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(RESEARCH ARTICLE)

Ethnomycological study of macromycetes used by the population of Mont-Ngafula, in Kinshasa, Democratic Republic of the Congo

Roger Batubenga, Félicien Luyeye Lukoki, Jeff Bekomo Iteku, Daddy Kileshe Kanika, Esther Kinyano Mwambay, Gédéon Ngiala Bongo *, Chapy Bafita Mukaya and Simon Mpulusu Dibaluka

Department of Biology, Faculty of Science, University of Kinshasa, Kinshasa, Democratic Republic of the Congo.

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Abstract

The present study is a contribution to the improvement of knowledge on fungal species of food and medicinal interest, their frequency of appreciation and consumption as well as their uses. The mycological surveys were carried out between August 10 and November 10, 2020. During this study, we used the survey-participation technique thru an interview. Participants were randomly selected and the sample size was 138. The focus was mainly on the description of macroscopic characters, to identify various taxa encountered. Data coding, analysis, and processing were done with Microsoft Excel 2016 and SPSS version 20.0The statistical analysis was based on association tests of Chi-square and Pearson correlation, at 5%. The findings show that22 taxa of fungi grouped in 5 families divided into 3 orders were listed. *Termito myces*genus was the most represented with 11 species. These species are used as food and as source of drugs. Statistical analysis revealed that the taxa of *Termitomyces* and *Auricularia*were the most appreciated. Taxa of *Termitomyces* were considered by the majority of respondents to be the most valued while *Auricularia* are considered to be the most popular all year round, followed by *Schizophyllum commune*. Statistical analysis did not show any link between age groups and frequency of appreciation We found that the proportion of respondents' gender profiles is predominantly female, which are also involved in mushroom-related activities in this area. However, statistical analysisshowed that women are very highly significantly related to the mycological activity profiles listed. The endogenous mycological knowledge held by the population of Mont-Ngafula, is a good start for constituting the fungal database of Kinshasa city. This study is only the beginning of a research that can be extended to the whole city and other Congolese provinces. In the future, research should be initiated on the inventory of edible and/or medicinal mushrooms of the city of Kinshasa.

Keywords: Ethnomycology; Macromycetes; Uses; Mont Ngafula; Kinshasa

1. Introduction

Ecosystems and the biodiversity along with services are intrinsically dependent on climate. The current relief and geological events have also transformed the climate and create favorable conditions for the diversification of fauna and flora [1].In Central Africa, mushrooms are critically important non-timber forest products (NTFPs), both nutritionally and economically [2]. Although they have never ceased to be exploited by certain ethnic groups such as the Pygmies of Central Africa, NTFPs have recently been the subject of renewed interest even by urban populations [3]. There are many edible mushrooms in Africa, most of them are delicious and highly nutritious. During the rainy season, rural communities in villages across the continent harvest various edible mushrooms to eat and sell in local markets. In some of these communities, surplus mushrooms from the rainy season are dried for further uses during the dry season [4].

*Corresponding author: Gédéon Ngiala Bongo
Department of Biology, Faculty of Science, University of Kinshasa, Kinshasa, Democratic Republic of the Congo.

In tropical Africa, traditional mycological knowledge is transmitted orally and the stability over time of the names used to designate edible mushrooms has been regularly highlighted [5]. In the Democratic Republic of the Congo (DRC), mainly in rural areas, mushrooms are a good source of protein. However, few species are known and consumed fresh in large urban areas such as Kinshasa. Only *Termitomyces* spp. are sold fresh in these towns, mushrooms that are only found on the market during the first two or three weeks of the rainy season. Otherwise, people are content to consume dried sporophores of a few saprotrophic species throughout the year, which are sold on the local market, often poorly preserved (moldy) or badly presented (different species in the same package or bundle, lots of waste and grains of sand in the sporophores), with risks of consumer poisoning when a poisonous specimen is inadvertently put in [6].It should be noted, however, that the indigenous knowledge of the mycoflora of the southern part of Kinshasa city, particularly Mont-Ngafula municipality, which is very rich according to our personal experience after having conducted a series of field trips, are not known at all.

We also note that to date, apart from the research of Dibaluka[7] and Dibaluka*et al.*[8], which appear to be the only works addressing the topic of fungi in this part of the province, henceforth there is a need of constructing a database on fungi of DRC due to the scarcity of literature in this research field. Therefore, this study aims to conduct a study based not only on indigenous and modern knowledge on fungi but also be reinforced by field observations. The goal of this work is to improve and document the knowledge of fungal species of food and medicinal interest exploited by the population of Mont-Ngafula municipality in Kinshasa city and their uses.

2. Material and methodology

2.1. Study area

Our study was carried out in Mont Ngafula municipality located in Kinshasa city. This city is located between 04°18' and 04°30' south latitude and between 15°15' and 15°22' east longitude. It is bordered to the East by the provinces of Mai-Ndombe, Kwilu and Kwango, to the South by Kongo Central province, to the North and to the West by the Congo River which constitutes the natural border with the Republic of Congo; and its average altitude is 300 m. Kinshasa city covers an area of 9,968 km^2 and its average density is estimated at 441 inhabitants per Km^2[7].

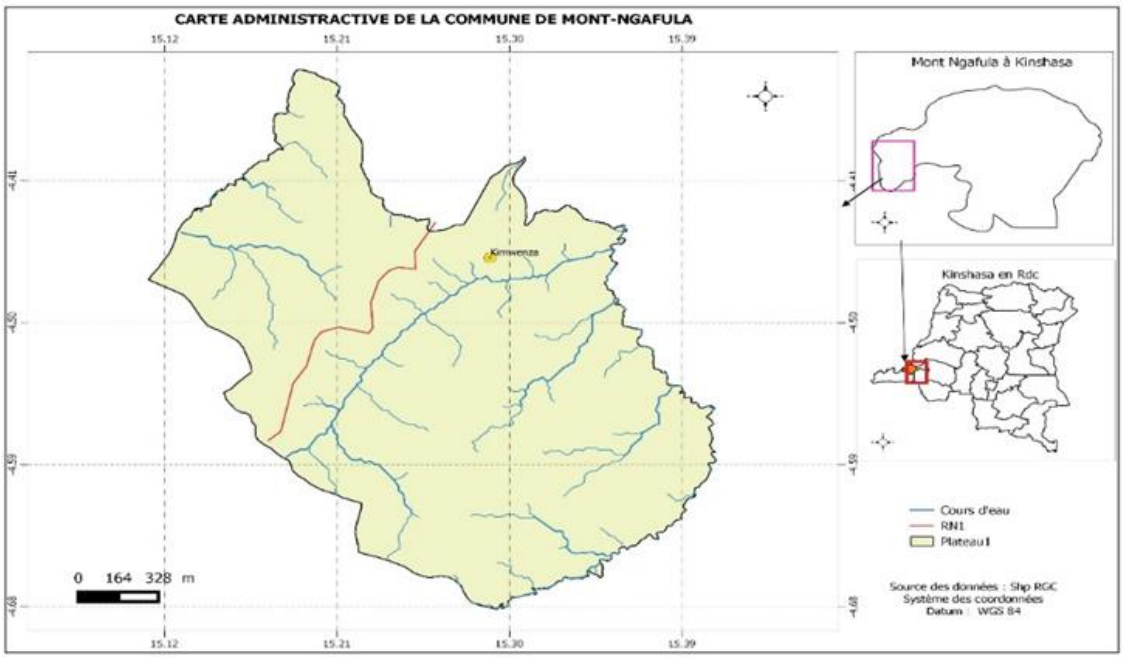

Figure 1 Administrative map of Mont-Ngafula municipality, Kinshasa

Mont-Ngafula is one of the 24 municipalities of Kinshasa, located in the southwest of Kinshasa. Originally, Mont-Ngafula was a large village located in a sub-urban territory and was on the land of Bahumbu, who are natives and owners. The name Mont-Ngafula is derived from two words, namely (a) Mont means Hill or Mountain and (b) Ngafulawhich means Village Chief.This municipality is borderedin the north by Makala, Selembao and Kisenso municipalities, in the south by the territory of Kasangulu (Province of Kongo Central), in the east by N'djili, Kimbaseke and N'sele municipalities and

in the west by Ngaliema municipality and Republic of the Congo (Brazzaville).It has an area of 358.90 km^2 andit is the third greatest municipality after Maluku (7. 948.80 Km^2) and N'sele (898.79 km^2).

2.2. Methodology

Several aspects were considered while designing this study, a preliminary sub-stage to acquire the knowledge of ground was performed first. We furrowed the municipality, the first information at our disposal, allowed us to identify the practice of exploitation of mushrooms. This approach facilitated the acquisition of useful information on the exploitation of fungal resources, marketing and know-how in this area. The survey form allowed us to record all the information received on a mushroom or group of mushrooms during the interview.

More than three people were interviewed before considering the information received as reliable and retaining it. Given the lack of credible information on the population in our study area, it was difficult to determine a priori the probability that each individual in the population would be retained for the survey.So we conducted a survey by randomly drawing 10 people on the knowledge or lack of knowledge of mushrooms and their uses. Based on the results of this preliminary step, the sample size was determined using the normal approximation of the binomial distribution [9]. We used as a technique, survey-participation, the interviewees and households were randomly selected, in total 138. They were distributed according to profile, age group, language spoken, origin, education levels, occupation and main activity.

We interviewed selected participants whom we met at the market (sellers and/orbuyers), along the way, at their place of service, or found at their home. The different fungal species found in the different markets were photographed and purchased for identification.

2.3. Data analysis

Data coding, analysis, and processing were done with Microsoft Excel 2016 and SPSS version 20.0. The qualitative and quantitative variables are presented in the form of figures [10]. The statistical analysis was based on association tests of Chi-square and Pearson correlation, at the significance level of 5% and the p-value allowed to accept or not the hypothesis that there is a relationship between the independent and dependent variables, as well as qualitative variables of the study.We accepted that there is a link between these variables when $p < 0.05$. Otherwise ($p > 0.05$), there is no relationship between the variables; the correlation test measured the relationship between two quantitative variables at the same significance level (5%) [10].

3. Results and discussion

3.1. Taxonomic identification of mushroom encountered in the markets

Table 1 presents the systematic overview of taxa of mushrooms encountered during our mycological surveys conducted in the markets of Mont-Ngafula municipality.

Table 1 Systematic overview of fungi identified

Order	Family	Species	Vernacular nouns
Agaricales	Lyophyllaceae	*Termitomycesaurantiacus*, *T. clypeatus,* *T. eurrhizus,* *T. fuliginosus,* *T. letestui,* *T. robustus,* *T. schimperi,* *T. striatus,* *T. titanicus.* *Termitomtces sp1,* *Termitomyces sp2*,	Mutumbula (Kikongo) ; Ntumbulantonto (Kikongo) ; Mayeboyaesobé (Lingala) ; Ntololo (Kilubakat) ; Busasi (Kiyaka)
	Pleurotaceae	*Pleurotus tuber-regium,* *P. cystidiosus*,	Tondo (Kikongo) Mayeboyapembe(Lingala)

	Schizophyllaceae	*Schizophyllum commune* Fr.	Bukolokoto (Kikongo) ; Liyeboyapembe (Lingala) ; Kamahaha (Kilubakat) Hafuwunyi (Tshibindi)
Auriculariales	Auriculariaceae	*Auricularia cornea,* *A. delicata,* *A. auricula-judae.* *A. subglabra.*	Kilebu (Kikongo) ; Bukutukutu (Kikinogo) ; MayeboyaMatoyi (Lingala) ; Matela (Tshiluba) ; Mankotuinkotui (Kilubakat)
Polyporales	Polyporaceae	*Lentinusbrunneofloccosus*, *L. squarrosulus,* *L. sajor-caju*	MayeboyaPembe (Lingala)

It is observed that 21 species of mushrooms were recorded and are grouped in 5 genera, 5 families and 3 orders. The genus *Termitomyces* is the most represented with 11 species listed.

Figure 2 Images of different species identified

Photos (1, 2, 3, 4, 5, 6, 7, 8, 9, 10): species of the genus *Termitomyces*; photo 11: species of *Auricularia*genus; photo 12: species of*Schizophyllum, Pleurotus* and *Lentinus* genera.

3.2. Profile and gender of respondents

The proportion of respondents' profiles by gender is shown in Figure 3.Figure 3 shows that women are more involved in mushroom-related activities than men (64.83%). The Chi-square test showsthat there is an association between the profile and the gender of the respondents proving that women are highly significantly related to the mycological activity profiles listed (X^2 = 26.77; p-value <0.001).

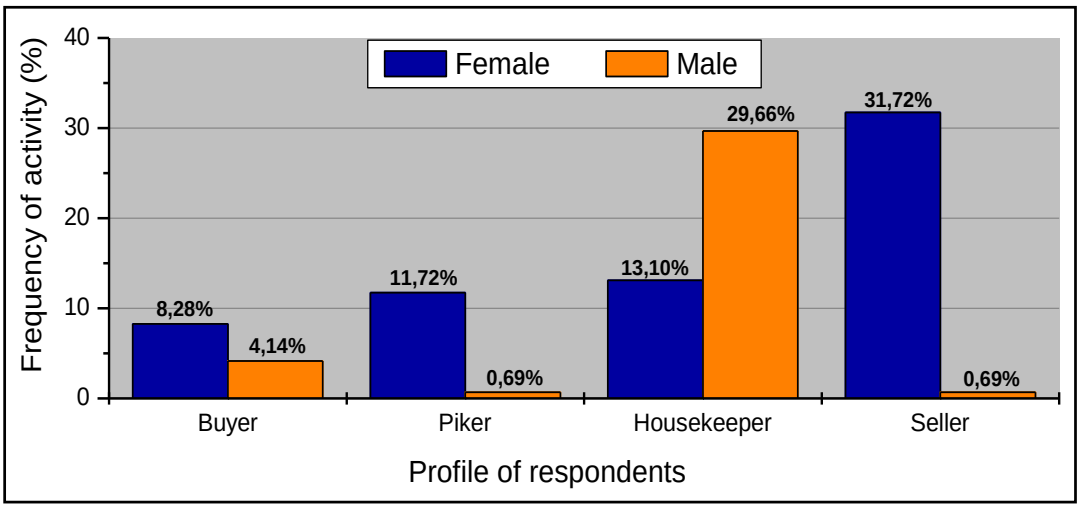

Figure 3 Distribution of the profile of respondents by gender

3.3. Age groups

3.3.1. Age groups and frequency of consumption

Figure 4 presents the frequency of consumption of mushrooms according to the age range of the respondents.

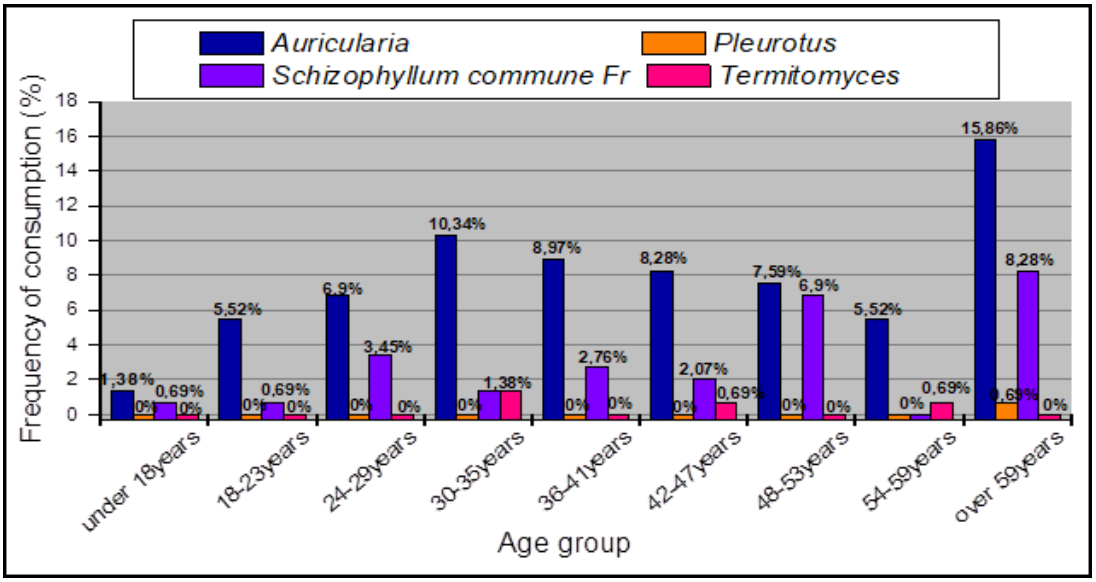

Figure 4 Frequency of consumption according the age group

It was observed that *Auricularia*genus and *Schizophyllumcommune* Fr species are consumed much more by people whose age range is more than 59 years (24.83%), followed by the group of 48-53 years (14.48%), 31-41 years (11.72%), 42-47 years (11.03), 24-29 years (10.34%) and last of 30-35 years (13.10%). The other age groups are each represented by less than 10%. However, these findings show no significant relationship between the frequency of mushroom consumption and the age range of respondents (X^2 = 25.41; p-value = 0.38).

3.3.2. Age range and frequency of appreciation

Figure 5 presents the level of appreciation of mushrooms according to the age range of respondents.Figure 5 shows that only two species of mushrooms are the most appreciated in all the age groups of respondents, of which *Termitomyces* and *Auricularia* (91.72% and 7.59 respectively). The Chi-square test shows that there is no significant relationship between the frequency of appreciation of mushrooms and the age groups of the respondents (X^2 = 11.11; p-value = 0.802).

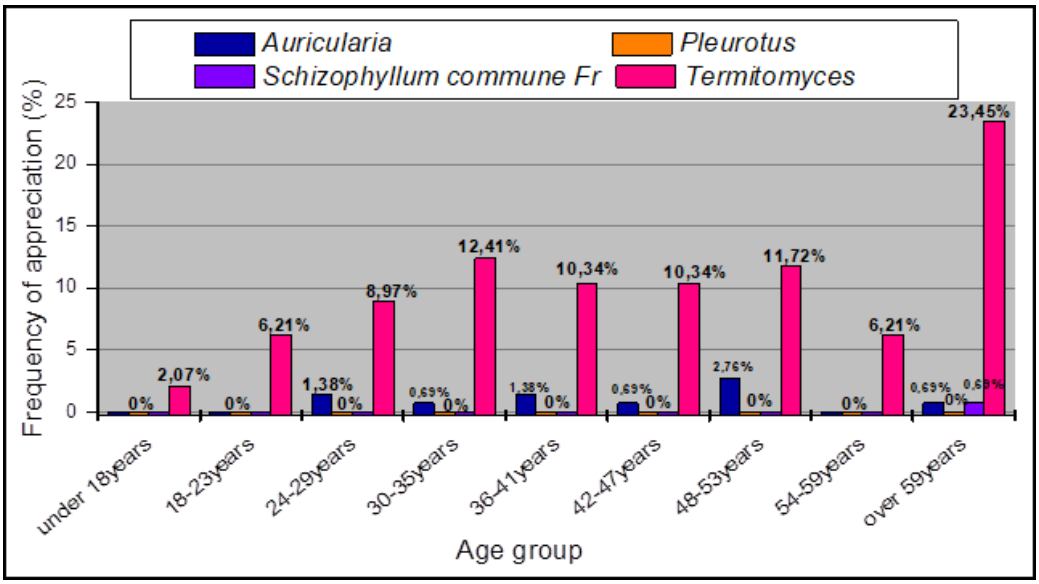

Figure 5 Frequency of appreciation by age groups

3.4. Language groups

3.4.1. Language groups and frequency of consumption

The frequency of consumption of mushrooms according to language groups is shown in Figure 6.

The majority of the language groups declared to consume more species of *Auricularia*genus (70.34%), followed by *Schizophyllumcommune*species (26.21%), *Termitomyces* species (2.76%) and species of *Pleurotus* genus (0.69%).

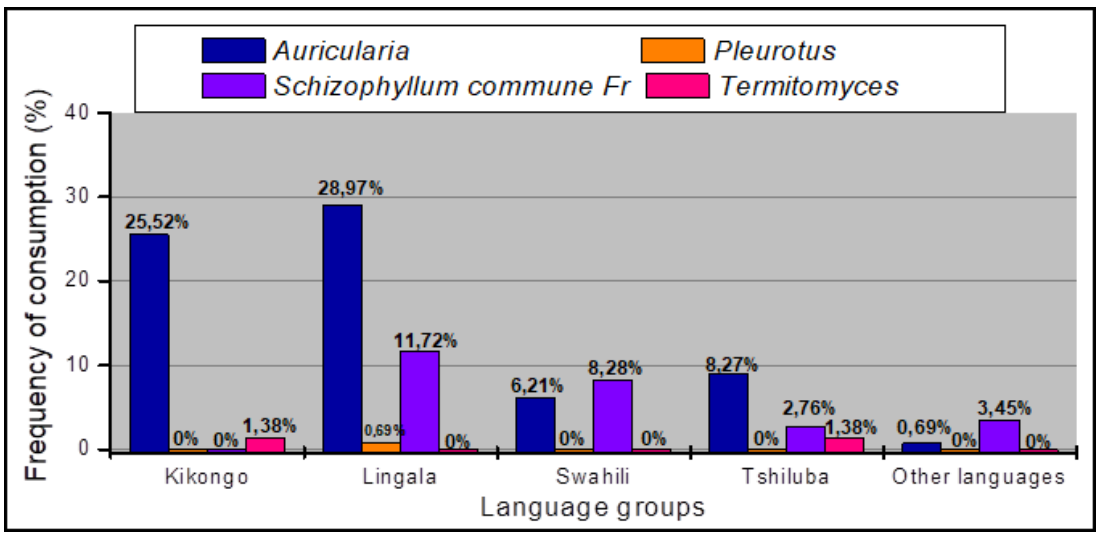

Figure 6 Frequency of consumption by language groups

On the other hand, whatever the linguistic group under study, it is observed a predominance of species of *Auricularia* genus as species with high frequency of consumption. The statistical analyses carried out show that there are no significant links between the frequency of consumption and the linguistic groups surveyed ($X^2 = 9.26$; p-value = 0.68).

3.4.2. Language groups and frequency of appreciation

The frequency of appreciation of mushrooms according to language groups is shown in Figure 7.

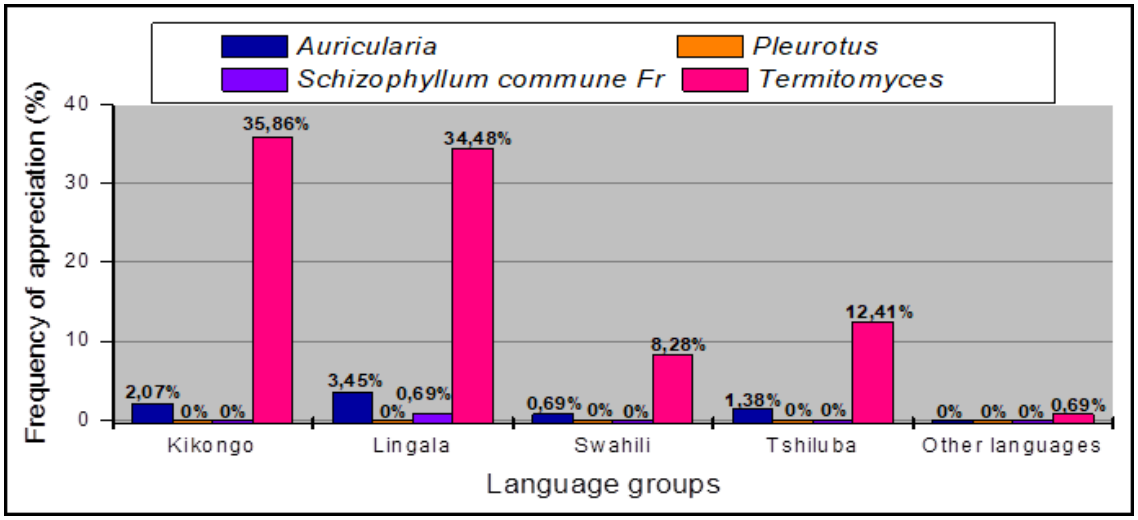

Figure 7 Frequency of appreciation by language groups

Figure 7 shows that the majority of the linguistic groups appreciate species of *Termitomyces* (91.72%), followed *Auricularia* (7.59%) and *Schizophyllum commune* (0.69%) as mushrooms for their consumption. The rest of the taxa represent a frequency of appreciation lower than 0.5% among respondents. As with the frequency of consumption, the frequency of appreciation of mushrooms is not significantly related to the language groups of the respondents ($X^2 = 2.37$; p-value = 0.96).

3.5. Seasonality and frequency of consumption

Figure 8 illustrates the frequency of consumption of mushrooms according to the seasonality of mushrooms.

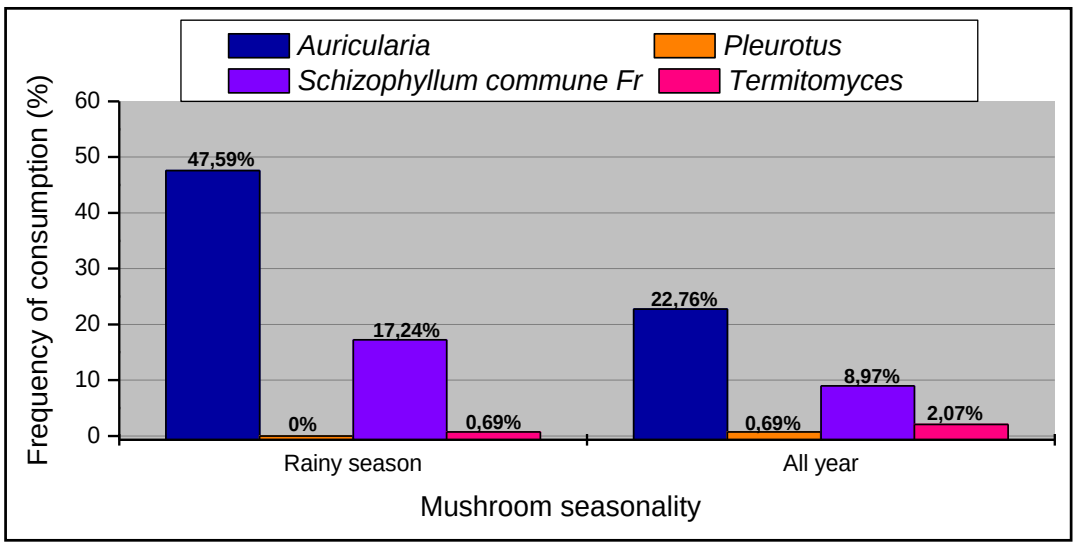

Figure 8 Mushroom Seasonality and Frequency of consumption

It was observed that the most consumed mushrooms are more available during the rainy season as reported by the majority of respondents (65.52%), compared to 34.48% who report that mushrooms are available throughout the year.

Thus, the species of *Auricularia* genus are more consumed during the rainy season than during the whole year with a consumption frequency of 70.34%, followed by *Schizophyllum commune Fr* with a consumption rate of 26.21%. However, these findings attest that the level of consumption of mushrooms has no significant relationship with the seasonality of the latter (X^2 = 5.013; p-value = 0.17).

3.6. Medicinal use of mushrooms

Figure 9 illustrates the respondents' knowledge of the medicinal use of mushrooms.

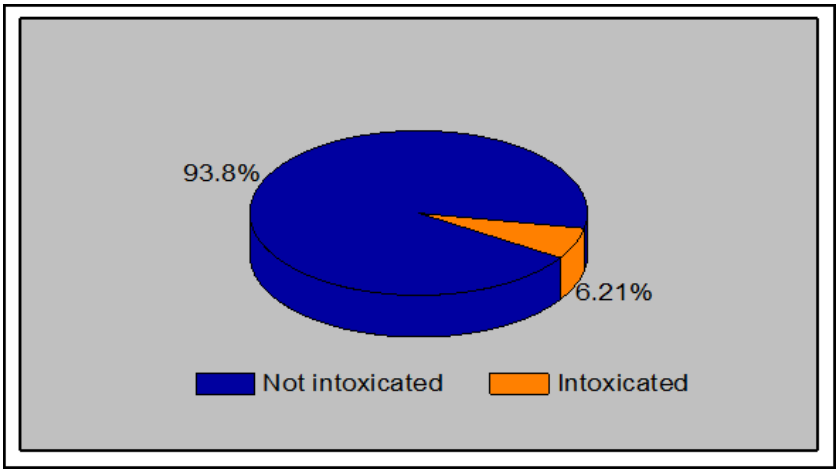

Figure 9 Value of medical use of mushrooms

Figure 9 shows that the majority of respondents (95.2%) declared that they did not know the medicinal use of mushrooms, compared to 4.8%.

3.7. Food use value of mushrooms

Figure 10 presents the state of knowledge of respondents on the food use of mushrooms.

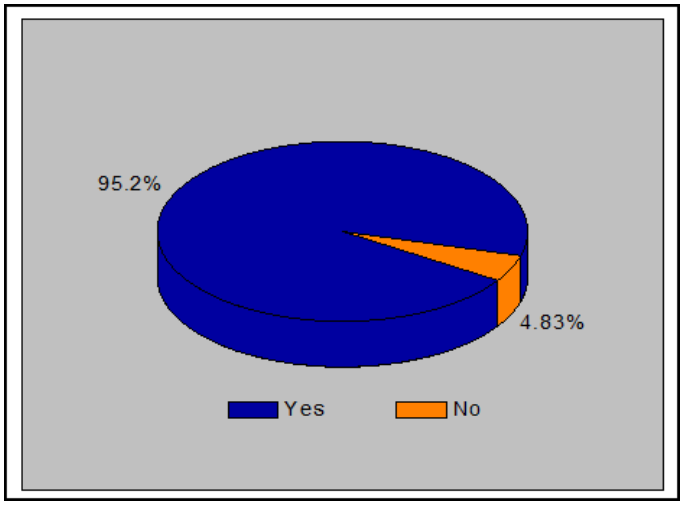

Figure 10 Food use of mushrooms

It was observed that the majority of respondents know the food use of mushrooms (97.9%), against 2.1% of respondents who ignore the potential of mushrooms in their diet.

3.8. Accident due to mushroom poisoning

Figure 11 illustrates the toxicity of mushroom consumption.

It was observed that the majority of respondents (93.8%) stated that they had not been poisoned by eating mushrooms, compared to a rate of 6.2% of respondents.

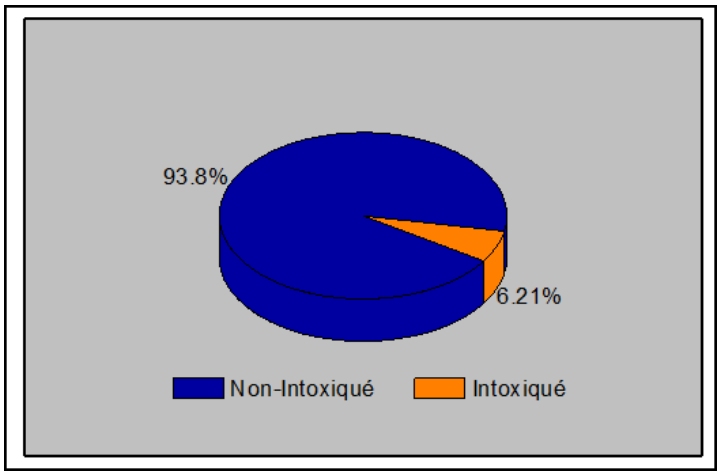

Figure 11 Accident due to food poisoning by mushrooms

3.9. Mushroom preservation techniques

Figure 12 illustrates the state of knowledge on the preservation techniques of mushrooms by the respondents.

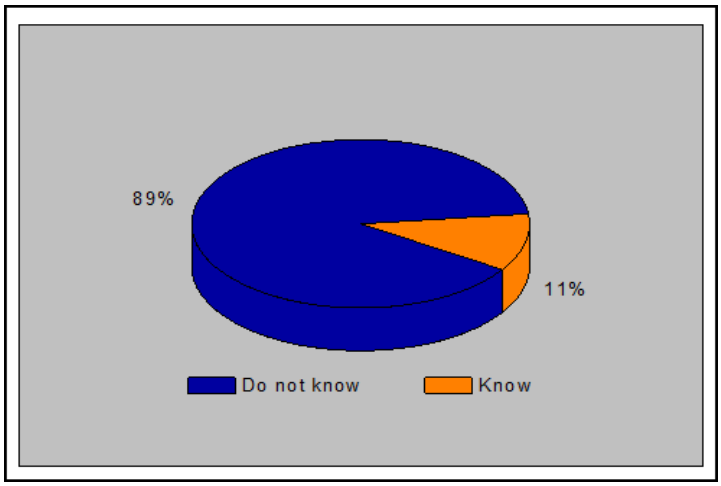

Figure 12 Knowledge of mushroom preservation techniques

The majority of respondents (89%) do not know the techniques of conservation of mushrooms, versus a rate of 11% of the respondents who know the techniques of conservation of mushrooms.

3.10. Typology of mushroom habitats

Regarding the habitats, the mushrooms under study occupy practically all the production systems as shown in figure 13 below.

The findings above show that the savannah with a rate of 47.59%, is the preferred habitat of fungi, followed by the savannah and forest, with a rate of 45.52%. These two habitats are therefore preferential spaces for mushrooms.

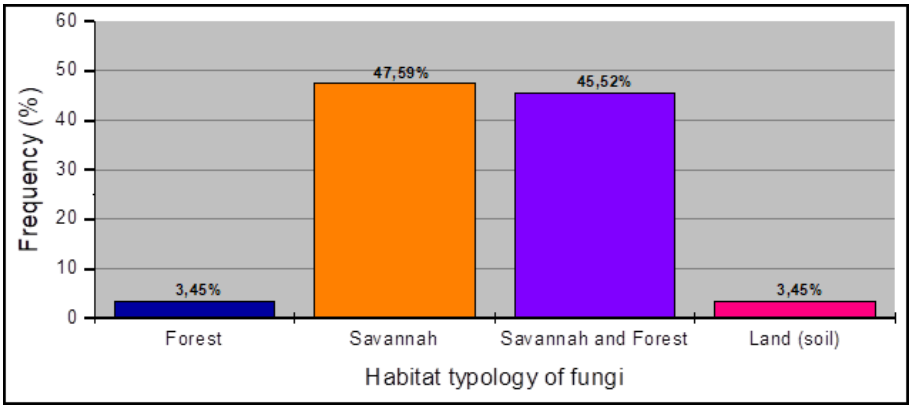

Figure 13 Type of habitats

4. Discussion

4.1. Taxonomic identification of collected mushrooms

The collection of wild edible mushrooms is a valuable commercial activity in both developed and developing countries. In most regions, mushrooms are usually collected during trips to the forest for fruit picking, hunting, fishing, or after returning from work in the fields [11]. The sale of wild edible mushrooms in piles on the local market is an important source of income for many rural and urban populations[12-13].

The findings obtained on the systematic overview of taxa of mushroom listed5 genera, 5 families divided into 3 orders. The genus *Termitomyces* is the most remarkable with 11 species listed. It should be noted, however, that the population assigns identical names to all species of the same genus such as *Termitomyces* species for example, it is the same for species belonging to different genera but which present similarities in color or shape such as species of *Pleurotus*genus and those of *Lentinus* genus. This means that the same vernacular name can be attributed to taxa with morphological similarities.

On the other hand, the same mushroom can also have different names in the same language, such as species *Auricularia* (called Kilebu and Bukutukutu in Kikongo), and *Termitomyces* (called Ntumbulantonto and Mutumbula in Kikongo). The same observation was made by EyiNdong[11] in northern Gabon and Thoen et al.[14] in the province of Katanga in DRC on the use of mushrooms in Katanga. All these, justify the very reduced number of taxa listed during the period of our investigations.

4.2. Profile and gender of respondents

The proportion of respondents' profiles divided by gender shows that the profile of respondents is predominantly female. We found that 64.83% of respondents in the mycological sector of Mont-Ngafulamunicipaliy are female. However, the statistical analysis shows that women are highly significantly related to the mycological activity profiles identified (χ^2 = 26.77; p-value <0.001). These findings corroborate with EyiNdong et al. [3], whom reported that in most parts of Africa where Bantu populations live, mushrooms are preferentially collected by women and their children. The same author observed that among Bantu women are the traditional harvesters and know mushrooms better than men and these men harvest mushrooms occasionally.

However, Dibaluka[15]reported that the majority of the population who harvest mushrooms in the Kimvula region is women.Mikobi[16] in the Luki Biosphere Reserve and its surroundings, where women and younger people are more involved in the collection of macromycetes to contribute substantially to the food and sale to meet family needs. However, it is important to point out that the attention of women towards mushrooms is very varied. It goes from the gastronomic interest to the scientific interest.

This is the case, for example, of Mrs. Goossens, who was the wife of the director of the botanical garden of Eyala, Mr. M.V. Goossens, and who for 15 years collected, drew, painted and noted the characteristics of all the mushrooms that she saw growing in the regions she lived in [17].

4.3. Age range and appreciation of mushrooms

The frequency of consumption of mushrooms according to the age range of respondents show that mushrooms (*Auricularia spp*. and *Schizophyllum commune*) are consumed much more by people whose age range is more than 59 years (24.83%), followed by those of 48-53 years (14.48%), 31-41 years (11.72%), 42-47 years (11.03), 24-29 years (10.34%) and those of 30-35 years (13.10%). The other age groups are each represented by less than 10%. Furthermore, the Chi-square test showed no significant relationship between the frequency of mushroom consumption and the age range of the respondents. This could be justified by the fact that older people know more species of wild edible mushrooms than younger people [18].

Moreover, our findings obtained on the level of appreciation of mushrooms according to the age range of respondents show that only two species of mushrooms are the most appreciated in all the age groups namely*Termitomyces* and *Auricularia* genera, yet *Termitomyces* was the most reported. The statistical analyses associated with thesefindings show that there is no significant relationship between the frequency of appreciation of mushrooms and the age groups of the respondents. The same observation was on the frequency of appreciation of mushrooms according to language groups, showing that the majority of language groups appreciate *Termitomyces* spp. much more (91.72%), followed by *Auriculariaspp*. (7.59%) and *Schizophyllum commune* Fr. (0.69%) as mushrooms for consumption. As with the frequency of appreciation of mushrooms by age range, the frequency of appreciation of mushrooms was not significantly related to the language groups of the respondents.

EyiNdong[11]reported on the appetence and culinary aspect in the appreciation of mushrooms by the Baka, Bakoya, Fang, Kota and Kwélé populations. Furthemore, Oso [19]stated that in Nigeria *Termitomycesrobustus* species is consideredasthe sweetest of all mushrooms. The same is true in Benin where *T. schimperi* is considered to be the most appreciated mushroom by the population [20]. A similar observation was reported in Burundi by Buyck[21], where the quality of *T. robustus* is attested to be clearly superior to that of the meat.

Degreef et al.[22] reported that *Termitomyces spp.* contained almost twice the protein content of other species consumed in tropical Africa.Yet, these are the species that are sold on the market only in the first two to three weeks of the rainy season [6]. The transfer of innovative technologies for the cultivation of *Termitomyces* species in the region is a palliative solution to make them available in all seasons.

4.4. Frequency of consumption

The frequency of consumption of mushrooms according to language groups show that the majority of language groups consume more *Auricularia spp.* (70.34%), followed by *Schizophyllum commune* (26.21%), *Termitomyces spp.* (2.76%) and *Pleurotus spp*. (0.69%). On the other hand, whatever the linguistic group under study, it is observed a predominance of *Auricularia spp.* as a taxon with a high consumption frequency. The statistical analyses carried out show that there are no significant links between the frequency of consumption and the language groups surveyed .

The frequency of consumption according to the seasonality of mushrooms show that 65.52% of respondents affirm that the most consumed mushrooms are much more available during the rainy season, against 34.48% who affirm that mushrooms are available during the whole year.Thus, *Auricularia* are the most consumed during the rainy season than during the year with a consumption frequency of 70.34%, followed by the common *Schizophyllum spp.* with a consumption rate of 26.21%. This is explained by the fact that the mushrooms of the species of *Auricularia* and *Schizophyllum commune* are of an ecological range [3]. Their revivalist character ensures the survival of sporophores well beyond the rainy season, unlike other species of edible fungi. This feature allows them not only to spread the harvest and consumption throughout the year but also to preserve them easily.

4.5. Uses of mushrooms

The value of medical use of mushrooms in our study area show that the majority of respondents (95.2%) declared not to know the medical use of mushrooms against 4.83%. These results corroborate those of Dibaluka[15]who reported that the uses of macromycetes in traditional therapy are poorly exploited and documented in Kimvula city and its surroundings (Kongo Central/DRC). Francia *et al.*[23]reported that macromycetes are little used in traditional medicine. However, there are several fungal species of medical interest that can be exploited to make mycomedicines. The knowledge of respondents on the food use of mushrooms show that the majority of respondents know the food use of mushrooms (97.9%), versus2.1% ofrespondents who do not know the food property conferred to mushrooms. These results corroborate those of Kouagou et al. [24] and EyiNdong[11], who found that mushrooms are considered to be a substitute for meat or fish and are the object of much attention during the harvesting period. They should never be

overcooked, they should remain slightly crunchy to retain their flavors and not be mushy [21]. Thus, the pleasant taste of mushrooms is indeed a very important aspect for consumers.

4.6. Accidents due to mushroom poisoning

The toxicity of mushroom consumption shows that the majority of respondents (93.8%) declared not to have already suffered from intoxication related to mushroom consumption versus a rate of 6.21%. These results coincide with those of Mikobi[16] relating to intoxication due to the use of macromycetes, according to which 93.3% of the people interviewed in the Bas-fleuve District, in the Luki Biosphere Reserve and its surroundings did not know of any cases of intoxication due to the consumption of macromycetes compared to a minority (6.7%) who acknowledged cases of intoxication. It is important to note here that before mushroomsare consumed by the entire population of a region, it must first have been successfully consumed by an individual, family, clan or tribe.Moreover, Thoen et al.[14] estimate that the percentage of toxic species must be very low in Africa since cases of poisoning are extremely rare.

4.7. Typology of habitats and conservation techniques for mushrooms

With regard to habitats, the mushrooms under study occupy practically all the production systems. The results on the typology of habitats show that savannah (47.59%) is the preferred habitat of mushrooms consumed by the population of Mont-Ngafula, followed by savannah and forest (45.52%). Finally, 6.89% consisting of forest and habitat types other than those mentioned. These two habitats are therefore the preferred areas for mushrooms consumed by this population.

The state of knowledge of mushroom conservation techniques among the respondents show that the majority of respondents (89%) stated that they did not know mushroom conservation techniques, compared to 11% of respondents who did know mushroom conservation techniques. These results could be explained by the fact that the quantity of mushrooms harvested is so small that the majority of respondents prefer to consume and/or sell them rather than preserve them, and on the other hand by the fact that drying modifies or weakens the taste of the mushroom and concentrates the aroma [11]. Therefore, mushrooms are generally consumed fresh to retain their aroma and consistency, which makes them pleasant to eat.

5. Conclusion

The aim of this work was to improve knowledge of the fungal species of food and medicinal interest exploited by the population of Mont-Ngafula municipality, and their uses. The findings showed that the population of Mont-Ngafula municipality has a very high level of mycological knowledge that remains to be discovered.

The ethnomycological surveys conducted in this study area allowed us to draw up a list of 5 species grouped into 5 genera, 5 families and divided into 3 orders of mushrooms consumed by the population of the commune of Mont Ngafula.

This study, which is one of the first in Kinshasa, is a reason for real satisfaction for the results presented. We have sufficiently documented the endogenous mycological knowledge held by the population of the commune of Mont-Ngafula, south of the city of Kinshasa, thus constituting a database. This study is only the beginning of a research that can be extended to the whole city.

In the future, research should be initiated on the inventory of edible and/or medicinal mushrooms of the city of Kinshasa. Given that the taxa of the genus *Termitomyces* are the most appreciated, an in-depth ecological study must also be initiated on the representatives of this group (*Termitomyces*) sold and harvested in Kinshasa and trials on their cultivation to make them available in all seasons. A look should be taken at the taxa of *Auricularia* and *Schizophyllum*considered to be the most consumed mushrooms, all year round.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that no competing interests exist.

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