (CSe), carbon equivalent (EqC) and basal area (BA or G) were carried out according to the following equations as previously reported [24-28]:

$$AGB = Exp(-0.37 + 0.333 * \ln(DBH) + 0.933\, ln(DBH)^2 - 0.122 * \ln(\mathrm{DBH}) \quad (1)$$

$$CSe = 0.47 * AGB \quad (2)$$

$$EqC = 3.667 * CSe \quad (3)$$

$$G = \frac{\pi}{4S}\sum_{i=1}^{n} di^2 \quad (4)$$

Where DBH is the diameter at breast height; S is the surface of the plot; di is the diameter of the tree I, n is the total number of trees with (dbh) ≥ 10 cm measured at 1.30 m height; Ht is the total height; d is the specific density of the wood.

The Microsoft Excel 2007 and IBM SPSS statistics version 14.0 software packages were used for data analysis while the allometric the equations were used to evaluate the correlation between some parameters (AGB and density, AGB and dbh, AGB and G, etc.).

3. Results

88 different plant species have been listed and identified overall. These species are divided into 71 genera, and 32 families (Table 1). Fabaceae is the group with the highest number of species and genera. Indeed, this group contains 24 species in total, or 27.27% and 15 genera, or 21.43%. It is very distantly followed by Sapotaceae; Clusiaceae and Myristicaceae with respectively 6; 4 and 4 species each, which is to say 6.82; 4.54 and 4.54%. Eight families have 3 species each, i.e. 24 species in all. These are Annonaceae; Apocynaceae; Chrysobalanaceae; Malvaceae; Meliaceae; Moraceae; Strombosiaceae and Ulmaceae. As for the twelve remaining families, they are monospecific. The genera *Celtis*, *Chrysophyllum* and *Distemonanthus* each have three different plant species. They are followed by twelve others with 2 species each. In terms of number of individuals, *Scorodophloeus zenkeri* Harms*, Staudtia kamerunensis* Warb. and *Anonidium mannii* (Oliv.) Engl. & Diels have a high number of plants, respectively 152 ± 50.67 trees/ha; 119 ± 39.67 trees/ha and 108 ± 36.00 trees/ha. Six species are weakly represented. These include *Entandrophragma angolense* (Welw.) C.DC. (1 tree/ha); *Celtis tenuifolia* Nutt. (1 tree/ha). The numerical number of trees varying between 10 and 28 was observed in 11 species, including *Petersianthus macrocarpus* (P.Beauv.) Liben (85 ± 28.33 trees/ha), *Maranthes chrysophylla* (Oliv.) Prance ex F.White (65 ± 21.66 trees/ha), *Pterocarpus mildbraedii* Harms (59 ± 19.66 trees/ha), *Duboscia viridiflora* (K.Schum.) Mildbr. (34 ± 11.33 trees/ha), etc.

Table 1. List of identified plant species and their ecological characteristics

Botanical name	Family	Phyto distribution	Biological type	Diaspora type	Foliar type
Albizia adiantifolia (Schumach) W.Wight	Fabaceae	GC	MgPh	Bal	Mi
Albizia gummifera Var. *(*Schum W.F.Wight.)	Fabaceae	GC	MsPh	Bal	Me
Amphimas ptercarpoïdes Harmas	Fabaceae	GC	MsPh	Bal	Me
*Angylocallyx marginervatus(*Baker) Baker.F	Fabaceae	GC	MsPh	Bal	Me
Anisophyllea polyneura Engl.	Anisophylleaceae	CG	MsPh	Sar	Me
Anodium mannii (Oliv.)Engl et Diels	Annonaceae	GC	MsPh	Sar	Ma
Anthocleista shweinfurthii Gilg.	Gentianaceae	GC	McPh	Sar	Ma
Anthrocaryon micraster De Wild.	Anacardiaceae	GC	MsPh	Sar	Me
Antrocaryon klaineanum Pierre	Anacardiaceae	GC	MsPh	Sar	Me
Aubrecavillea kerstingii Brenan	Fabaceae	CG	MsPh	Pte	Me
Brachystegia laurentii Louis ex.Hoyle	Fabaceae	CG	MgPh	Bal	Me
Brachystegia sp (De Wild.) Louis ex Hoyle.	Fabaceae	CG	MgPh	Bal	Me

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Botanical name	Family	Phyto distribution	Biological type	Diaspora type	Foliar type
Brenania brieyi Petit	Rubiaceae	CG	MsPh	Sar	Me
Canarium schweinfurthii Engl.	Burseraceae	CG	MsPh	Sar	Me
Canthium arnoldianum (De Wild.et Th.Dur) Hepper	Rubiaceae	CG	MgPh	Sar	Me
Celtis sp	Ulmaceae	GC	MsPh	Sar	Me
Celtis tenuifolia Nutt.	Ulmaceae	CG	MsPh	Sar	Mi
Celtis zenkzri Engl.	Ulmaceae	GC	MsPh	Sar	Me
Chrysophyllum africanum Pierre.	Sapotaceae	CG	MgPh	Sar	Me
Chysophyllum lacourtianum De Wild.	Sapotaceae	CG	MgPh	Sar	Me
Coelocaryon preussii Warb.	Myristicaceae	CG	MsPh	Sar	Me
Cola lateritia K.Schum.	Malvaceae	CG	MsPh	Sar	Me
Detarium macrocarpus Guill& perr.	Fabaceae	CG	MgPh	Sar	Me
Diospyros crassiflora Hiern.	Ebenaceae	BGC	MsPh	Sar	Me
Distemonanthus benthamianus Baill	Fabaceae	CG	MsPh	Sar	Me
Distemonathus macrophylla Baill.	Fabaceae	GC	MsPh	Sar	Me
Duboscia viridiflora Boca.	Malvaceae	CG	MsPh	Sar	Me
Enanthia clorantha Oliv.	Annonaceae	GC	MsPh	Sar	Me
Entandrophragma angolense (Deilt.) A Chev	Meliaceae	GC	MgPh	Sar	Me
*Entandrophragma utile (*Dawe et Sprague)	Melaceae	GC	MgPh	Pte	Me
Eriocoelum macrocarpum	Sapindaceae	GC	MsPh	Pte	Me
Erismadelphus exsul Mildbr.	Vochysiaceae	GC	MsPh	Pte	Me
Erythroxylum mannii Oliv.	Erythroxylaceae	CG	MsPh	Sar	Me
Ficus mucuso Welw. Ex.Ficalho	Moraceae	At	MsPh	Sar	Me
Furtumia elastica (Preuss) Staf	Apocynaceae	GC	MsPh	Scl	Me
Gambeya beguei Aubrev. & peller	Sapotaceae	CG	MsPh	Sar	Me
Gilbertiodendron dewevrei L.	Fabaceae	GC	MgPh	Sar	Me
Guarea thompsonii (A. Chev) Pellegr.	Meliaceae	GC	MgPh	Sar	Me
Homalium sp	Salicaceae	GC	MsPh	Sar	Me
Irvingia robur Mildbr.	Irvingiaceae	CG	MsPh	Sar	Me
Lovoa trichiliodes Harms	Meliaceae	GC	MsPh	Scl	Me
Manilkara sp	Sapotaceae	CG	MgPh	Sar	Me
Maranthes chrysophylla (Oliv) Prance	Chrysobalanaceae	CG	MsPh	Sar	Me
Maranthes glabra (Oliv) Prance	Chrysobalanaceae	CG	MsPh	Sar	Me
Mildbraediodendrom excelsum Harms	Fabaceae	CG	MsPh	Bal	Me
Milicia excelsa (Welw.) Berg.	Moraceae	GC	MgPh	Sar	Me
Musanga cecropioides Roxb. Br.	Urticaceae	GC	MgPh	Sar	Me
Nesogordonia papaverifera (A. Chev.) Copur	Malvaceae	GC	MsPh	Sar	Me
Omphalocarpum elatu Miers	Sapotaceae	GC	MgPh	Sar	Me
Oncoba welwitschii	Salicaceae	GC	McPh	Sar	Me
Ongokea gore Pierre	Olacaceae	GC	MgPh	Sar	Me
Pachyelasma mannii Sabine	Fabaceae	GC	MgPh	Bal	Me

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DOI: https://doi.org/10.30564/jbr.v3i4.3505

Botanical name	Family	Phyto distribution	Biological type	Diaspora type	Foliar type
Pachyelasma tessmannii Harms	Fabaceae	GC	MgPh	Bal	Me
Pachypodianthium staudtii (Engl.et Diels)	Annonaceae	CG	MsPh	Sar	Me
Panda oelosa Pierre	Pandaceae	GC	McPh	Sar	Me
Parinari excelsa Sarbine	Chrysobalanaceae	CG	MgPh	Sar	Me
Pentaclethra macrophylla Benth.	Fabaceae	GC	MsPh	Sar	Me
Pentadesma butyracea Sabine	Clusiaceae	FC	MsPh	Sar	Me
Pentadesma excelliana Staner.	Clusiaceae	FC	MsPh	Sar	Me
Pentadesma grandiflora Staner	Clusiaceae	FC	MsPh	Sar	Me
Petersianthus macrocarpus Beauv. Liben.	Lecythidaceae	GC	MgPh	Sar	Me
Picralima nitida (Baill.) Urb.	Apocynaceae	GC	MgPh	Sar	Me
Poga oleosa Gurke	Rhizophoraceae	GC	MsPh	Sar	Me
Polyscias fulva (Hiern) Harms	Araliaceae	CG	MgPh	Pte	Me
Prioria balsamifera Vern.	Fabaceae	GC	MgPh	Bal	Me
Pterocarpus mildbraedii Taub.	Fabaceae	GC	MsPh	Pte	Me
Pterocarpus tinctorius Hams	Fabaceae	At	MgPh	Sar	Me
Pycnanthus angolensis Warb.	Myristicaceae	GC	MsPh	Sar	Me
Sacoglottis gabonensis L.F.Baill.	Humiriacea	GC	MsPh	Sar	Me
*Santiria trimera (*Oliv.) Aubreu.	Burseraceae	CG	MsPh	Sar	Me
Schrebera arborea Welw.	Oleaceae	At	MsPh	Pte	Me
Scorodophloeus zenkeri Harms	Fabaceae	CG	MgPh	Bal	Me
Scyphocephallium mannii W.orb.	Myristicaceae	GC	MsPh	Sar	Me
Staudtia kamerunensis Warb.	Myristicaceae	CG	MsPh	Sar	Me
Strombosia pustulata Hook.F.	Olacaceae	CG	MsPh	Sar	Me
Strombosia tetandra Hook.F.	Olacaceae	CG	MsPh	Sar	Me
Symphonnia globulifera L.F.	Clusiaceae	At	MsPh	Sar	Me
Synsepalum msolo (Engl.) T.D.Penn.	Sapotaceae	GC	MsPh	Sar	Me
Tabernaemontana crassa Benth.	Apocynaceae	GC	McPh	Sar	Me
Tessmania africana Harms.	Fabaceae	GC	MgPh	Bal	Me
Trilepisium madagascariense DC.	Moraceae	GC	MsPh	Sar	Me
Vitex congolensis Dewild et Th. Dur.	Verbenaceae	GC	MsPh	Sar	Me
Vitex grandifolia(Gurk) W.piep	Verbenaceae	CG	MsPh	Sar	Me
Vitex welwitschii Gurke	Verbenaceae	GC	MsPh	Sar	Me

The highest basal area (BA) and above-ground biomass (AGB) values were obtained for the following plant species (Figure 2): *Scorodophloeus zenkeri* Harms (7.34 ± 2.45 m^2/ha), *Brachystegia laurentii* (De Wild.) Hoyle (5.82 ± 1.94 m^2/ha), *Entandrophragma utile* (Dawe & Sprague) Sprague (5.28 ± 1.94 m^2/ha), *Pentadesma butyracea* Sabine (4.53 ± 1.51 m^2/ha) (for BA) and *Pentadesma butyracea* Sabine (31.44 ± 10.48t/ha), *Picralima nitida* (Stapf) T.Durand & H.Durand (14.95 ± 4.98 t/ha), *Antrocaryon micraster* A.Chev. & Guillaumin (9.56 ± 3.19 t/ha), *Synsepalum msolo* (Engl.) T.D.Penn. (6.96 ± 2.32 t/ha), *Poga oleosa* Pierre (6.36 ± 2, 12 t/ha), *Entandrophragma utile* (Dawe & Sprague) Sprague (5.02 ± 1.67 t/ha), *Brenania brieyi* (De Wild.) E.M.A.Petit (4.71 ± 1.57 t/ha), *Aphanocalyx margininervatus* J.Leonard (4.61 ± 1.54 t/ha), etc. for AGB. The highest values of stored carbon and their carbon equivalent were observed in the following species: *Pentadesma butyracea* Sabine (15.13 ± 5.00 and 50.55 ± 16.85 t/ha), *Picralima nitida* (Stapf) T.Durand & H.Durand (7.02 ± 2.34 and 23.66 ±

7.88 t/ha), *Strombosiopsis tetandra* Engl. (6.56 ± 2.18 and 22.10 ± 7.36 t/ha), etc. The lowest values of these parameters were obtained in *Piptadeniastrum africanum* (Hook.f.) Brenan with 0.05 ± 0.01 and 0.18 ± 0.06 t/ha of sequestered carbon and its carbon equivalent (Figure 2). The average dbh of the species, measured at 1.30 m above the ground, is 28.82 m, and the highest dbh value was observed in *Poga oleosa* Pierre with 85.43 m. The lowest dbh value characterizes the species *Manilkara sp* with 14.17 m. The diametric structure of the sampled trees by class is shown in Figure 3.

It illustrates the density structure (number of stems/ha) according to the dbh classes. The range of dbh classes considered is 15.99. In total 4 classes of dbh were determined. These include: class 1 (10 - 25.99 cm), class 2 (26 - 41.99 cm), class 3 (42 - 57.99 cm) and ≥58 cm. Class 2 has the highest number of stems per hectare, 41 trees, followed by class 1 with 37 stems/ha. Class 4 is sparsely represented at 2 stems/ha.

According to ecological spectra and phytogeographic distribution, Mesophanerophytes represented 69.32% (Figure 4); Mesophylls (88.64%: Figure 5) and Sarcochores (68.18%: Figure 6) while Guinean-Congolese species were the most represented (60.23%: Figure 7). Table 2 and Figure 8 established the correlation between AGB and BA. From their analysis, it appears that the two compared parameters are positively correlated ($R^2 > 0.75$; p value < 0.05).

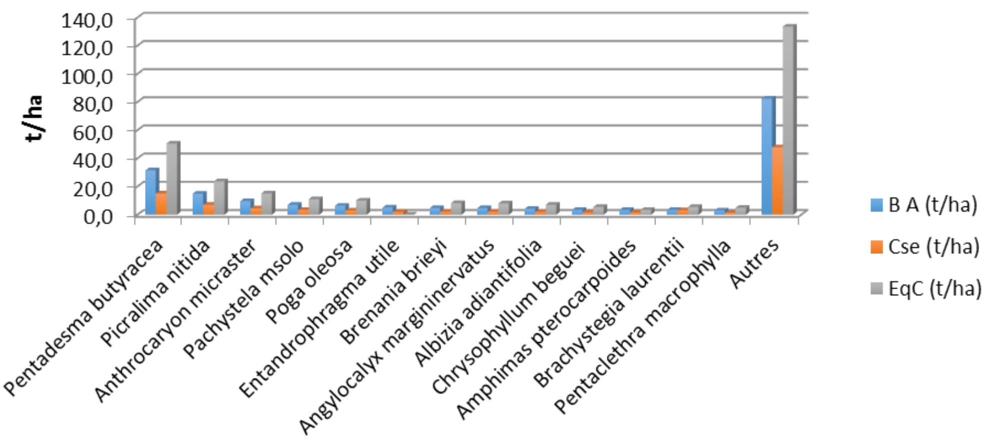

Figure 2. Measurement of BA, Cse and EqC

(Legend: BA = Basal area; Cse = Sequestered carbon; EqC = Carbon equivalent)

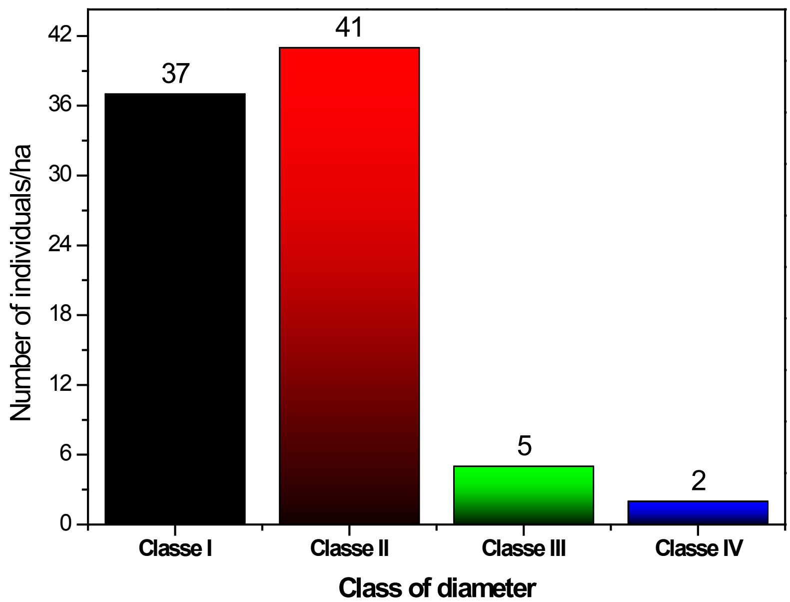

Figure 3. Diameter structure of trees listed by class

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DOI: https://doi.org/10.30564/jbr.v3i4.3505

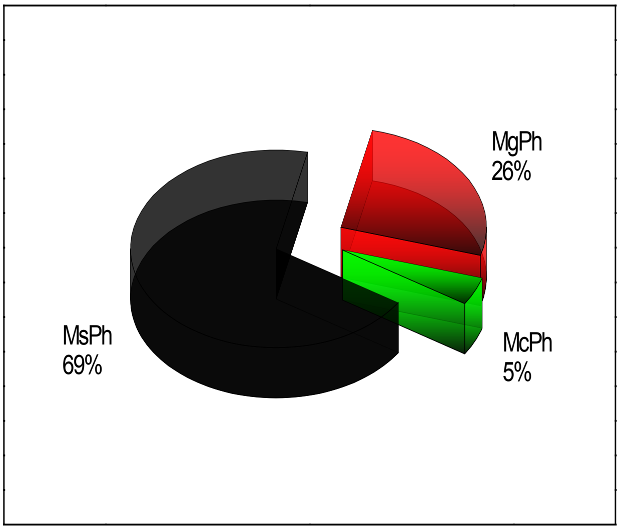

Figure 4. Biological types

(Legend: MsPh: Mesophanerophyte; MgPh: Megaphanerophyte; McPh: Microphanerophyte)

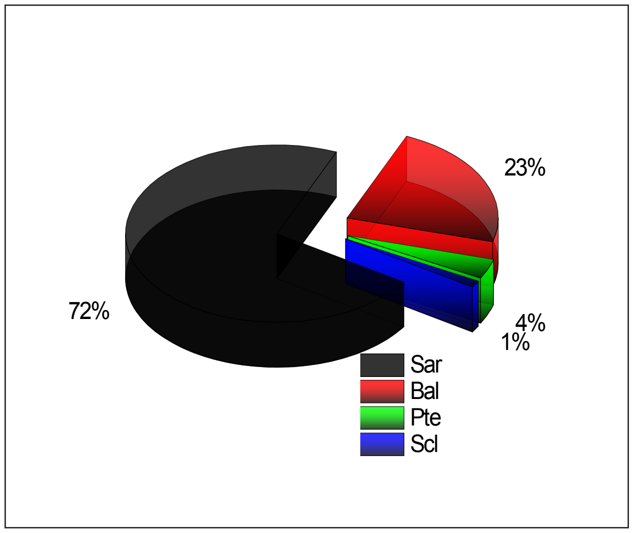

Figure 6. Types of diaspora

(Legend: Sar: Sarcochores; Bal: Ballochores; Pte: Pterochores; Scl: Sclerochores)

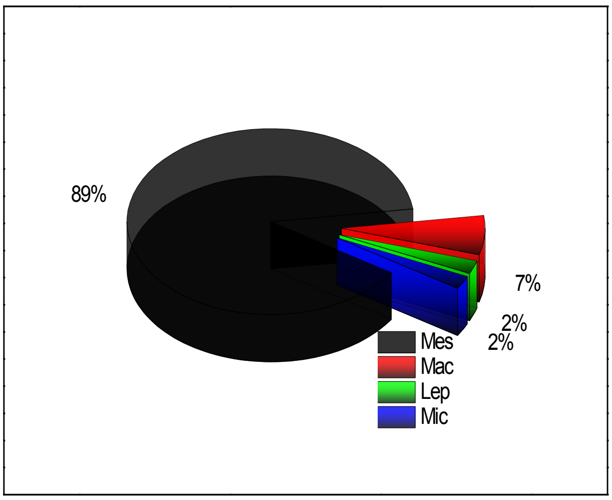

Figure 5. Types of leaf size

(Legend: Mes: Mesophyll; Mac: Macrophyll; Lep: Leptophyll; Mic: Microphyll)

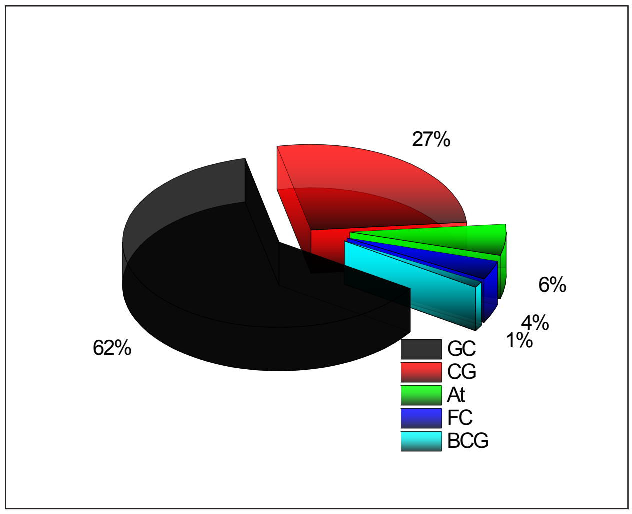

Figure 7. Phytogeographic distribution types

(Legend: GC: Guinean-Congolese species; CG: Central Guinean species; At: Afro-tropical species; FC: Central forester; BCG: Lower Guinean-Congolese species species)

Table 2. Relationship between AGB and basal area

Equation	Summary of models					Estimates of the parameters			
	R Square	F	ddl1	ddl2	p-value	Constant	b1	b2	b3
Linear	0,981	474,205	1	33	0,000	31,383	7,399		
Logarithmic	0,829	39,211	1	37	0,001	430,276	191,018		
Quadratic	0,858	424,527	2	26	0,002	20,920	3,600	0,046	
Cubic	0,798	435,374	2	46	0,002	20,910	2,410	0,057	0,001

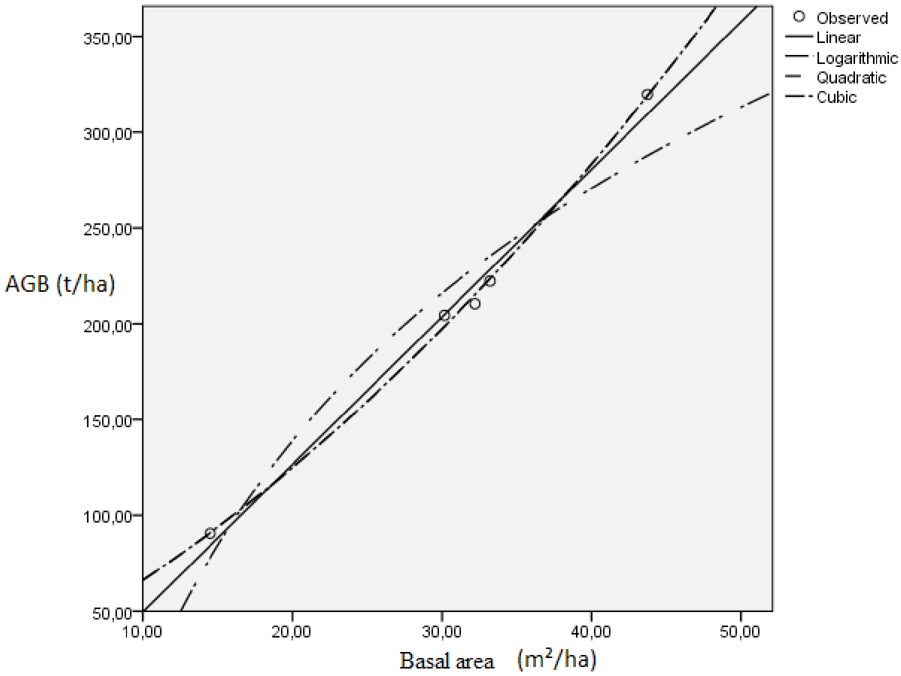

Figure 8. Regression equation curves between AGB and basal area

4. Discussion

The results obtained in this study in terms of density are similar to those obtained by Kidikwadi et *al.* [28] in the Luki Biosphere Reserve (194 individuals/ha). The Misomuni forest has a large number of plant species density compared to that obtained by Ngo [29] in the INERA/Kiyaka reserve (density: 5 trees/ha) and those obtained by Kibe [30] in the Ngoso forest. The difference in the results of different studies could be justified by the fact that the present work considered trees with a dbh measured at 1.30 cm from the ground ≥ 10 cm which is also a syntaxons made up of small trees and undergrowth shrubs or by habitat fragmentation. The density of the studied stand is high; it is about 1651 ± 550 trees/ha. This value of 550 trees/ha is in accordance with those reported by Lejoly [31] in the Ngotto forest and by Masens [21,22] in the forest ecosystems of Kamaba (Kipuka) and Nzundu (Imbongo) in the same region; the forest massif studied is specifically poor and fairly homogeneous. Similar observations had already been made by Kidikwadi et *al*. [28] and Lubini et *al.* [32] who studied respectively the *Prioria balsamifera* and *Hylodendron* stand in the Luki reserve and the semi-evergreen rainforest with *Celtis milbraedii* and *Gambeya lacourtiana* in the Kikwit region (Zaire/DRC), and by Pierlot [33] in the *Scorodophloeus zenkeri* forest (Yangambi, inventory n° 25). In Zaire, Malaisse [34] inventoried 1463 plants/ha in the dense dry forest; Devineau [35], in Côte d'Ivoire, listed 2884 plants/ha in the *Celtis sp.* forest (Lamto). The results obtained by these authors are highly superior to those observed in the Misomuni forest. This situation can be attributed to the very young age of this phytocenosis.

Among the most abundant trees, *Scorodophloeus zenkeri* has 50.67 individuals/ha, *Staudtia kamerunensis*, 39.67 individuals/ha; *Anonidium mannii* 36.00 individuals/ha, *Petersianthus macrocarpus*, 28.33 individuals/ha; *Maranthes chrysophylla*, 21.67 individuals/ha; *Brachystegia laurentii*, 21.33 individuals/ha; *Prioria balsamifera*, 20 individuals/ha; *Pterocarpus mildbraedii*, 19.67 individuals/ha and *Tessmannia africana*, 18.33 individuals/ha, etc. These results are compatible with those already observed in the same region by Kakiki [36], Masens [22]; but superior to those obtained in Kiyaka Forest Reserve by Lula [37]; Mungubushi [38]. It should also be noted that Gentry [39] obtained densities ranging from 167 to 1947 trees/ha for species with dbh ≥ 10 cm in neo-tropical forest ecosystems. Thus, our results are well within the ranges determined by Rollet [40] for Africa and America and those established by Gentry [39] for neotropical forests.

A value of 183.78 ± 61.26 t/ha of AGB was obtained in this forest massif; this value of AGB obtained is largely inferior in comparison with those observed by Sokpon [41] in the various forest stands of Benin. According to this author, the biomass values obtained in these stands vary from 378.8 to 391 t/ha. Synthesizing woody biomass values for moist and semi-deciduous forests, Bernhardt-Versat et *al*. [42], report that woody biomass values range from 233 t/ha for secondary forests in Ghana to 475 t/ha for primary forests in Malaya. Edouard and Grubb [43]

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studying dense rainforests in New Guinea obtained biomass values between 330 and 430 t/ha. The low values of AGB, as well as those of basal area (G), obtained in this phytocenosis are attributed to the state of degradation of this forest massif and the scarcity of large trees. Indeed, we numbered 7 emergent with dbh measured at 1.30 m at breast height and ≥ 40 cm against 81 trees and shrubs with dbh located between 10 and 39.9 cm. This would prove the immature state of this ecosystem and hence the low values obtained for the relevant parameters. The structure of the studied stand correlates with this assertion (i.e., the distribution of the listed and identified trees in dbh classes).

As shown in the figure for an uneven-aged stand, characterized by trees of all ages and sizes, the distribution of wood numbers by size categories takes the form of a curve with a decreasing trend [41]. Referring to the G, Malaisse [13] demonstrated that the G is a good tool for the classification of earth forma plant formations. He suggested that there is 30-40 m^2/ha of G in the *Entandrophragma delevoyi* dry forest in Zaire (DRC). In the Yapo forest, Bernhard-Reversat et *al.* [42], estimated 1 m^2/ha of BA and 30 m^2/ha for the Khade forest (Ghana). When considering the entire area prospected, i.e. 3 ha, the BA value obtained in this study is in the same order of magnitude as those of the authors mentioned above. It is however very low when it is reduced to one hectare. Indeed, the value of BA obtained is 55.18 ± 18.39 m^2/ha. This is probably due to the rarity of large emergent in this plant community. Indeed, the plant species presenting elevated values of basal area (BA) are also those that produce important quantities of aerial biomass (AGB). Thus, more BA increase, more AGB are important (expressed as CO_2 sequestration), it shows that the production of the aerial biomass is linked to the density of the individuals. The protection and the conservation of such a forest massif permits to fight so much against the climatic changes on a local scale (regulation of microclimate) as well as at the regional level.

5. Conclusions and Suggestions

The Misomuni forest massif is much floristically diversified (88 plant species belonging to 71 genera and 32 families) and plays a significant role in the sequestration of CO_2. The total AGB of the inventoried trees is 183.78 ± 61.26 t/ha corresponding to stored carbon and carbon equivalent of 96.63 ± 32.21 t/ha and 289.92 ± 96.64 t/ha respectively. The protection of this ecosystem is highly needed for combatting climatic changes at local scale and for the conservation biodiversity habitat.

It is therefore a necessity for the Congolese government to establish a partnership with universities and research institutes across the country in order to finance the related themes, and to extend such research within the forest ecosystems, or at least what is left of it in this country, as recommended by the REDD+ program. This would help our country to assert its rights to the payment of the environmental services related to the stock of carbon credit in these types of ecosystems.

Acknowledgements

The authors are indebted to Alfred Clément Inkoto, Santos Kavumbu, Blaise Mbembo-Wa-Mbembo, Laurent Gbanzo and Peter Mpilembo for their collaboration and assistance.

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ARTICLE

Storage Mycoflora in Sesame Seed Production in Benue State, Nigeria

M. Elaigwu[1*] H.O.A. Oluma[2] A. Onekutu[3]

1. Department of Integrated Science, College of Education, Oju, Benue State, Nigeria
2. Department of Botany, Federal University of Agriculture Makurdi, Benue state, Nigeria
3. Department of Zoology, Federal University of Agriculture Makurdi, Benue state, Nigeria

ARTICLE INFO

Article history
Received: 26 July 2021
Accepted: 16 August 2021
Published Online: 7 September 2021

Keywords:
Storage fungi
Mycoflora
Storage sesame
Benue state

ABSTRACT

Sesame (*Sesamum indicum*) is usually contaminated with many fungi where some of them are mycotoxigenic causing economic and health problems. This study investigated the percentage composition of fungi contamination of sesame seeds in Benue state Nigeria. Using direct plating technique; the study revealed twelve species of fungi contamination in sesame seed obtained in Benue State. The percentage occurrence of fungal isolates shows that *Aspergillus flavus* and *A. niger* were found in all the locations and their occurrence was significantly different ($P \leq 0.05$). The percentage contamination of Sesame samples collected from Otukpo LGA has the highest fungal (23.35%) contamination and was significantly higher ($P \leq 0.05$) from samples of other places whereas Sesame contamination from Gboko was the least with total percentage of (12.05%). In conclusion, considering the benefits of sesame, it is recommended that several treatments should be applied to reduce the levels of contamination in sesame seeds before consumption utilization such as environmental conditions leading to fungal proliferation (a high temperature, humidity, poor soil fertility, drought and insect damage). Also poor harvesting practices, unsuitable storage conditions, improper transportation, marketing and processing should be discouraged.

1. Introduction

Sesame seeds (*Sesamum indicum* L.), otherwise known as beniseed, grouped under the family pedaliaceae is one of the oldest and most traditional oilseed crops known to mankind [1]. It is called 'Queen of oil seeds' due to its high quality polyunsaturated stable fatty acid, which restrains oxidative rancidity [2-4]. Sesame production in Nigeria probably began in the Middle Belt (North –Central) region of the country and later spread out between latitudes 60ºN and 100ºN. Sesame is commonly grown by small holder farmers in Nigeria. The major producing areas in order of priority are Nasarawa, Jigawa and Benue States [5].

Sesame (Beniseed) is one of the major cash crops that are popularly cultivated in Benue State. It was in this regards that OLAM Nigeria Limited distributed Sesame seedlings to 7,000 farmers in Benue and Nasarawa States to improve productivity of the cash crop in 2007 [6]. The prominent sesame producing local government areas of the state are: Makurdi, Gwer-West, Gwer-East, Logo, Katsina-

**Corresponding Author:*
M. Elaigwu,
Department of Integrated Science, College of Education, Oju, Benue State, Nigeria;
Email: elaigwumatthew1986@gmail.com

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Ala, Ukum, Agatu, Oju, Obi, Gboko, Ogbadibo, Ohimini, Guma and konshisha, Vandeikya and Otukpo [7]. There are three major varieties of sesame cultivated in Benue state: Yandev 55 characterized by smaller seeds and brighter in colour, E7 is with dull colour medium seeds and medium yield and E8 is having bigger seeds, high yielding and more oil [7]. Sesame production, and post-harvest handling business, producers, mainly smallholder farmers in Benue state are facing strong constraints and challenges to achieve significant increases in their incomes. Among many constraints is the risk of contamination during storage by mycotoxins especially the unbiquitous and hepatotoxic aflatoxins which are produced when seeds are kept under conditions that favour the development of these fungi [8]. The most vital mycotoxins are produced by fungi such as: *Fusarium* spp, *Aspergillus* spp, *Penicillum* spp, *Alternaria* spp, *Emericella* spp. These organisms thrive in moist and environments with moderate rainfall. They are regularly found in improperly stored staple commodities such as cassava, chili peppers, corn, cotton seed, millet, peanuts, rice, sesame seeds, sorghum, sunflower seeds, tree nuts, wheat, and a variety of species [9]. However, there is dearth of information on fungi contamination with Sesame in Benue state. The objective of this study is to evaluate storage mycoflora contamination in sesame sold in Benue state North central Nigeria.

2. Materials and Methods

Benue state is located in the Southern Guinea Savanna which is a transition belt between the grassland savanna in the North and the rainforest in the South. Benue State, Nigeria is designated with (latitude 6°21′ - 8°10′ N and longitude 7°44′ E - 9°55′ E).

Sampling collection

The State has three agricultural zones namely: North which comprises (Buruku, Guma, Gboko, Tarka, Makurdi, Gwer-West and Gwer) Local government Areas, East (Konshisha, Vandeikya, Kwande, Ushongo, Katsina-Ala, Ukum and Logo), and South (Apa, Ado, Agatu, Otukpo, Ohimimi, Okpokwu, Ogbadibo, Obi and Oju). For the purpose of this study, two (2) zones were purposively selected; North and South which are known as the belt of sesame production in the State [7]. Of these zones, a total of six LGAs including Guma, Gboko and Makurdi (Benue North) and Otukpo, Obi and Ogbadibo (Benue South) was included in the survey. Four samples were collected each from four different markets within each of the six surveyed LGA resulting in a total of 96 samples. Markets from selected local government areas were identified through local government departments' of agriculture and traditional authorities.

Determination of Representative Sample Size (DRSS)

Research work in this area of study is scanty, as such this research work will served as basis for the estimation of the representative sample size and it was calculated using the formula below:

$$S = \frac{x^2PQ}{l^2}$$

S = Number of markets/ Centers

x = the x score for a given confidence interval

P = Estimated prevalence

Q = 1-p

l = allowable error of estimation

In this research the desired confidence interval was 95% with an allowable error of estimation 0.05 the estimated prevalence that was considered as 47% according to Ezekiel and Sombie [10].

Isolation of Fungi by direct plating method

Sabouroud Dextrose Agar (SDA) was used throughout the study. The method described by Jha [11] Agar plate method was used for the isolation of fungi.

Fungal Identification

The Sub cultured fungi were primarily identified using cultural and morphological (colony colour, surface texture) features and microscopic characteristics (Nature of spore, conidiophores, sporangiophore, and vesicles) using identification keys by Davis [12] and Clich [13].

Statistical analysis

Means for the distribution of concentrations of Aflatoxin were calculated and tested for significance by DMRT at 95 percent confidence level by one-way ANOVA.

3. Results and Discussion

The study revealed that twelve (12) fungal species were isolated from different samples of sesame collected from six different Local Government Areas of Benue State. The fungal species identified were: *A. flavus, A. fumigatus, A. nidulans, A. niger, A. parasiticus, A. tamarrii, A. terreus, A. versicolor, Fusarium oxysporium, Mucor mucedo, Penicillium digitatum, Rhizopus stolonifer.*

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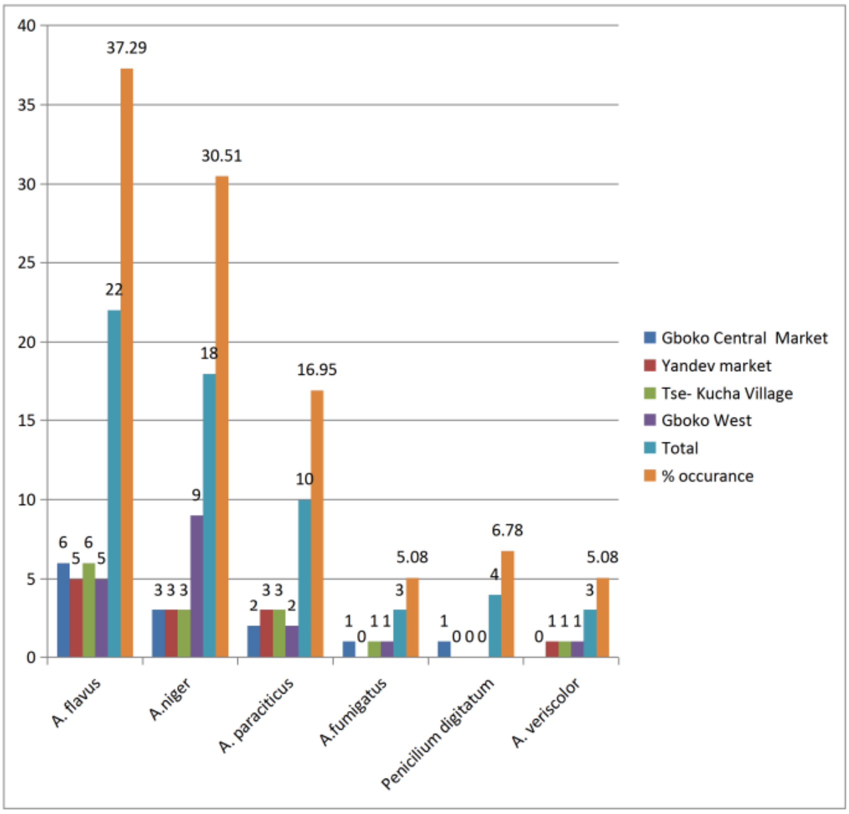

Figure 1. Occurrence (%) of fungi isolated from samples obtained from Gboko LGA

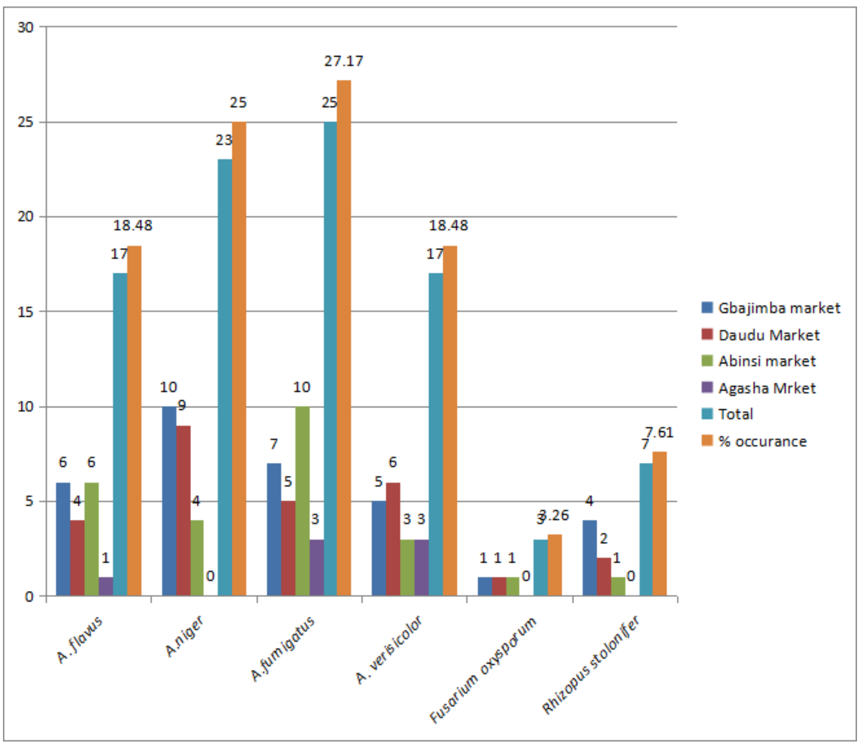

Figure 2. Occurrence (%) of fungi isolated from samples obtained from Guma

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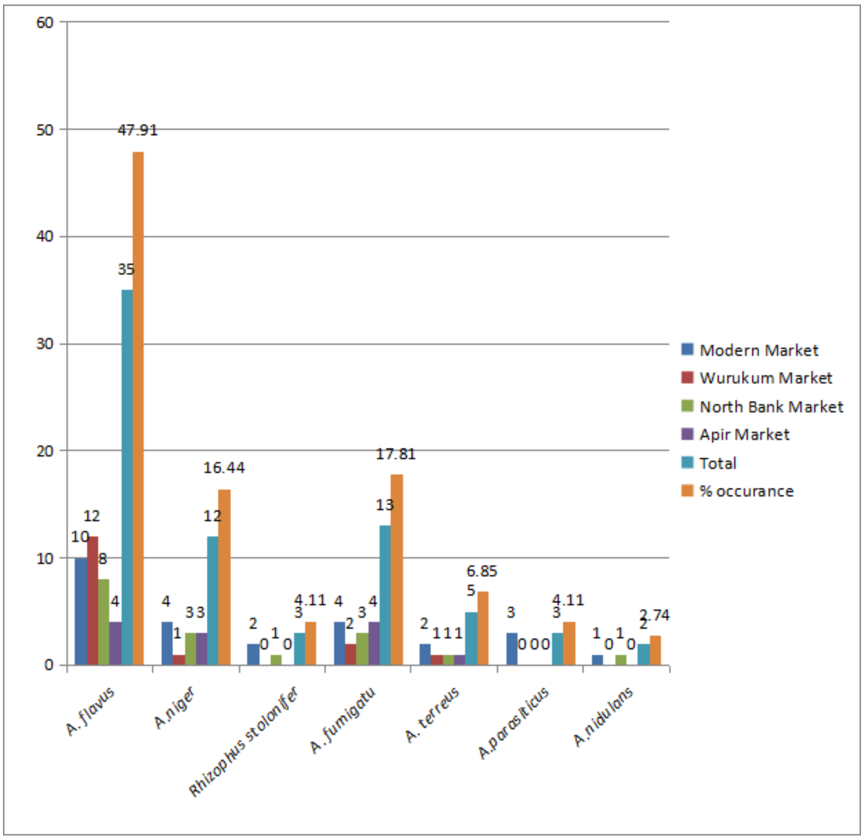

Figure 3. Occurrence (%) of fungi isolated from samples obtained from Makurdi

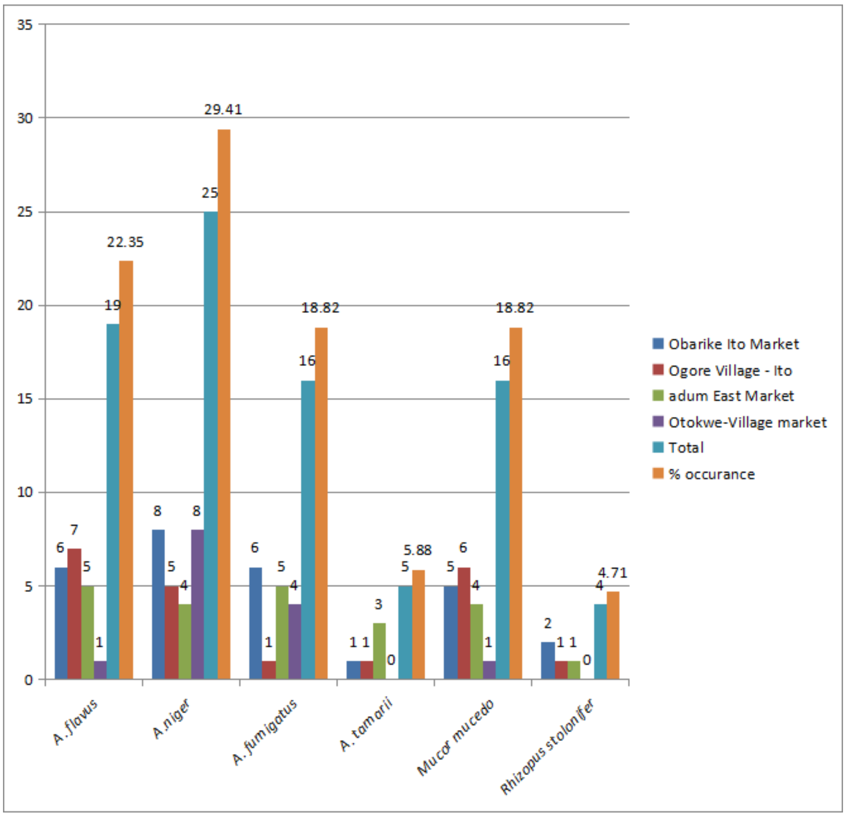

Figure 4. Occurrence (%) of fungi isolated from samples obtained from Obi LGA

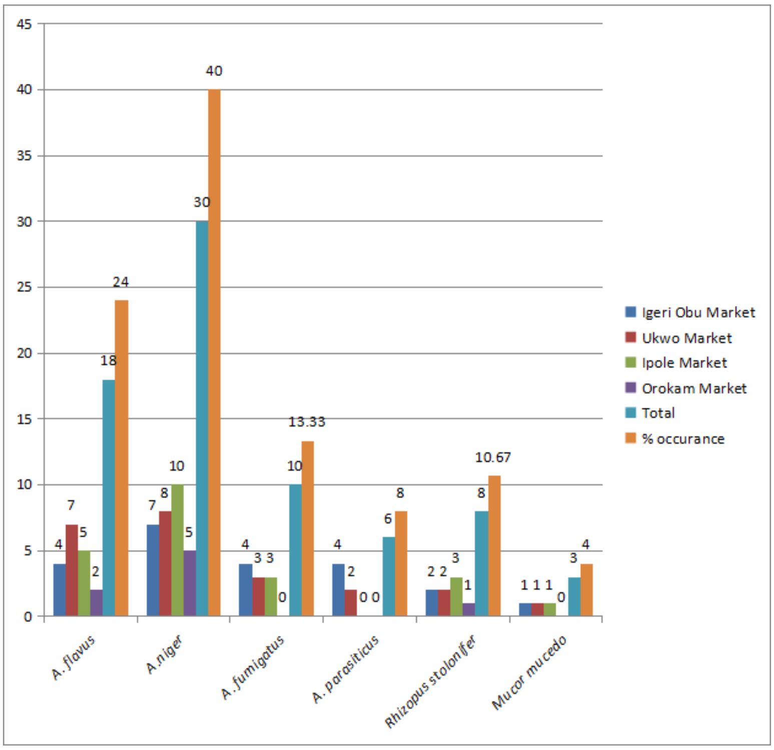

Figure 5. Occurrence (%) of fungi isolated from samples obtained from Ogbadibo LGA

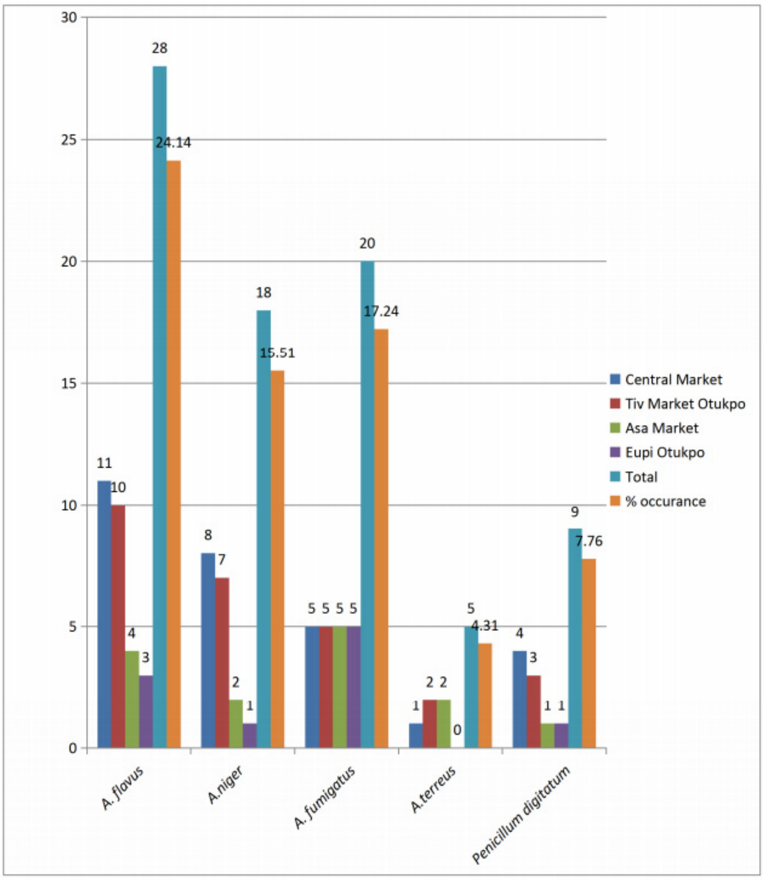

Figure 6. Occurrence (%) of fungi isolated from samples obtained from Otukpo LGA

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Table 1. Occurrence (%) of the isolated fungi from six local government areas.

Fungal Isolates	Occurrence (%) of the isolated fungi from						Total	Mean No: of Colonies ±S.E
	Gboko	Guma	Makurdi	Obi	Ogbadib	Otukpo		
A.flavus	22(36.67)	17(18.45)	35(5.00)	19(22.35)	18(24.00)	28(24.14)	139(27.91	23.2±2.9[a]
A.fumigatus	3(5.00)	25(27.17)	13(18.57)	16(18.82)	10(13.33)	20(17.24)	87(17.47)	14.5±3.2[a]
A.nidulans	0(0.00)	0.(0.00)	2(2.86)	0(0.00)	0(0.00)	0(0.00)	2(0.40)	0.33±0.3[b]
A.niger	18(30.00)	23(25.00)	12(17.14)	25(29.41)	30(40.00)	18(15.52)	126(25.30)	21.0±2.6[a]
A.Parasiticus	10(16.67)	0.(0.00)	0.(0.00)	0.(0.00)	6(8.00)	36(31.03)	52(10.44)	3.2±1.7[b]
A.tamarii	0(0.00)	0.(0.00)	0(0.00)	5(6.01)	0(0.00)	0(0.00)	5(1.00)	0.83±0.8[b]
A.terreus	0(0.00)	0(0.00)	5(7.14)	0(0.00)	0(0.00)	5(4.31)	10(2.01)	1.7±1.11[b]
A.versicolor	3(3.00)	17(18.48)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	20(4.02)	3.33±2.8[b]
Fusarium Oxysporum	0(0.00)	3(3.26)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	3(0.62	0.5±0.5[b]
Mucor mucedo	0(0.00)	0.(0.00)	0(0.00)	16(18.82)	3(4.00)	0(0.00)	19(3.82)	3.2±2.6[b]
Penicillium digitatum	4(6.67)	0.(0.00)	0(0.00)	4(4.71)	0(0.00)	9(7.76)	17(3.41)	3.0±1.5[b]
Rhizopus stolonifer	0(0.00)	7(7.61)	3(4.29)	0(0.00)	8(10.67)	0(0.00)	18(3.61)	3.0±1.5[b]
Total	60(12.05)	92(18.47)	70(14.06)	85.(17.00)	75(15.06)	116(23.29)	498	
Mean No: of colonies±S.E	5 ±2.21[a]	7.7±2.87[a]	5.8±2.9[a]	7.1±2.6[a]	6.3±2.7[a]	9.7±3.7[a]		

P value

Fungal Isolates: 0.000**

4. Discussion

Sesame has been reported to be contaminated with different genera of fungi including *Alternaria, Aspergillus, Fusarium, penicillium* and *Cladosporium* whereas *Aspergillus* was the dominant genera [14]. Sesame from Otukpo (23.29%) and Guma (18.47%) contained more fungi than those obtained from Ogbadibo (15.06%), Makurdi (14.06%) and Obi (17.00%). The variation might be due to the differences in ecological zone and probably of differences in environmental conditions of the area because warm, humidity and climatic conditions favoring fungal growth [14]. Another reason for their high incidence might be due to their cosmopolitan nature and they are known to be obligate saprophytes so can survive in the environment with a wide range of temperatures varying from 18-32°c [15]. Apeh *et al.* [16] reported that fungi and aflatoxin levels were higher in sesame than millet and sorghum and that Fungi load in sesame seeds increased with latitude.

The Occurrences of different fungal species revealed that *Aspergillus* species had the highest frequency of occurrence in all sesame obtained from different local government areas.. This result is in agreement with the previous studies that *Aspergillus flavus* members are common colonizers of all types of millet and sesame during post-harvest storage [17-19], whereas *A. parasiticus* was the dominant one fungi among the *Aspergillus* genera [14]. In another research conducted by Elewaa [20] and Elaigwu *et al*. [21] showed that sesame has been heavily attacked by many fungi such as *F. oxysporum, F. sesame* and *Macrophomina phaseolina.* Among the *Aspergillus* species obtained *A. flavus* and *A. niger* were the most prevalent and this following the pattern of the findings of Amienyo, *et al*. [22] that *Aspergillus niger* showed the highest percentage occurrence of 10.3% in *Sesamum indicum* from Faringada market in Nigeria. This might be due to their ability to survive in the range of varying environmental factors (temperature and humidity) as compared to other species isolated. Recently, different species of *Alternaria, Aspergillus* and *Penicillium* were isolated from sesame in varying proportions [10].

5. Conclusions

The present report is a major investigation into the incidence of fungi in Sesame production in Makurdi Benue state Nigeria. Mycoflora contamination constitutes a major setback to export trade in grains and cereals proceeding from Africa. As a result it poses a challenge to food security in areas that are dependent on these staples. The work necessitates implementation of management and intervention strategies by concerned stakeholders and regulatory bodies. Considering their health and economic implications, there is therefore the need to elucidate the mycotoxin profile of these crops within regions where they are produced and marketed, with a view to generating incidence data which can be used to proffer intervention strategies. In view of the above, there is need for proper orientation and awareness campaign on the impending danger of overdependence on sesame in the area sampled.

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ARTICLE

Assessment of Coffea Shade Value through Comparison of Mountainous Area with Farm Land Coverage, in Arsi Gololcha District, Oromia, Ethiopia

Alemayehu Diriba Roba*

Oromia Agricultural Research Institute, Mechara Agricultural Research Center, Mechara, Ethiopia

ARTICLE INFO

Article history
Received: 17 August 2021
Accepted: 24 September 2021
Published Online: 9 October 2021

Keywords:
Farm lands versus mountainous areas
Ecological value of Coffea shade trees

ABSTRACT

Coffea cultivation with shade tree is used for improving soil health, increasing coffea production, sustaining agro ecology. The study was attended in two kebele, on 36 farmers' fields, at Gololcha district of East Arsi zone. The study was intended to assess the influence of coffea shade trees on farm lands versus mountainous area. Household interviews were used to get imperative separately, i.e. from old farmers, middle age farmers and young farmers. Significant difference value was observed between farm land and mountainous area coverage. Based on this respondents' idea, before 25-30 years; the 'condition of tree coverage at mountainous' area in Arsi Gololcha district was 'medium condition' but not normal that means as deforestation of mountainous area have been starting before 30 years' time; while the condition of tree coverage at farmland area also has been starting before 30 years' time. The third respondents' idea was interpreted with the real situation of the district, that it gave us a constructive inspiration on the role of coffea shade tree to enable the farm land to be taken as regular natural forest. The existing coffea shade trees are Cordia africana followed by Erythrina abyssinica and Acacia senegal. Farmers accounted 95% of coffea shade users and 4.6% without shade users. The respondents said that even if the rainfall intensity is increasing at farmland rather than mountainous area occasionally due to shade tree effect. On the contrary side, mountainous area exposed to deforestation since the farmers have been shifting to hilly side for their livelihood dependency.

1. Introduction: Background and Justification

Coffea plantation with shade tree is taken as agroforestry system which is mainly viewed as significant donors of income opportunity, environmental facilities through ecofriendly well beings and as a portion of well-designed operational sceneries [14,15]. Coffea production with shade is as agroforestry scheme that casually satisfactory, cautiously viable and biologically maintainable than rising coffea without shad. A great role of shade tree is timber production which has a low management costs and it considered as a 'exchangeable account' that can be comprehended at times of low prices or failure of the fundamental crop yields [3]. The integration of trees with agricultural sectors to be taken as an agro-forestry scheme which takes probable towards improve biodiversity, improve soil richness, decrease soil destruction problem, advance water eminence, rise aesthetics value and

**Corresponding Author:*
Alemayehu Diriba Roba,
Oromia Agricultural Research Institute, Mechara Agricultural Research Center, Mechara, Ethiopia;
Email: alemayhudiriba@gmail.com

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requisition impressive carbon [8,9,12,16]. Coffea production with shade tree consumes remained healthy accepted due giving comforts and welfares as to be agro-forestry schemes through assortment of spatial and temporal arrangements [7].

Agro-ecosystems come from agroforestry which deliver significant properties and facilities that donate towards anthropological relief, financial advance and poverty mitigation. Agro-forestry, currently, nearby a countless deal of attention trendy provided that monetary welfares towards property-owners. Coffea production with coffea shade tree is one of the main agro-forestry schemes and the farmers with land use achievement that stand-in respected conservational amenities headed for anthropological residents in addition for agriculturalists originating revenue opportunity as of their customary invention system [4]. Coffea production with shade trees has a great role in providing environmental facilities and improving sustainable bio-diversity safeguarding [10]. Therefore, worldwide have to be focused on payment for environmental amenities and coffea guarantee schemes so as to deliver incentives towards coffea growers thereby to produce organic quality coffea [11].

In many parts of coffea growers have been used versatile trees as shade, shelterbelt and windbreaks to avert coffea vegetation as of extreme sun and extraordinary illnesses [6]. Organic coffea production increases annual income of producers' and GDP of countries. Coffea dependent countries that containing Ethiopia; disseminate coffea product about more than 160 countries those as long as a source of revenue intended for many individuals [5].

In Africa, Ethiopia is the chief principal arabica coffea producer among 25 countries, and the 5th of worldwide with the form of home garden coffea production system by small scale farmers [1]. Subsequently 25% of Ethiopian population depends on coffea product through producing, processing, distributing, exporting and also consuming, as well as 25% of country's GDP based of coffea product [10].

In Ethiopia, the driving force of *coffea* production in the form of home garden Coffea is land shortage. The place where coffea growing areas have been occupied with highly populated and this is resulted for farm land shortage in the country. For example; in the study area, cultivable land shortage has been rising due to population size increment. So the land owners exposed to have owned a small piece of land.

However, on that limited cultivable land; enable the farmers merely alternative to use coffea plantation with shade trees on what they have had at all specific farm land considerately rather than cereal crop utilize which is needed extensive farm land. So the agriculturalists implemented with concentrated endowment of coffea manufacture with shade tree invitation on their specific farm land as their usual practice in Gololcha district. The concentrated functions of shade trees are revealed as if natural woodland at coffea farmstead terrestrial only. In the discordant of this, hilly areas which were out of coffea plantation have been continuing deforestation problem. This problem occurred due the societies have been cultivating towards mountainous sideway for their living reliance is exactly reflecting in Gololcha district.

The study areas were designated due to nomination of district with pure biological coffea production as a result of shade tree effect on coffea farm lands. Therefore; the study was carried out to assess farmers' perception on coffea shade value through comparison of mountainous area exposure with farm land coverage, and also to conscious consideration of farmers, administration and further shareholders headed for guarantee and incentive approach for organic *coffea* growers.

2. Materials and Methods

2.1 Explanation of the Investigation Extent/ Location

Rendering to Oromia existing framework (2006), Gololcha district (Figure 1) is solitary of the vicinities originate in Arsi zone, Oromia regional state-owned of Ethiopia. The district is traced situated 307 km South East of Addis Ababa that capital city of Ethiopia. The topographical straight of the extent is between 08°00'0" and 08°37'00" N and 40°00'00" and 40°29'00" E.

2.2 Climate and Rainfall

The study area experiences by mean annual and monthly minimum and maximum temperature were 15 and 27°C, correspondingly; and takes mean annual and monthly precipitation (Figure 2) is 550 mm in the year of 2015 cropping period. The seven years statistics of mean annual and monthly rainfall (Figure 3) in the study area are 703 mm minimum in the year of 2012 and 1486 mm maximum in the year of 2013, correspondingly; which illustrate the extent partaking a bimodal precipitation nature.

2.3 Land-use/Land-cover Change

Coffea plantation is solitary of the foremost crops in the constituency. Production of Khat and *coffea* are imperative currency product. Out of the total area of the constituency, 20.6% is cultivable land, 21.7% is meadowland, 27% is forest and shrubs, and the left over 30.7% is well thought

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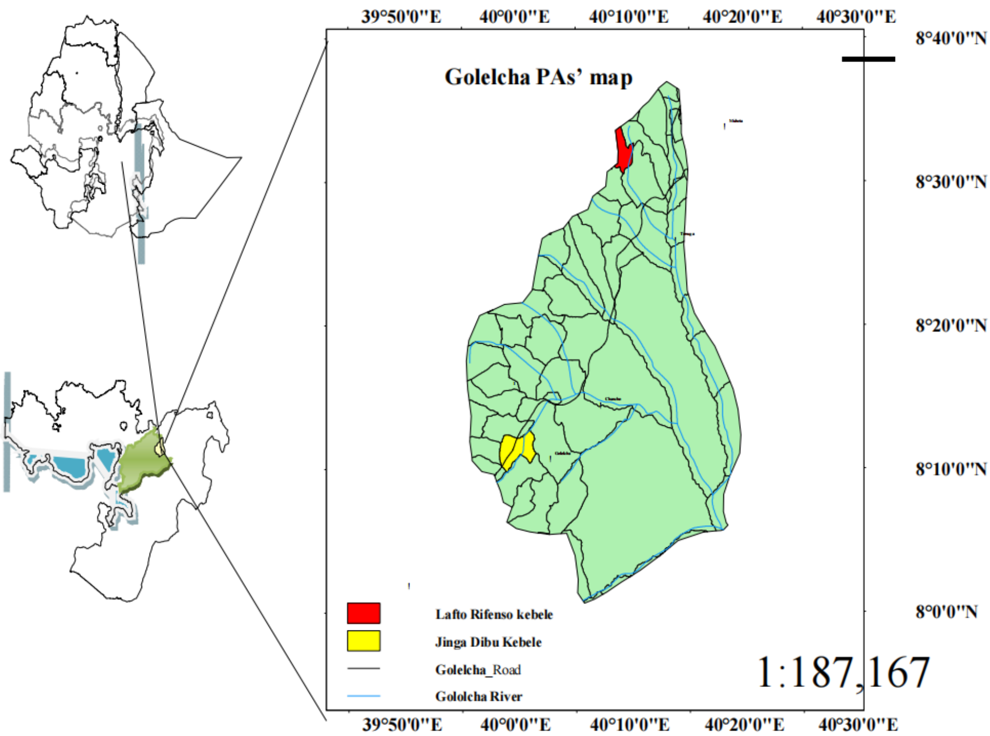

Figure 1. Specific location of the studies area

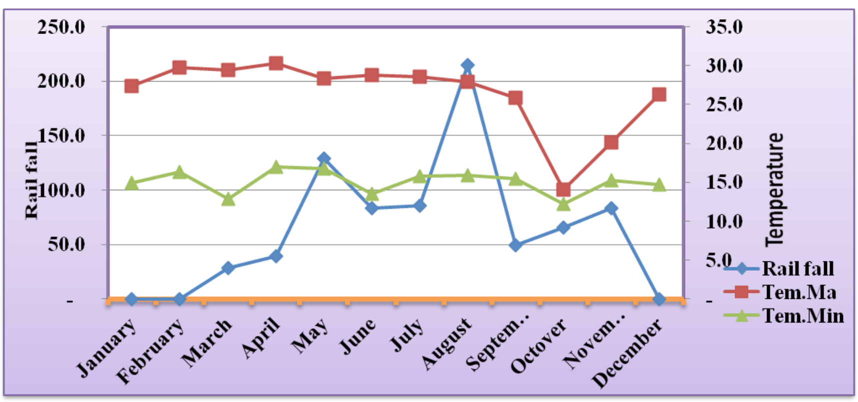

Figure 2. Rain fall and Temperature data of Arsi Gololcha district, 2015 GC

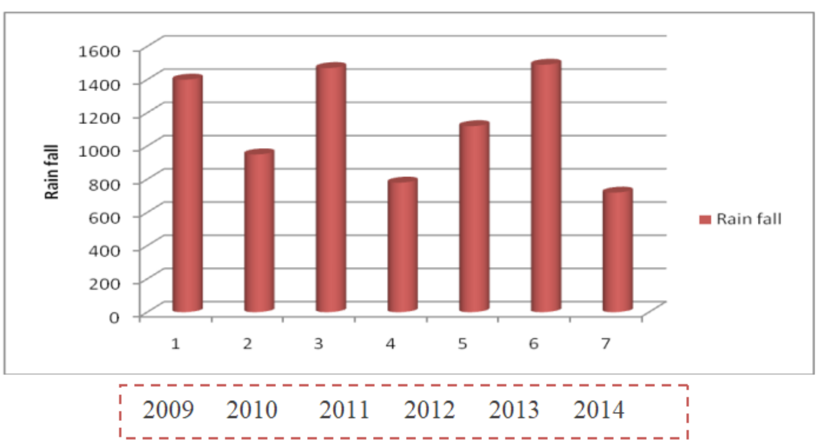

Figure 3. Seven years only (2009-2015GC) Precipitation statistics of Arsi Gololcha district

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of marshy, hilly or then impracticable part. Gololcha has appraised inhabitants with concentration of 94.7 individuals per square kilometer. As of an entire part of 1,818.120 square kilometers, and the overall soil of the district cambisol which is the superlative for agrarian persistence that according to Oromia living profile of 2006.

2.4 Location Assortment

The research was directed in Gololcha District at two PA (Jinga dibu and Lafto rifenso). As of the designated PA, three settlements were allocated commencing each PA along the boundary of mountainous area. Then the study was under taken on six farmers as of every settlement. To do this route, humble investigation review was genuine in order to handpick settlements and agriculturalist's meadow for supplementary inquiry.

2.5 Exploration Appraisal and Agriculturalist's Field Assortment

The reconnaissance survey had been processed on six farmers in each village as replication based on field quality which was the best of all with different physical observation for all study purposes in each village across PAs. The agriculturalist's meadow was occupied, as a demonstrative crosswise PAs ended site with comparable controlling trial; advancement and gradient were measured for together unshaded and shaded coffea cultivated area, plus the concerned and subjugated of coffea shade plants in the areas were well considered.

2.6 Data to be Collected

Recognizance survey results of farmers' perception concerning to coffea shade value on farmlands versus mountainous areas and the kind of shade trees used were collected.

2.7 Farmers Assortment

The schoolwork was conducted in Gololcha district at two PA. As of the designated PAs, three settlements were allotted starting every PA along the border of mountainous area. Then the study was under taken on six farmers as of each settlement. To do this route, modest investigation survey and questioners were smeared in command to get overall answers of questioners. The results of the surveys and questioners were based on farmers' age category (15-25, 25- 45 and >45 age). The farmers responded to the subject concerning to coffea shade utility related to environmental and ecological condition.

Exposure of farm land coverage versus mountainous area and the relative abundance of coffea shade tree in the district were identified. Six farmers were assigned for each age category as respondent in each village, those (18 farmers from each PA and 36 farmers across PAs) were taken differently, and they responded the subject that "the condition of tree coverage at mountainous versus farm land area" during 15-25 years old of each respondent in order to answer the queries based on the questioners.

2.8 Data Analysis

The collected data from key informant and household interviews were summarized in narrative form that presented and analyzed descriptively.

3. Results and Discussion

3.1 Farmers' Knowledge Approach on Coffea Shade Value in the District

The consequence of hands-on investigation approaches and the appreciation on the protagonist of indigenous acquaintance in the strategy and administration of agro forestry schemes have been universally quantified. This schoolwork originated that agriculturalists have a very clear, explanatory, and coherent way of understanding the miscellaneous natural progressions that occurred in their coffea farmsteads and how these progressions narrate to coffea manufacture, delivery of ecological unit amenities and including biodiversity maintenance. They evidently accustomed how coffea production with shade tree is imperative point for ecosystem service thereby natural resources management in accordance within their plantations. Agriculturalists constantly identified that *coffea* productivity, ecosystem services, and biodiversity preservation are stabled due to the existence, profusion, assortment and executive of shade tree sorts. They figure their own shade tree well-designed arrangements correlated to the delivery of ecofriendly facilities and income opportunity grounded on shade tree features specially on coffea farmers which is, as if natural forest instead of mountainous area was happened before.

The respondents reasoned that trees are reserved by agriculturalists inside coffea plantations; because of their interactions with coffea plants that provide environment amenities [4,13]. The earlier endowments deliver a base for more demanding investigations of the natural surroundings and degree of coffea cultivators' friend.

3.2 Farmers' Response on Coffea Shade Value in the District

Farmers in different age categories responded to the

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Figure 4. Farmland of coffea plantation versus with non-farmland on the top of mountain area

question, what was the condition of tree coverage at mountainous area was like, the respondents answered the following. 'Decreasing condition,' was given by the first age category, 'Medium condition', was given by the second age category and 'Increasing condition' was given by the third age category. Concerning to what was the condition of tree coverage on farm lands like; again the respondents were answered the questions saying the following. 'Increasing condition', was given by the first age category, 'Increasing condition' was given by the second age category and 'Decreasing condition' was given by the third age category during 15-25 years old of each respondent respectively (Table 1).

These results indicated that the third age category (elder) when they were young, there was no deforestation at mountainous area while deforestation was at farm land area. The opposite of the third age category's answerers were responded by the first age category of respondents that there was deforestation at mountainous area while there was no deforestation at farm land area. These ideas reflect the present condition of Gololcha district.

The second age group respondents' thought were similar to the first age group respondents' thought and opposite of the third age group respondents' idea on the 'condition of farm land tree coverage' during their 15-25 years old but the 'condition of mountainous tree coverage 'area was not share neither the first nor the third age group respondents' idea. Based on this respondents' idea, before 25-30 years, the 'condition of tree coverage at mountainous' area in Arsi Gololcha district was 'medium condition' but not normal that means as deforestation of mountainous area have been starting before 30 years time while the condition of tree coverage at farmland area also has been starting before 30 years time. The third respondents' idea was interpreted with the real situation of the district, that it gave us a constructive inspiration on

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Table 1. Summary of Reconnaissance survey result at Laftorifenso and Jingadibu PA

No. of farmers With age		Tree coverage at farm land during 15-25 years old of respondents	Tree coverage at protected area during 15-25years old of respondents	Average land holding for coffea in ha		Average land holding for cereals in ha		Coffea with shade users%		Coffea without shade users%		Cordia shade users for coffea%		Erythrina shade users for coffea %		Other shade tree users for coffea %	
				LPA	JPA	LPA	JPA	LPA	JPA	LPA	JPA	LPA	JPA	LPA	JPA	LPA	JPA
1rst Age	6farmers <25year	Increasing	Decreasing	0.35	0.25	0.15	0.125	97	98	3	2	60	48	23	26	17	26
2snd Age	6 farmers <45year	Increasing	Medium	0.7	0.75	0.4	0.25	93	96	7	4	50	50	35	31	15	19
3rd Age	6 farmers <65year	Decreasing	Increasing	0.65	0.6	0.2	0.125	93	95	7	5	40	46	32	25	28	29
Average		-	-	0.6	0.5	0.25	0.16	94	96	5.6	3.6	96	48	3.6	27.3	20	25

*LPA=Lafto-rifenso PA, JPA=Jinga-dibu PA, ha=hectare, PA=Peasant Association

the role of coffea shade tree to enable the farm land to be taken as regular natural forest in steady of mountainous area before.

According to description of Arsi Gololcha district with (Oromia livelihood profile, 2006), there is a problem of farm land shortage due to over population. This idea is true as to be understood from the respondents' answerer and the surviving prerequisite. Anon (2001) reported four categories of coffea manufacture schemes in Ethiopia: Woodland coffea (10%), Semi Woodland coffea (35%), Garden coffea (50%) and Estate farm coffea (5%). Arsi Gololcha district employed; garden *coffea* production system by small scale *coffea* growers. As a shortage of farm land in the district, farmers use multi-purpose utility of *coffea* shade tree for their livelihood dependency through coffea production thereby as fuel wood, feed, furniture, windbreak and shelter of *coffea* plant in specific farm land rather than cereal crops utilize which needs extensive farm lands.

3.2.1 Farmers' Problem

Average lands holding by the first age categories were 0.15ha for cereal crops and 0.35ha for coffea production. Average land holdings by the second age categories were 0.4 for cereal crops and 0.7 ha for coffea production. Average land holdings by the third age categories were 0.2ha for cereal crops and 0.65ha for *coffea* production at Ginga-dibu PA while at Lafto-rifenso PA, average land holding by the first age categories were 0.125ha for cereal crops and 0.25ha for coffea production. Average lands holding by the second age categories were 0.25ha for cereal crops and 0.75ha for coffea production. Average lands holding by the third age categories were 0.125ha for cereal crops and 0.6ha for coffea production (Table 1). This result implies that at both PA, there is severe of farm land problems for both coffea and cereal crops across PAs.

3.2.2 The Kind of Coffea Shade Used

The most familiar coffea shade plants at the district are *Cordia africana* followed by *Erythrina abyssinica* and *Acacia senegal*, it sues as timber, fodders, fuels, etc. at both PA, respectively. Almost all farmers accounted 96% of coffea shade users and 3.5% without any shade users were observed in Lafto-rifenso PA. In Ginga-dibu PA, thus 94% coffea shade users, 5.6 % without any shade tree users were identified. So farmers used *Cordia africana* shade tree is 48%, *Erythrina abyssinica* shade tree is 27.3% and other shade tree is 25 % in Lafto-rifenso PA. In Jinga-dibu PA, farmers used *Cordia africana* shade tree is 50%, *Erythrina abyssinica* shade is 30% other shade tree is 20 % (Table 1). As a result of this, 90% of the farm land in the district was covered by coffea plantation with shade tree application. The respondents have been truly reflecting that even if the rainfall intensity is increasing at farmland rather than mountainous area occasionally. On the contrary side, mountainous area exposed to deforestation since the farmers have been shifting to mountainous sideways for their living reliance. Generally, farmers have to be used the best agroforestry practice based on the value of shade tree for coffea plantation as well as for other utilities on what they have had a limited farm land with the recommended technology.

4. Conclusions and Recommendations

In Gololcha district; *coffea* grower agriculturalists have a treasure of knowledge with *coffea* gardening. Agriculturalists recognize that the dynamics disturb coffea production as well as how to increase the delivery of biota amenities within coffea farms. All age groups comprehend

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with fact that the protagonist of coffea shade trees in together coffea production and delivery of other biota amenities. Recurrently; agriculturalists revealed trade-offs amongst biota amenities' delivery and production. The other point to be considered the value of coffea shade is soil development and avoidance soil destruction on farm lands. This is perceived synergistically with farm land production, while biodiversity upkeep is the opposite. These much of native acquaintance should be confirmed.

Ethiopia is agricultural dependent by periodic precipitation coincidental. Planting of shade trees on agricultural land, it is to be an agro-forestry exercises that to sustain environmental biodiversity, increase production and well ecological condition. Nevertheless, the value of shade tree; on soil fruitfulness and coffea productivity have not been broadly appraised and accurately renowned. Key informants and relevant households were used based on their age group. The information obtained from the survey, included problem identification and specially deforestation at mountainous area and afforestation of farm-lands.

In this assessment, the difference between *Erythrina abyssinica* and *Cordia africana shade trees* found higher significant with almost all farmers' perception. So that the governance of shade type in the coffea farm was primarily due to its financial worth that agriculturalists favored *Cordia africana* rather than environmental amenities. It concealed about 60% and 48% of farm-land in Lafto-rifenso and Jinga-dibu PA; while *Erythrina abyssinica* covered about 23% and 26% of farm-land in Lafto-rifenso and Jinga-dibu PA, respectively.

In conclusion, Gololcha district is deserved an assurance as they are model agriculturalists. That integration of coffea with shade tree can be principal to be originator of sustainable agriculturalists, organic coffea manufacturers and sponsor of climatic resilience. They deserve a certification because they can to be a model for other farmers with resilience to climate change and improved their livelihoods as well as they are sustainable producer of organic *coffea* production. Many writers positively articulated for this kind of views that certification approach should be advanced for organic coffea cultivators. The other point to be considered is fair traders had to be delivered different price premium which can be offer farmers distinct economic incentives. So that farmers can have a unique ecological standard in order to sustain *coffea* production with shade trees [14].

Accessibility of shade tree was presently being experienced in the area meaningfully with amended coffea manufacture, soil fruitfulness; ecological value and living of the people with vary of utility. Consequently the district's farmers have to be given recognized that the shade trees combination in the agricultural scheme is appreciated and should be encouraged by relevant stakeholders to be regarded as exemplar for farmers in neighboring districts who had been producing coffea without shade. This practice should be promoted in most districts of Hararghe that where coffea farmlands nearly wiped out and have been replacing with Khat.

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EDITORIAL

In View of Today's Realities: What should any Work with the Plant World Actually Gain us?

Sener Akinci*

Marmara University, Turkey

ARTICLE INFO

Article history
Received: 4 November 2021
Accepted: 5 November 2021
Published Online: 8 November 2021

Studies on plants are important evidence not only for their diversity and richness in the world, but also for revealing the relationship between the environment and the organisms. How important are the concepts of climate crisis and global warming? What is the number of people in the world, other than scientists, who are aware of the seriousness of the problem? Do we have any information about the number of people who have knowledge about what can be done? Do we want to experience the carbon richness of millions of years ago (Carboniferous) again? Let's not forget that this reality, which seems to be an advantageous situation at first glance, has actually been moved to a platform where today's leaders discuss the effects of climate balance. We need more and more plants all over the planet. With the increase in the human population, it is time to change our prejudices about "uncertain or suspicious" plants to be used. Could some toxic metabolites be usable or even edible by appropriate treatments? Can countries that are lucky in terms of endemic species make better use of these reserves? Plant biochemistry studies should be encouraged in this respect. In addition, there is evidence that the consumption of a large number of products that we use as food causes health problems that we do not know yet, but which can increase greatly with daily use and even be fatal when contaminated by pathogenic organisms.

What are the ways to safely store our food without using any additives? Food safety concerns many topics from the quality of herbal products to their shelf life. For example, if we can produce coffee, which is one of the most important economic plants of the world economy, against the climate crisis and moreover, if we can increase the amount of production, how can we ensure long-term protection of these coffee fruits/seeds?

Will the multitude of countries whose economies depend entirely on the cultivation and marketing of plantation products such as bananas (*Musa* Spp) , coffee (*Coffea arabica* L.) and cacao (*Theobroma cacao* L.) overcome their biggest obstacle, the dual problems? There will undoubtedly be a great need for all kinds of scientific research and efforts to support this issue. Plant researches will give important clues about

**Corresponding Author:*
Sener Akinci,
Marmara University, Turkey;
Email: akincisener23@gmail.com

maintaining the harmony of human and nature with good study topics selections.

Any study on botany will reinforce our knowledge in persuading us to reveal their importance in our lives with more and more sharp lines, based on the fact that the first human probably was the first food of a plant. Scientific publications are unique resources that will assume their responsibility in this regard.

Here in this issue of the journal, we present evidence that the more intensive plant researches are done, the more they will contribute to the maintenance of human-nature relations in an ecological balance.

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DOI: https://doi.org/10.30564/jbr.v3i4.4056

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ISSN 2630-5054

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