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Studies on some edible wild mushrooms from Nigeria: 1. Nutritional, teratogenic and toxic considerations

S.R.A. ADEWUSI[1]*, F.V. ALOFE[2], O. ODEYEMI[2], O.A. AFOLABI[1] & O.L. OKE[1]

[1]*Department of Chemistry and* [2]*Department of Microbiology, Obafemi Awolowo University, Ile-Ife, Nigeria* (**author for correspondence*)

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Abstract. The biological value of 5 mushrooms *Chlorophyllum molybditis, Psathyrella atroumbonata, Termitomyces robustus, Termitomyces striatus* and *Volvariella esculenta* from our collection of wild edible mushrooms were determined using weanling rats. *C. molybditis* supported rapid growth with PER (2.63) higher than the casein control (2.50). *P. atroumbonata* was average in biological performance (PER 1.50) while *T. robustus* and *V. esculenta* did not support growth at all. Rats on *T. striatus* dried at 60 °C for 48 h lost weight rapidly and showed pathological signs of toxicity by the second day. All rats on this diet died by the fourth day of the experiment. When the diet of *T. striatus* dried at 90 °C for about 8 h was fed, the rats gained weight marginally but all survived. Prolonged storage of *T. striatus* at 60 °C for 5–8 weeks also seemed to detoxify the poisonous component such that PER and NPR values were 0.8 and 2.0 respectively. 2 pairs each of adult rats fed *C. molybditis* and *Tricholoma lobayensis* diets for 10 days were mated. Rats of *C. molybditis* diet gave 5 and 6 litters each and only one of these litters seemed to have retarded growth. Rats on *T. lobayensis* diet did not produce any litters for 14 weeks but the female produced off-spring when mated with control male rats.

Introduction

Mushrooms are fast becoming a delicacy in Nigeria and other West African countries though they are still not cultivated on a commercial scale. In the villages where mushrooms abound, edible varieties are recognised by inspection but where there is any doubt, the mushrooms are first fed to chicken and/or other animals and, if they are refused by the animals, the mushrooms are assumed toxic.

Mushrooms are not only of nutritional significance to Nigerians, they are also considered for their religious and medicinal importance. Mushrooms such as *Plerotus tuber-regium* are used by the traditional healers in curing such ailments as headache, fever and cold while others like *Termitomyces robustus* and *T. striatus* are used as pot herbs. Another mushroom *Phalius*

aurantioca is used to ward off the evil spirit in some parts of Nigeria [Oso 1976, 1977].

Most of the reports on Nigerian wild mushrooms to date were descriptive [Alasoadura 1968, Zoberi 1972, 1973, Oso 1975, 1976]; but a few reports on the nutritive value have emerged [Oke 1966, Ogundana and Fagade 1982, Oso 1977]. Since these reports are brief and limited in scope, the present study has been designed to look at the nutritional value as well as some toxic parameters of a wider number of Nigerian mushrooms.

Materials and methods

In this report, 6 species that proved interesting from preliminary investigations [Alofe 1987] were studied. *Chlorophyllum molybditis*, *Psathyrella atroumbonata*, *Termitomyces robustus*, *Termitomyces striatus* and *Volvariella esculenta* were investigated for their nutritional value while *C. molybditis* and *Tricholoma lobayensis* were assayed for their effect on the reproductive system.

Materials

Mushroom samples were collected from various locations in Nigeria, cleaned in the laboratory and dried at 60 °C to a constant weight. The dried samples were homogenised using a Waring blender and stored at room temperature until used (within 1 week). Due to an error, a batch of *T. striatus* was dried at 90 °C for about 8 h while in another experiment the milled sample of *T. striatus* was kept at 60 °C for 5–8 weeks to prevent moisture absorption.

Animal experiment

Weanling litter-mate rats of the Wistar strain from our colony were collected at about 28 days of age, weighing 35–40 g and housed individually in screen-bottomed cages. They were fed the standard diet for 48 h during which period the animals became acclimatized to the cages. The rats were starved for 24 h thereafter and put on individual diets as shown in Table 1. The mushrooms supplied 10% protein in the diet. The other processes were carried out as previously described by Adewusi and Oke [1980]. Four rats per treatment were used and the experiment repeated once. *In vitro* digestibility was carried out by the method of Saunders et al [1973].

Nitrogen was determined by Kjeldahl's digestion method.

Table 1. Composition of the various mushroom diets and casein (control)

Component	% crude protein	Protein free diet	Casein diet	*C. molybditis* diet	*P. atroumbonata* diet	*T. robustus* diet	*T. Striatus* diet	*V. esculenta* diet
Glucose	–	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Corn starch	–	54.8	41.8	–	31.8	25.4	23.5	19.8
Casein	77.0	–	13.0	–	–	–	–	–
C. molybditis	31.4	–	–	31.7	–	–	–	–
P. atroumbonata	38.5	–	–	–	26.0	–	–	–
T. robustus	30.9	–	–	–	–	32.4	–	–
T. striatus	29.2	–	–	–	–	–	29.2	–
V. esculenta	26.3	–	–	–	–	–	–	38.0
Rice bran	–	5.0	5.0	2.0	2.0	2.0	2.0	2.0
Vitamin Mix[1]	–	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Salt Mixture[2]	–	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Palm-Oil	N.D.[3]	5.0	5.0	5.0	5.0	5.0	5.0	5.0

[1] Vitamin Mix is avicron E commercial product with the following composition/kg Vit. A 5 000 000 I.U. Vit. B_2 6 000 mg, Vit. B. 5 mg, Vit. C 20 000 mg, Vit. K 1 000 mg, Nicotinic acid 15 000 mg, d-panthothenic acid 7 000 mg, Tetracycline 40 000 mg and Erythromycin 20 000 mg.

[2] Grams per kilogram of salt mixture $CaCO_3$ 207; $CaUPO_4$ 323: $NaHP_4$ 186; KCl 208.6; $MgSO_4$ 65.7; $MnSO_4.H_2O$, 4.4; $CuSO_4$ 0.37; Ferric citrate 4.3; $ZnCO_3$ 0.6; KIO_3 0.03.

[3] ND, Not determined.

Table 2. Result of animal assay

	N consumed	PER	NPR	% *in vitro* digestibility
Casein Standard	7.61	2.5 ± 0.4	3.6 ± 0.5	98.6
C. molybditis	8.52	2.6 ± 0.9	3.8 ± 0.9	92.1
P. atroumbonata	5.72	1.5 ± 0.3	2.5 ± 0.4	86.5
T. robustus	7.67	−0.2 ± 0.4	0.8 ± 0.4	87.6
*T. striatus**	7.86	0.8 ± 0.5	2.0 ± 0.6	89.4
V. esculenta	7.82	−1.0 ± 0.3	1.1 ± 0.4	88.4

* *T. striatus* dried and stored at 60 °C for 5–8 weeks or dried at 90 °C for 8 h.

Effect on Reproduction

Two pairs of rats (2 males and 2 females) each were put on diets of *C. molybditis* and *T. lobayensis* at 10% protein level for 10 days. The rats were put back on the stock diet and mated. Each of the litters was examined for congenital problems some hours after birth and thereafter every week for 3 weeks.

Results

The result of the feeding trials presented in Table 2 showed that rats on *C. molybditis* diet grew rapidly and had a protein efficiency ratio (PER) of 2.63 better than (though not significantly) the casein control (2.50). Net protein retention (NPR) value of 3.75 was also higher than 3.64 recorded for the standard casein diet. Animals on *P. atroumbonata* diet were able to grow moderately (PER 1.5, NPR 2.5) yet one of them lost weight and died on the 11th day of the experiment while another lost considerable weight (17.2 g) indicating the possible presence of toxic factors in the mushroom. Rats on *T. robustus* and *V. esculenta* recorded a negative PER of 0.2 (± 0.4) showing that some animals on the diet marginally lost weight while others gained weight of the same magnitude. NPR data 0.8 and 1.1 respectively, however, showed that the 2 mushrooms could provide enough protein for maintenance. During the period of the experiment one rat on *T. robustus* diet died (day 12) having gained 1.84 g weight before its sudden death.

Animals on *T. striatus* gave interesting results. Rats fed *T. striatus* dried at 60 °C, lost weight rapidly and by the second day, the eyes of most of them were almost or completely closed.

They were weak and could hardly move their tails. They were nervous and jumpy whenever the cage was touched, they would jump into the air and land on their backs, then try to sit on their hind limbs, shivering. They could hardly move about on their forelimbs, and the hindlimbs seemed paralysed. One of the rats died on the third day and the rest on the 4th day of the experiment.

When *T. striatus* was dried at 90 °C for about 8 h or stored at 60 °C for several weeks, the animals on these diets gained weight marginally to record a PER around 0.8 and NPR of 2.0. Most important was the fact that no animal died on these 2 diets. The digestibility, determined by *in vitro* analysis was high-ranging from 86.5 to 89.4% for all the mushrooms indicating that probable toxicity of the mushrooms could not be due to lack of digestion.

Two pairs of rats fed *C. molybditis* for 10 days and mated produced 5 and 6 litters each after 14 weeks but one of them appeared retarded because the eyes opened 3 days later than the others and body hair growth was delayed for two weeks. Animals fed *T. lobayensis* diet did not produce any litter even after 14 weeks of mating. The male rats seemed to have been affected by the diet rather than the female. When the test male rats were replaced by rats on control diet, they produced normal litters whereas when the male on *T. lobayensis* diet was mated with a female on the control ration, no litters were produced.

Discussion

There is no doubt that *C. molybditis* is high in protein (CP = 31.4%), and is a very good source of protein with a PER higher than that of casein. As its local name in Yoruba 'a jegba'ariwo-orun' (eat and hear voices from-heaven) implies, this mushroom probably has hallucinogenic effect comparable to 'LSD'. This seemed to be confirmed by the voracious manner the rats ate the rations of *C. molybditis* as well as their extremely wild movements and aggressive behaviour. The presence of hallucinogens in mushrooms is not new; hallucinogenic substances such as Psilocin and psilocybin have been extracted and identified in *Plerotus salicinus* [Saupe 1981]. Animals on *P. atroumbonata* diet grew moderately well, this mushroom has a high crude protein content (38.6%) and high *in vitro* digestibility (86.5%). Its average performance, therefore, cannot be due to low protein content or indigestion. The possibility exists that toxic constituents are also present in this sample. The *P. atroumbonata* diet was not well consumed which might also indicate lack of palatability.

Termitomyces robustus and *Volvariella esculenta* diets did not support growth at all despite their high CP content (30.9 & 26.3% respectively), high digestibility (87.6 & 88.4%) and high intake by the animals.

The failure of these 2 mushrooms to support growth was probably due to toxic factors. Diets containing *T. striatus* proved to be very toxic since all the rats died within 4 days. From the general observations of the rats on this ration, it can be inferred that *T. striatus* contained some very toxic

substance(s) which on ingestion can cause partial paralysis from the waist down in rats. The loss/reduction of the potent factor and improved PER when heated at 90 °C for 8 h or during prolonged storage at 60 °C showed that the toxic factor is probably heat-labile. This idea was reinforced by the fact that the cooked form of this mushroom is generally consumed by Nigerians during the rainy season and no case of food poisoning as a result of its consumption has been reported. Rofalski et al. [1968] have however reported the death of rats fed field agaric rations for 5 days as a result of liver necrosis. Preliminary phytochemical screening showed that all the species tested contained appreciable amounts of alkaloids with *T. lobayensis* and *V. esculenta* containing higher concentration of the alkaloid in their pilei compared to the stipes. Some of the alkaloids present may be toxic especially in *T. striatus*. Mushrooms such as *Gyromitrin esculenta* (false morals) have been reported to contain gyromitrin, a lethal alkaloid which has been found to be extremely toxic when consumed raw [Pyssalo and Niskanen 1976]. In addition to the presence of alkaloids, tannins are also present in the pilei of *C. molybditis*, *P. atroumbonata*, and *V. esculenta* whereas it is present abundantly in *T. robustus*, *T. striatus* and *Tricholoma lobayensis*. Tannins are known to retard growth through reduced digestion and/or absorption [Laurena et al 1984] and can also be lethal within a few days above a concentration of 2% [Osuntogun 1984]. The possibility of a synergistic effect between the alkaloid and tannins present in the mushrooms especially in *T. striatus* cannot be ruled out. Apart from alkaloids and tannins, some mushrooms are known to contain compounds like alpha and beta amanitin which belong the group of deadly toxins called amatoxins that have been implicated in partial paralysis and death of dogs that consume *Amanita pantheria*, a mushroom that contains these toxins [Hunt and Funk 1977].

The fact that one out of eleven litters produced by *C. molybditis* fed rats showed symptoms of retarded growth raises the possibility that *C. molybditis* may also contain growth retardants in addition to containing hallucinogens. Animals fed *T. lobayensis* failed to produce litters after mating for 14 weeks. The female rats could produce litters when mated with control male rats but male rats fed *T. lobayensis* could not produce offspring when mated with control female animals. This tends to show that the toxic factor in *T. lobayensis* seems to produce sterility in males. These results have wide nutritional and toxicological implications. It is therefore recommended that these mushrooms should be consumed sparingly if total abstenance is not possible until further research into detoxification process is completed.

Work is in progess on the isolation, identification of the alkaloids in these mushrooms and their possible pharmacologic role in animals.

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