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Wild edible mushrooms from a Zambezian woodland area (Copperbelt Province, Zambia)

Champignons sauvages comestibles d'un territoire de forêt claire zambézienne (Province de Copperbelt, Zambie)

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Résumé : Dans de nombreux pays d'Afrique tropicale, la consommation de champignons sauvages constitue un appoint alimentaire non négligeable pour les populations locales. La présente étude fut menée dans la Copperbelt Province (Zambie), un territoire situé en Région zambézienne. La récolte de sporophores et les enquêtes participatives menées auprès des villageois ont permis de dresser une liste de 47 taxons de champignons comestibles. Les dénominations vernaculaires et des données écologiques sont présentées. Un inventaire de la connaissance actuelle concernant les champignons comestibles de Zambie est présenté ainsi que la séquence phénologique de 21 espèces de la dition. L'étude développe des informations complémentaires relatives aux protéines, acides aminés, composition minérale et valeur calorifique, ainsi qu'aux lipides de quelques champignons comestibles des forêts claires zambiennes. Enfin, plusieurs aspects ethnomycologiques et socio-économiques sont signalés, compte tenu du fait que dans de nombreux villages la commercialisation des champignons sauvages, ainsi que d'autres produits forestiers non ligneux (charbon de bois, chenilles, fruits…), permettent de générer un revenu familial essentiel pour les populations locales.

Mots-clés : Zambie - miombo - champignons comestibles - phénologie - composition chimique-ethnomycologie

Abstract : In many countries of tropical Africa, the consumption of wild mushrooms constitutes an appreciable food supplement for the local populations. The present study was conducted in Copperbelt Province (Zambia), an area located in the Zambezian region. Harvesting of present state of knowledge regarding edible fungi found in Zambia is given and the phenological sequence for 21 species of this region is presented. This study presents complementary information on protein, amino-acids, mineral contents and calorific value, as well as on the fatty acid composition of twelve edible fungi of the Zambian woodlands. Finally, this note gives several ethnomycological and socio-economical aspects according to the fact that, in many villages, the trade of wild mushrooms, as well as other forest products (charcoal, caterpillars, fruits...), enables local populations to generate essential family incomes.

Key words : Zambia-miombo- edible mushrooms-phenology-chemical composition-ethnomycology

INTRODUCTION

The consumption of wild edible mushrooms by local populations has been reported in many areas of tropical Africa (RAMMELOO & WALLEYN 1993). These studies have mainly been led in Benin (DE KESEL *et al.* 2002), Nigeria (ZOBERI 1973, 1978, OSO 1975, OGUNDANA 1978, ADEWUSI et al. 1993), Burundi (BUYCK 1994, BUYCK & NZIGIDAHERA 1995), Democratic Republic of Congo (CHINN 1945, ADRIAENS 1953, THOEN *et al.* 1973, PARENT & THOEN 1977, MBEMBA & REMACLE 1992, DEGREEF *et al.* 1997), Tanzania (HÄRKHÖNEN *et al.* 1993b), Zambia

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Fig. 1.: Map of Africa showing the Zambezian Region, Zambia and Copperbelt Province.
Carte d'Afrique indiquant la Région zambézienne, la Zambie et la Province de la Copperbelt

(PEGLER & PIEARCE 1980, PIEARCE 1981a), Malawi (MORRIS 1994) and Zimbabwe (RYVARDEN *et al.* 1994). In some regions, especially the Zambezian woodlands (MALAISSE & PARENT 1985), these forest foodstuffs constitute an essential contribution to the local diet. Indeed, PARENT & THOEN (1977) estimate that in Upper-Katanga (Democratic Republic of Congo) the large mushrooms consumed by natives reach to about thirty kilograms per year (fresh weight) and per inhabitant. In the Copperbelt Province of Zambia, these edible mushrooms appear during the whole rainy season even when most of the cultures are still in stages of development. As caterpillars and termites (MALAISSE 1997), mushrooms provide an important nutritional supply to the local populations, at this period of the year.

THE AREA OF STUDY

Our inventory was carried out from January to April 1996, in the Zambian Copperbelt Province, near Mpongwe (Fig. 1), in a miombo woodland, 60 kilometres South of Luanshya (13° 9' S, 28° 25' E). The prospected area is at about 1300 m elevation. The mean annual temperature ranges from +20°C to +22°C. The rainy season generally extends from November to April, with an annual rainfall of 1200 mm.y-1, but with important variations from one year to another. Some years, there is a short dry season, in January or February, lasting 10 to 15 days.

Woodlands occupy large areas in Zambia. They include open forests as well as wooded and tree savannas. According to the definition proposed at the C.C.T.A.\ C.S.A. meeting, held at Yangambi (Democratic Republic of Congo), in 1956, open forest is a vegetation type essentially formed by trees which density is sufficient to induce a floristic composition of the herbaceous layer

C.C.A.T.: Commission de Coopération Technique en Afrique au sud du Sahara
C.S.A.: Conseil Scientifique pour l'Afriquez au Sud du Sahara

different from that of the savanna formation. Theoretically, open forest is distinct both from wooded savanna and tree savanna, the first one presenting a tree layer covering over 60 % (MALAISSE 1978).

Several types of woodland are distinguishable among which the most important is the miombo, a woodland dominated by species of *Brachystegia, Julbernardia* and *Isoberlinia* genera (MALAISSE 1973).

MATERIAL AND METHOD

Inventory

Mushrooms have been collected, photographed and described on the field by BUYCK and EYSSARTIER during January and February 1996 and by BOURDEAUX from February to April 1996. Specimens have been deposited in the Mycological Herbarium of the Museum National d'Histoire Naturelle, in Paris. Identifications were supplied by BUYCK. Some detailed studies of tremendous taxa have been published (BUYCK and EYSSARTIER 1998).

Inquiry

The species phenology data are based on direct observations or on village inquiries (Fig. 2). Ethnomycological and socio-economical information have been collected through interviews in small villages or in the markets of Kitwe (ca. 600,000 inhabitants), Ndola (ca. 300,000 inhabitants) and Luanshya (ca. 100,000 inhabitants). These inquiries were based on the Rapid Rural Appraisal method (R.R.A.) (GUEYE *et al.* 1991), a participatory research method and continuous learning process for a better knowledge of the local conditions of life and problems of the population. Inquiries dealt with approximately 25 items which the most important concerned mainly harvesting, selling prices, clientele, incomes, culinary preparation, consumption, conservation and cultivation of mushrooms.

Chemical analyses

Fresh sporophores were brushed and dried at a temperature of 50°C, using an electric drying oven. Some field dried specimens were freeze-dried, weighted and finally grinded.

Total protein level was measured in defatted seedcake meal by the Kjeldahl method using a Kjeltec Tecator 1030 auto-analyser. Since the hyphal walls are mainly made of chitin (a galacturonic acid polymer), the total nitrogen-protein conversion value of 4.38 was selected instead of 6.25, conventionally used for plant proteins (CRISAN & SANDS 1978).

Amino acids were determined with a Pharmacia-LKB Plus II analyser after acid hydrolysis (HCl 6M/ 24h at 120°C) using norleucine as internal standard. Due to hydrolysis conditions, methionine and cystin were systematically under-estimated and tryptophan contents were not available. The results are expressed as percentage of dry matter.

The lipids were extracted with a chloroform-methanol 2/1 (v:v) mixture according to Folch *et al.* (1957). Fatty acid methyl esters (FAME) were prepared from crude lipids by boron-trifluoride catalysed transmethylation (IUPAC 1979) and analysed by gas chromatography (GC). A Hewlett Packard HP5880A chromatograph fitted with a flame ionisation detector (T° = 250°C) and a cold " on-column " injector was used. The different fatty acids methyl esters were identified on the basis of chromatographic retention data. In reason of the particular FAME profile of the *Cantharellus* species, a GC-MS indentification was undertaken in the following conditions: apparatus Hewlett Packard HP5972MS (electron impact mode at 70 eV, source at 150°C and interface at 240°C) coupled to a HP5890 Series II chromatograph, fitted with a 25mm x 0.25mm (CP-WAX 52 CB Column) Chrompack, 0.25μm film thickness, temperature programme: from 55 to 150°C at 30°C min^{-1} and from 150 to 240°C at 5°C min^{-1} ; helium at 1 ml min^{-1} was used as carrier gas.

Mineral composition was determined by flame emission spectroscopy for Na and K and by atomic absorption spectrometry for Ca, Mg, Fe and Mn (DUBOIS *et al.* 1995).
The calorific value was determined with an adiabatic calorimeter (PARR 1241, Parr Inc., Moline, IL, USA).

RESULTS

Ecology

The edible mushrooms harvested in the miombo woodland essentially belong to three biological categories: ectomycorrhizal, saprophytic and termitaria mushrooms. The ectomycorrhizal mushrooms are characterized by the presence of root symbiotic association mainly with the dominant forest tree genera, *Brachystegia, Julbernardia* and *Isoberlinia* (HÖGBERG & PIEARCE 1986). Ectomycorrhizae have a double advantage for the tree : they reinforce the nutritional balance of the tree by improving the capacity of absorbing mineral components; they insure a protective function, in preventing altering agents to penetrate into the roots. The saprophytic mushrooms develop at the expense of animal or plant waste and dead organic matter. Finally some mushrooms found on termitaria result from a remarkable symbiosis with termites. These termites belong to Macrotermitidae which are restricted to Asia and Africa. They build high termitaria in woodland area and are responsible for one third of total plant decomposition (RUELLE 1964). The insects create inside the termite hill a propitious environment for the mycelium growth whilst mushrooms, thanks to their action of decomposition and biopolymer digestion, facilitate the assimilation of nutritional and energizing constituents necessary to the life of the insects.

Inventory

Forty-seven edible fungi have been listed for the studied area (Table I, Fig. 3). Among them 32 species are ectomycorrhizal, 7 species are considered as saprophytic and 8 species live in symbiosis with termites. It should be noted that, in 1980, PEGLER & PIEARCE pointed out only 18 wild edible fungi for Zambia, whilst more than one hundred edible fungi have presently been recorded from the Zambezian woodland area (BUYCK, unpubl. data). Vernacular names are provided as well as reference material.

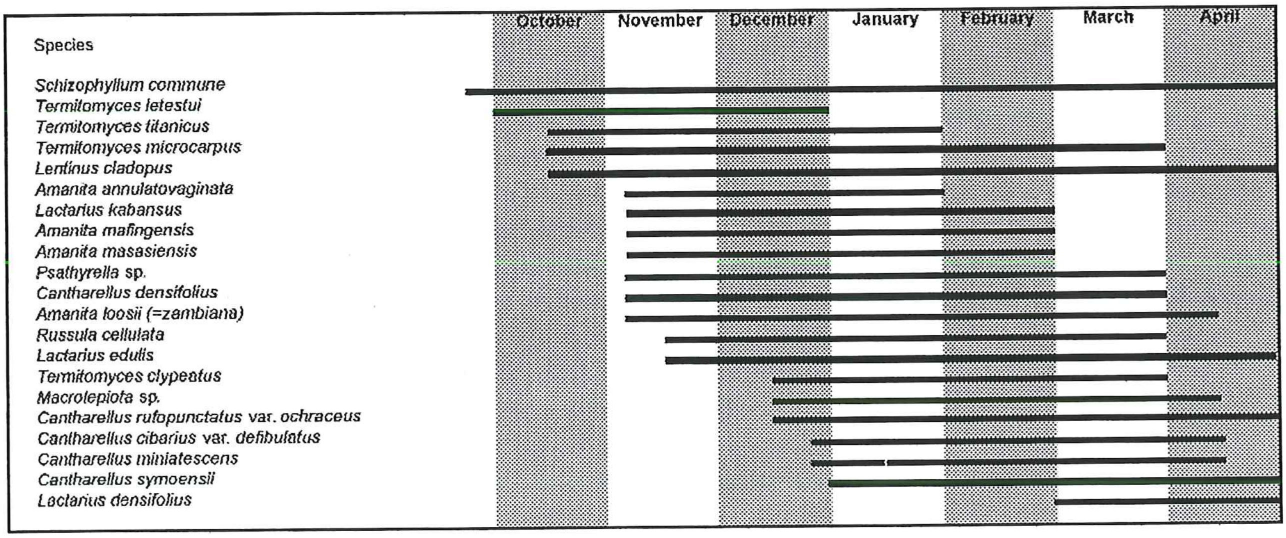

Fig. 4. Phenology of 21 edible mushrooms harvested in miombo woodland, Copperbelt Province, Zambia
Phénologie de 21 champignons comestibles récoltés en forêt claire de type miombo, Province de Copperbelt, Zambie

Fig. 2. - Edible mushrooms are a very important source of income for the rural population of Zambia.

A. 10 km S of Kapiri Mposhi.
B. *Termitomyces titanicus*, a fine find for these two scholars.
C. Young men offering *Amanita loosii* for sale near Lusaka.
D. In villages, small platforms are used to dry mushrooms in the sun for late consumption.
E. Women's morning gathering in the vicinity of Mpongwe.

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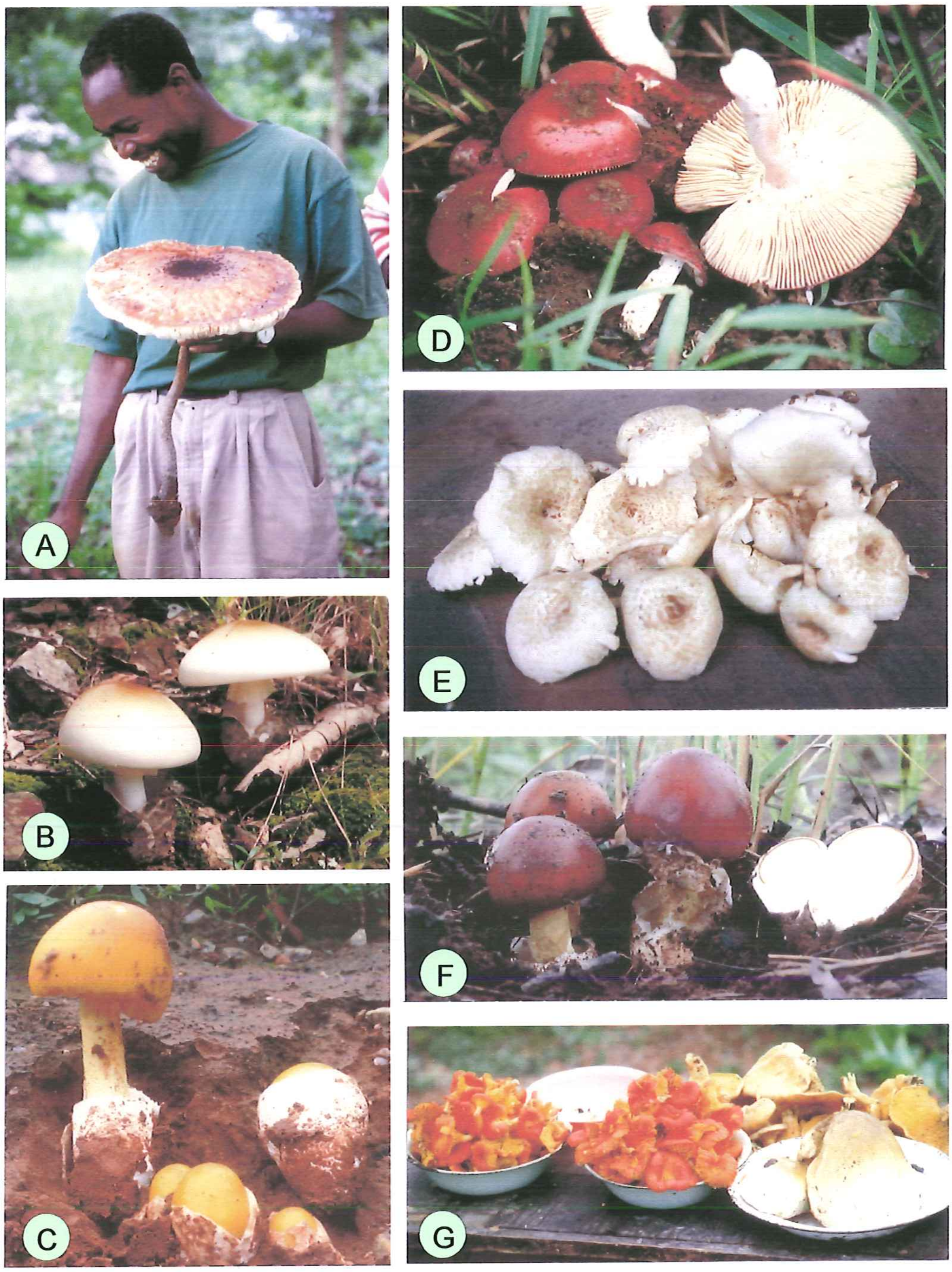

Fig. 3. - Edible mushrooms harvested in Zambia

A. Kankolenkole or *Macrolepiota* sp is a very highly appreciated mushroom growing often in and around fields.
B. Telia or *Amanita loosii*, the most wanted mushroom in the Copperbelt.
C. Longwa or *Amanita masasiensis*.
D. Ntanga is the common Lamba name for a group of red-coloured *Russula* species consumed in family circle but seldom sold.
E. Amakabanka or *Lentinus cladopus* is one of the few saprophytic mushrooms consumed in Zambia.
F. *Amanita mafingensis*.
G. *Cantharellus symoensii* (left), *Amanita loosii* (front, right) and *Cantharellus rufo-punctatus* for sale at a roadside stall near Kabwe.

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Table 1. Inventory, Biology and vernacular names of 48 edible mushrooms harvested in miombo woodland, Copperbelt Province, Zambia

Species		BIOLOGY Ecto.[2]	Sapr.	Term.x	Vernacular names[1]
1. *Amanita annulato vaginata* BEELI	BB 6326	x			Imfuti (1), Musholomwa (2)*
2. *Amanita loosii* BEELI	BQ 005	x			Telia (1), Tente (2)*, Walenda (5), Ninedzi (6), Ndelema (7, 9)*
3. *Amanita mafingensis* HÄRKÖNEN & SAARIMÄKI	BB 6324	x			Longwa (1), Akatalukwa (1), Chongororo (3)
4. *Amanita masasiensis* HÄRKÖNEN & SAARIMÄKI	BB 6323	x			Longwa (1), Chongororo (3)
5. *Amanita pudica* (BEELI) WALLEYN	BB 6224	x			
6. *Cantharellus cibarius* var. *cantharellus* FRIES : FRIES	BB 6321	x			Bwitondwe (1)
7. *Cantharellus cibarius* var. *defibulatus* HEINEMANN	BB 6200	x			Bwitondwe (1)
8. *Cantharellus cibarius* var. *latifolius* HEINEMANN	BQ 012 / BB 6293	x			Bwitondwe (1)
9. *Cantharellus congolensis* BEELI		x			
10. *Cantharellus cyanescens* BUYCK	BB 6003	x			
11. *Cantharellus cyanoxanthus* HEIM	BB 6004	x			Bwitondwe (1)
12. *Cantharellus densifolius* HEINEMANN	BB 6277	x			Kasununu (1), Chitondo mwaiche (2), Kasweta (2)*
13. *Cantharellus microcibarius* HEINEMANN	BB 6272	x			
14. *Cantharellus nov.* sp. HEINEMANN		x			Kasununu (1)
15. *Cantharellus ruber* HEINEMANN	BQ 007 / BB 6014	x			Kasununu (1)
16. *Cantharellus rufopunctatus* var. *ochraceus* HEINEMANN	BQ 002 / BB 6237	x			Mumpukutu (1), Manyame (3), Bachiwa Mabombo (4), Uchonjo (5), Chiyombiro (6)
17. *Cantharellus splendens* BUYCK	BB 6306	x			Chilomochamumba
18. *Cantharellus symoensii HEINEMANN*	BQ 004 / BB 6002	x			Chilomochamumba (1), Chitondo munono (2), Tsuka Tsuka (6)
19. *Cantharellus floridula* (s.s. PEGLER) HEINEMANN	BB 6083	x			
20. *Clitopilus prunulus* (SCOP. : FRIES) KUMMER	BB 6132		x		Mamfwenfwe (1)
21. *Dendrogaster congolensis* HENNINGS	BB 6313,6314	x			Ifilyamfumu (1), Chituli (2)
22. *Lactarius cf. aureifolius* VERBEKEN	BQ 014 / BB 6280	x			Chinyange (1), Mabele (1), Bwebwe (2)
23. *Lactarius cyanovirens* VERBEKEN	BB 6150	x			Chisukubiya (1), Macinsunkwa (2), Usole (5)
24. *Lactarius densifolius* VERBEKEN & KARHULA	BB 6168	x			Kapinda (1), Musefwe (1), Uhoko (5)
25. *Lactarius edulis* VERBEKEN	BQ 001 / BB 6005	x			Musefwe (1), Busefwe (2), Unge (5)
26. *Lactarius gymnocarpoides* VERBEKEN	BB 6152	x			Chinyange (1), Tsikadzi maha (6)
27. *Lactarius kabansus* PEGLER & PIEARCE	BB 6059	x			Kabansa (1, 2)*, Nzewe (6), Nakandoma (8)*, Kombowa-mbowa (4)*
28. *Lactarius* sp. 1	BQ 008	x			Musefwe (1), Busefwe (2), Chisuku (2)
29. *Lactarius* sp. 2	BQ 006	x			Inkulo (1), Chinsukwa (1), Cititamuto (2), Chisuku (2), Ukufa (5)
30. *Lentinus cladopus* LEVEILLE	BB 6281,6141		x		Amakabakaba (1)
31. *Macrolepiota* spec.	BB 6007,6131		x		Kankolenkole (1)*, Tunkolenkole (9)*
32. *Pleurotus* sp.	BB 6193		x		
33. *Psathyrella* sp.	BB 6162		x		Tindi bushiki (1)
34. *Russula cellulata* var. *ntama* BUYCK	BQ 013 / BB 6312	x			Munya (1, 2, 9), Waseselya (5)
35. *Russula* sp. (red)	BB 6164	x			Ntanga (1, 9), Mushinge (1)
36. *Schizophyllum commune* FRIES : FRIES	BQ 010		x		(Ubu)sepa (1), Sepa (2)*
37. *Termitomyces clypeatus* HEIM	BQ 009 / BB 6292			x	Akatyotyo (1), Tutyotyo (1), Chibengele (2)*, Tunkulubindi (2), Nyozwa (3)*, Uzuma (3)*
38. *Termitomyces letestui* (PAT.) HEIM				x	Nsanda (1), Katoto (2)
39. *Termitomyces microcarpus* (BERK. & BR.) HEIM	BQ 011 / BB 6202			x	Tande (1), Nsamfwe (1), Ichisamfu (1), Samfwe (2)*, Nsamvu (2)*, Chisamfu (2)*, Chiswa (2)*, Nyongwe (3), Manda (3)*
40. *Termitomyces microcarpus* var. *major* HEIM	BB 6264			x	Nsamfwe (1), Ndavuzababa (3)
41. *Termitomyces* cf. *microrhizus*	BB 6171			x	
42. *Termitomyces schimperi* (PAT.) HEIM				x	Kiribunkungwa (1)
43. *Termitomyces striatus* (BEELI) HEIM	BB 6119			x	Bukwesenge (1)
44. *Termitomyces titanicus* PEGLER & PIEARCE	BB 6006			x	Bunkungwa (1), Chikolowa (2)*
45. *Volvariella speciosa* (FR. : FR.) SINGER	BB 6291		x		Chamwipulao (1)
46. *Xerocomus* sp.	BB 6318	x			Chimbwi (2)
47. *Xerocomus subspinulosus* HEINEMANN	BB 6205	x			

1 Dialects : Lamba (1), Bemba (2), Nyanja (3), Tonga (4), Tschokwe (5), Shona (6), Tumbuka (7), Lozi (8) and Kaonde (9). 2 Ecto. : Ectomycorrhizic fungi; Sapr. : Saprophytic fungi; Term. : Termitaria fungi.
* Data given by Pegler & Piearce (1980). Reference material : BB = Buyck Bart, BQ = Bourdeaux Quentin, GE = Eyssartier Guillaume

Phenology

Sporophores production is highly seasonal, with the exception of *Schizophyllum commune*, which is observed all year round. As shown by the phenology sequence (Figure 4), it is clear that some fungi appear immediately after the first rains, announcing the start of the rainy season. This is the case of *Termitomyces letestui* and *T. titanicus*, whose remarkable caps spread out on, or near, termite mounds, as already reported by PIEARCE (1987). The emergence period of *Cantharellus spp.* globally occurs towards the end of the rainy season.

Table II.- Total protein content and amino-acids composition of 12 edible mushrooms harvested in miombo woodland, Copper belt Province, Zambia.
Teneur totale en protéines et composition en acides aminés de 12 champignons comestibles récoltés en forêt claire de type miombo, Province de la Copperbelt, Zambie.

	N° 1	N° 2	N° 3	N°4	N° 5	N° 6	N° 7	N°8	N° 9	N° 10	N° 11	N° 12
Total N (g 100 g^{-1} DM)	3.32	4.74	3.04	3.92	5.67	4.94	7.22	4.88	5.61	6.07	2.29	
Total protein (100 g^{-1} DM) (facto 4.38)	**14.54**	**20.76**	**13.32**	**17.17**	**24.84**	**23.96**	**21.64**	**31.62**	**21.38**	**24.57**	**26.58**	**10.03**
Aspartic acid(1)	1.69	1.99	1.50	2.21	2.37	2.38	2.44	3.57	2.26	2.98	2.31	1.18
Threonine	0.86	1.06	0.81	1.21	1.47	1.27	1.25	1.68	1.03	1.38	1.53	0.58
Serine	0.80	1.00	0.73	1.00	1.35	1.18	1.15	1.62	1.03	1.46	1.30	0.53
Glutamic acid(2)	2.42	4.66	2.14	2.88	3.71	3.41	3.08	6.21	4.66	5.50	4.83	1.95
Proline	0.92	1.10	0.74	0.96	1.30	1.30	1.18	1.28	0.91	1.36	1.70	0.53
Glycine	0.89	1.03	0.77	1.04	1.40	1.46	1.30	1.82	1.35	1.48	1.43	0.66
Alanine	0.97	1.26	0.94	1.24	1.65	1.66	1.59	2.18	1.50	1.75	2.69	0.75
Cystine	0.12	0.26	0.07	0.11	0.30	0.19	0.15	0.24	0.20	0.28	0.28	0.06
Valine	0.95	1.13	0.90	1.23	1.73	1.86	1.55	1.77	1.24	1.86	1.75	0.71
Methionine	0.15	0.19	0.09	0.14	0.39	0.35	0.42	0.23	0.31	0.43	0.33	0.12
Isoleucine	0.86	1.03	0.80	1.11	1.25	1.21	1.21	1.42	0.95	1.48	1.34	0.56
Leusine	1.26	1.53	1.17	1.39	1.77	1.80	1.80	2.24	1.53	2.12	1.96	0.86
Tyrosine	0.49	0.69	0.40	0.68	0.52	0.54	0.60	1.09	0.75	0.75	0.54	0.24
Phenylalanine	0.80	1.07	0.74	0.96	1.11	1.15	1.13	1.43	1.00	1.26	1.20	0.49
Histidine	0.41	0.57	0.32	0.53	0.59	0.53	0.54	1.16	0.93	0.80	0.63	0.32
Lysic	0.90	1.35	0.73	1.16	1.16	0.99	1.16	2.43	1.63	1.74	1.01	0.78
Arginine	1.11	1.91	1.02	1.33	1.43	1.32	1.21	1.61	1.26	1.64	1.40	0.69
Amino-butyric acid	0.16	0.10	0.11	0.16	0.30	0.47	tr	0.15	0.20	0.39	0.63	0.08
Glucosamine	1.40	1.43	1.37	0.72	2.21	1.05	2.57	tr	1.96	tr	1.93	tr
Total amino acids	**17.15**	**23.35**	**15.35**	**20.04**	**26.01**	**24.09**	**24.33**	**32.12**	**24.68**	**28.65**	**28.77**	**11.08**

N° 1: *Cantharellus* cf. *contortus*	N° 5: *Lactarius edulis*	N° 9: *Termitomyces microcarpus*
N° 2: *Cantharellus ruber*	N° 6: *Lactarius* sp. 1	N° 10: *Amanita loosii*
N° 3: *Cantharellus rufopunctatus* var. *ochraceus*	N° 7: *Lactarius* sp. 1	N° 11: *Russula celluata*
N° 4: *Cantharellus symoensii*	N° 8: *Termitomyces clypeatus*	N° 12: *Schizophyllum commune*

(1) including asparagine; (2) including glutamine; tr = trace

Chemical composition

The chemical composition was determined for 12 mushrooms, frequently sort for sale on urban and rural stalls.

Protein content varies from 15 % to 25 % of the dry matter (Table II). Distinctly higher values are observed for *Termitomyces* species, especially *T. clypeatus* (32 %). PARENT & THOEN (1978) and DEGREEF *et al.* (1997) noticed also already this general tendency in the same genus. At the opposite, *Schizophyllum commune* is characterized by a low protein content (10 %).

Human beings need in their alimentation 8 essential amino acids for the maintenance of the nitrogen equilibrium. Each fungal species contains generally high proportions of these amino acids, except for cystin which is systematically under-estimated (it is partly degradated during the hydrolysis process). At the opposite, the 12 analysed samples are found to be rich in valin and leucin. MBEMBA & REMACLE (1992) noted also this characteristic for mushrooms from the Kwango region (Democratic Republic of Congo).

The average lipid content of the investigated mushrooms (Table III) is quite low. It ranges from 3.5 (*Lactarius edulis*) to 5.5 g 100 g-1 dry matter (DM) (*Russula cellulata*). *Schizophyllum commune* and *Amanita loosii* differ significantly from the others. Indeed, the former is very poor in lipids

Table III. - Fatty acids content of lipids of 12 edible mushrooms harvested in miombo woodland, Copper belt Province, Zambia (results in % of dry weight)
Teneur en acides gras des lipides de 12 champignons comestibles récoltés en forêt claire de type miombo, Province de la Copperbelt, Zambie (résultats en % du poids sec)

	N° 1	N° 2	N° 3	N°4	N° 5	N° 6	N° 7	N°8	N° 9	N° 10	N° 11	N° 12
% Lipids/D.M.	**4.91**	**5.35**	**5.18**	**4.77**	**3.45**	**4.10**	**4.64**	**5.52**	**5.13**	**10.66**	**5.49**	**1.57**
C 14	0.4	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND
C 15	1.6	1.0	1.2	ND	ND	ND	ND	ND	0.2	ND	ND	ND
C 16	15.9	13.1	17.9	15.0	18.3	20.8	19.5	15.4	20.1	18.1	13.6	15.6
C 16 :1	6.9	1.5	1.3	0.7	0.7	0.6	2.2	0.5	1.4	0.3	0.8	1.4
C 17	0.3	2.6	0.3	0.3	0.3	ND	0.3	0.4	0.3	0.1	0.2	0.4
C 18	9.6	6.7	5.9	3.4	3.9	5.2	6.5	5.6	7.8	7.3	2.9	4.9
C 18 :1	25.6	40.1	19.7	9.5	40.5	44.5	46.5	24.4	26.3	47.1	30.1	15.3
C 18 :2 (EFA)	**30.9**	**26.6**	**39.8**	**59.9**	**26.6**	**21.9**	**15.1**	**52.5**	**41.4**	**25.2**	**46.5**	**52.8**
C 18 :3 (EFA)	ND	ND	ND	1.7	2.0	1.5	0.9	ND	0.2	ND	ND	4.0
C 20	ND	ND	ND	ND	ND	ND	1.1	ND	ND	0.6	0.2	ND
C 20 : 1	0.3	0.4	ND	ND	ND	ND	0.3	0.3	0.3	ND	ND	0.3
NI 1	0.4	ND	2.3	0.3	ND	ND	ND	ND	ND	ND	1.3	ND
NI 2	4.1	4.4	7.6	8.7	ND	ND	ND	ND	ND	ND	0.6	ND
Sum of identified FA	91.4	92.0	86.3	90.5	92.2	94.5	92.4	99.0	97.9	98.6	94.3	94.6
	8.6	8.0	13.7	9.5	7.8	5.5	7.6	1.0	2.1	1.4	5.7	5.4
Saturated	27.8	23.4	25.5	18.7	22.5	26.0	27.3	21.4	28.4	26.1	17.0	20.9
Mono-unsaturated	32.8	42.0	21.0	10.2	41.2	45.0	49.1	25.1	28.0	47.4	30.9	16.9
Poly-unsaturated	30.9	26.6	39.8	61.6	28.6	23.4	16.0	52.5	41.6	25.2	46.5	56.7
Pol/Sat (**)	**1.1**	**1.1**	**1.6**	**3.3**	**1.3**	**0.9**	**0.6**	**2.4**	**1.5**	**1.0**	**2.7**	**2.7**

N° 1: *Cantharellus* cf. *contortus*	N° 5: *Lactarius edulis*	N° 9: *Termitomyces microcarpus*
N° 2: *Cantharellus ruber*	N° 6: *Lactarius* sp. 1	N° 10: *Amanita loosii*
N° 3: *Cantharellus rufopunctatus* var. *ochraceus*	N° 7: *Lactarius* sp. 1	N° 11: *Russula celluata*
N° 4: *Cantharellus symoensii*	N° 8: *Termitomyces clypeatus*	N° 12: *Schizophyllum commune*

(1.6 g 100 g-1 DM) whereas the total lipid amount in the latter reaches 10.6 g 100 g-1 DM. These results confirm those previously published by PARENT & THOEN (1978) on edible mushrooms from Upper-Shaba (Democratic Republic of Congo). As shown in Table III, six to eleven different fatty acids - depending on the species - were identified on the basis of their chromatographic retention data. Among these, palmitic, oleic and linoleic acids predominate. Nevertheless, their relative proportions reflected by the PolyunSaturated Fatty Acids / Saturated Fatty Acids ratios (PUFAs/ SFAs) vary in function of both the genus and the species. From a nutritional point of view, 6 fungal species (*Cantharellus cf. contortus, C. ruber, Lactarius edulis, Lactarius* sp.1, *Lactarius sp.*2 and *Amanita loosii*) are characterized by PUFAs/ SFAs ratios close to the values generally recognized as good

Table IV.- Mineral composition of 12 edible mushrooms harvested in miombo woodland, Copper belt Province Zambia (results in % of dry weight)
Teneur en minéraux de 12 champignons comestibles récoltés en forêt claire de type miombo, Province de la Copperbelt, Zambie (résultats en % du poids sec)

	Chantarellus cf. *contortus*	*Cantharellus ruber*	*Cantharellus rufopunctatus* var. *ochraceus*	*Cantharellus symoensii*	*Lactarius edulis*	*Lactarius sp. 1*
Na	0.007	0.020	0.008	0.006	0.004	0.015
K	3.700	4.890	4.07	4.040	2.920	3.230
Ca	0,008	0.030	0.006	0.007	0.005	0.013
Mg	0,106	0.120	0.108	0.103	0.069	0.095
Fe (mg/kg DM)	752	660	898	483	236	252
Mn (mg/kg DM)	31	35	27	34	16	16

	Termitomyces clypeatus	*Termitomyces microcarpus*	*Amanita loosii*	*Russula celluata*	*Schizophyllum commune*
Na	0.09	0.023	0.010	0.007	0.015
K	2.270	1.90	4.070	3.330	0.890
Ca	0.016	0.120	0.027	< 0.005	0.049
Mg	0.132	0.158	0.105	0.090	0.122
Fe (mg/kg DM)	95	1100	483	169	1470
Mn (mg/kg DM)	33	131	34	26	42

Table V.- Calorific value of 12 edible mushrooms harvested in miombo woodland compared with mainfood stuffs consumed in Copperbelt

Valeur calorifique de 12 champignons comestibles récoltés en forêt claire de type miombo comparée avec celle des aliments principaux en Province de la Copperbelt, Zambie.

Species	Energy
Cantharellus cf. contortus	1634
Cantharellus ruber	1723
Cantharellus rufopunctatus var. ochraceus	1583
Cantharellus symoensii	1548
Lactaria edulis	1853
Lactarius sp 1	1883
Lactarius sp. 2	1857
Termitomyces clipeatus	1886
Termitomyces microcarpus	1558
Amanita loosii	1994
Russulata cellulata	1910
Schizophyllum commune	1519
Chicken[1]	2583
Groundnut[1]	2552
Maize[1]	1484

[1] Favier et *al.* 1995

(0.5 - 0.8) for human consumption. The higher proportion of linoleic acid in the 5 other mushrooms is depicted by ratios reaching 3.3.

In all *Cantharellus* species we systematically detected 2 additional fatty acid methyl esters (NI1 and NI2, Table III) eluted just after the eicosenoïc homologue. The most important of these 2 molecules has already been reported - but tentatively identified - by PARENT & THOEN (1978) who proposed a C20:2 (eicosadienoïc) structure. Careful GC-MS re-examinations in the Electron Impact mode at 70 eV have highlighted that both unknown molecules belong to the acetylenic fatty acid series. The interpretations of the fragmentation pattern of NI2 have led to the conclusion that it corresponds to an octadiynoïc fatty acid methyl ester. This acid could be tentatively attributed to the dehydrocrepenynic acid (cis-9, cis-14 diene-12yne-octadecanoic acid) which was already identified in the Cantharellus species (Hiroi & Tsuyuki 1992). The position of the two triple bounds has not yet been determined. The purification and determination of the complete structure of this molecule are in progress.

As far as mineral content is concerned (Table IV), we note high levels for K and Fe and low values for Na and Ca.

The low calorific values listed in Table V confirm that mushrooms can not be considered as energizing foodstuffs but only as a supplementary contribution to the total diet.

Ethnomycological and Socio-Economical aspects

As frequently reported in tropical Africa, women and children are the traditional mushroom pickers in the Zambezian area (THOEN *et al.* 1973, OGUNDANA 1978, BUYCK & NZIGIDAHERA 1995, DEGREEF *et al.* 1997). They often gather in restricted family groups to avoid the disclosure of the most productive places. After each harvest, mushrooms are either offered for sale or are directly prepared for immediate consumption. Some women prefer to store them. Apart from road stalls, high quantities of mushrooms are sold on urban markets. Several women, busy in the wild products trade cover long distances with the hope to sell their goods in town. Motorized transports are rare in the region and very expensive for the villagers who rely upon this transport for their agricultural products. Nevertheless, this trade allows to generate a significant income. Indeed, in Upper-Shaba, DEGREEF et al. (1997) observed a progressive price increase from rural area to town. In the Copperbelt Province, we noticed also a similar price increase around the three cities of Kitwe, Ndola and Luanshya.

Before consumption, mushrooms are immersed in water in order to eliminate mud and dust soiling the sporophores. With some species of *Termitomyces* and *Amanita,* the stipe is cut in reason of its very tough texture or because of the infestation by various organisms such as grubs, coleoptera, etc... A traditional preparation consists in scalding fresh mushrooms for a few minutes. Dried mushrooms will first be rehydrated in water or milk for several hours. Then, women fry the mushrooms in oil, with groundnuts. Tomatoes, onions, egg-plants, pumpkins and corn pastry will accompany this delicate food. A few suggestions for the cooking of mushrooms have also been given by PIEARCE (1981a) for Zambia, and by BUYCK (1994b) for Burundi.

Wild mushrooms also play an undeniable cultural role. Some edible species and even some genera are systematically discarded according to some believes. Reported from generation to generation, diverse myths and legends around some fungal species account for this attitude and incite pickers to be careful during the harvest. In Zambia, *Termitomyces*, as elsewhere in tropical Africa (OSO 1975, 1977, HEIM 1977, OGUNDANA 1978, PIEARCE 1981, BUYCK 1994b), predominate in the local folklore. PIEARCE (1981) has given a detailed account of customs and folklore for Zambia.

DISCUSSION

Most of the wild edible mushrooms collected in the Zambian miombo woodland are ectomycorrhizal (Table 1). The mycorrhizal fungi basically serve as an extend of the plant root system, exploring soil far beyond the reach of the roots and transporting water and nutrients to the roots. In return, the plant is the primary energy source for the fungus, providing simple sugars and vitamins produced in photosynthesis and transported to the roots and then the fungus. When trees are harvested, these mycorrhizal fungi die and do no longer produce sporocarps until the new forest is well established (MOLINA *et al.* 1993). Excessive deforestation and woodlands degradation will entail a rarefaction of these mycorrhizal fungi and an upset of the whole ecosystem.

The period of edible sporocarps occurrence depends upon climatic conditions (mainly temperature and rainfalls) and is closely related to the rainy season. During the rainy season, i.e. from November to April, fungi do not appear at random, but according to a calendar output related to each species phenology. Although differences may occur related to particular climatic conditions. Nevertheless, it is possible to establish sporocarps occurrence sequences for several fungal species. These sequences can be explained as they are connected to the soil hydratation of the diverse plant formations (MALAISSE & KAPINGA 1987). Some species, for instance *Cantharellus spp.*, can start growing only when the soil is sufficiently moistened. The existence of an emergence sequence of wild fungal species throughout the season has already been brought to the fore in Burundi (BUYCK 1994b) and in Southern Shaba (DEGREEF *et al.* 1997). As BUYCK (1994b) pointed out for Burundi, some species do no more appear just after the small dry season in January or February, whereas other species are still observed in the same period but in small quantity. Our study completes the data available for the Zambezian region by reporting the phenology sequence of 11 never quoted taxa.

To the authors' knowledge, the literature dealing with the chemical composition of edible species from African areas is limited (CHINN 1945, ADRIAENS 1953, KIGER 1959, VUJIVIC & VUJIVIC 1971, THOEN & PARENT 1973, PARENT & THOEN 1977, 1978, ALIAN & MUSENGE 1978, OGUNDANA & FAGADE 1982, MBEMBA & REMACLE 1992, ADEWUSI et al. 1993, DEGREEF *et al.* 1997).

Edible mushrooms analysed have a low N content. This is in agreement with data obtained by CHINN (1945), ADRIAENS (1953), KIGER (1959), PARENT & THOEN (1978) and DEGREEF *et al.* (1997), considering that we have used a conversion factor from nitrogen to protein equal to 4.38.

Regarding our results, chemical composition similarities were determined for *Cantharellus* species, notably the specific presence of two fatty acid methyl esters (NI1 and NI2). The interpretations of the fragmentation pattern of NI2 have led to the conclusion that it corresponds to an octadiynoïc fatty acid methyl ester. The occurrence of this octadiynoïc acid could be used as a chemotaxonomic feature, typical of the *Cantharellus* genus. Additional studies are needed to confirm this hypothesis.

If, from a calorific point of view, edible mushrooms do not play an essential role in human diet, and although their total protein level seems to indicate a secondary role, the relative importance of minerals, vitamins (ALIAN & MUSENGE 1978) and several essential amino acids contributes to value mushrooms as good qualitative food supply, especially when considering the time of the year they can be relied upon. Indeed the main harvest period coincides with the starvation months.

Mushrooms trade allows some villagers to generate an essential income. A study undertaken in several Copperbelt villages (BOURDEAUX 1996) shows the population's vulnerability to the nutritious security problem, particularly during the second half of the rainy season. This bad time of the year corresponds to an important turning point in the rainy season as most of the land is still under cultivation at the vegetative stage. In this context, local communities managed to find some alternatives to provide for their needs : apart from the wild mushrooms trade, they market mainly charcoal and sweet beer. In some Zambian villages, edible macromycetes sale represents the main income source for households during the rainfall period. However, the progressive destruction of the woodland ecosystem, which today seems ineluctable on the outskirts of the Copperbelt mining towns, inevitably induces a rarefaction of these wild foodstuffs.

Finally, it is interesting to point out the growing interest of industrialized countries for this product. Exportation of African fresh fungal species could be growing on the European Market in coming years, notably according to the fact that the supply period coincides with the European winter.

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