J. Mycopathol. Res. **28**(2) : 97-109 (1990). *Printed in India.*

Ethnobotanical and chemical nature of hallucinogenic mushroom, *Amanita muscaria* (L. ex Fr.) Hook.

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The history of hallucinogenic mushroom, *Amanita muscaria* along with its morphological and diagnostic features were described. The chemical constituents of this mushroom was also reported.

Key words : Ethnobotany, Chemical nature, Hallucinogenic mushroom, *Amanita muscaria*

Hallucinogenic species occur among the highest evolved flowering plants (angiosperms) and in one division (fungi) of the simpler plants. They are rich in bitter tasting alkaloids which have a wide range of physiologic activity including teratogenic and toxic effects (Siegel 1984).

The history of hallucinogenic mushroom and their role in religious rites and ceremonies of primitive cultures is quite long and interesting These fungi played more than a minor role in structuring the lives, beliefs, hopes and values of a large number of people of preindustrial societies (Dobkin de Rios 1984).

From early uses by primitive peoples to later experimentation, hallucinogens followed a natural path dictated by certain chemical properties and behavioural possibilities. The word hallucinogen is defined as substances capable of producing hallucinations. Hallucinations in turn is derived from latin *alucinatio*, meaning a wandering mind, idle talk, prating. Certain extracts of *Amanita muscaria* are probably the oldest known hallucinogenic drugs, although their use for intoxicating purposes is virtually restricted to the tribes of northern Siberia. Rituals, magic, religious or medicinal uses of these drugs date back into the early history of

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both old and new world peoples (Wasson 1968). Folklore and mythology are replete with example of man's discovery of these hallucinogens.

In this paper attempts have been made to investigate the following aspects viz, (a) History of the use of hallucinogenic mushroom, *Amanita muscaria*, (b) The morphological and diagnostic features of *Amanita muscaria*; (c) The active principles of *Amanita muscaria* and (d) Nature and effects of the chemical constituents of *A. muscaria*.

(a) *History of the use of Amanita muscaria*

Amanita muscaria is commonly called as Fly-agaric. The name Fly-agaric is derived from insect killing properties of the mushroom, although its action is poor in comparison to modern insecticides and is more in nature of a temporary stupefaction. This fungus is perhaps man's oldest hallucinogen. The native peoples of Asian forest and tundra regions in Siberia, who employ fly-agaric in shamanistic practices, have observed their reindeer browsing the mushrooms. This browsing results in the reindeer becoming unmanageable and suffering profound mental disturbances. The natives may have copied this behaviour only to discover the hallucinatory effects they later employed in their shamanism (Wasson 1968). The best known Siberian tribesmen who used the mushroom were the Chukchee, the Koryak, the Kamchadal and the Yukagir. The fly-agaric were collected during the month of August when the caps were in bloom Only young girls could gather the plant and dry it. The Koryaks did not eat the mushroom fresh because they feared its toxic effects so they dried the mushroom in the sun first. Women were not permitted to eat the mushroom, although they were required to chew it and keep the quid in their mouths for a long time without swallowing it (Jocelson 1905, and Bogoras 1910). The mushroom causes the user to exhibit great physical movements, which may be the source of the so-called ecstatic states of Siberian Shamanistic seances. Before Siberians entered shamanic trances, they often consumed the mushroom. Many of the data on fly-agaric, in fact, give us insight into traditional shamanic concepts, a large number of which are considered native to the Siberian peoples. The Koryaks in Siberia were urine drinkers. They discovered that the active principles of fly-agaric are excreted unchanged in the urine and practiced saving their postmushroom urine for additional intoxications. As a result, men waited outside a house where the plant was being consumed in order to collect the urine of a user in a special wood container. The process was repeatable for five cycles before the drug began losing its potency. The fly-agaric mushroom has been used in several defferent ways of the Siberian reindeer herdsmen, generally by tribal elders (Jocelson 1905). The mushroom was used

to diagnosis the case of illness, to divine the future, to facilitate communication with the supernatural, and for enjoyment on festive occasions such as weddings, when it was offered to guests. Sometimes, when fly agaric was consumed, people asked questions of the person under the plant's intoxication, which he may have answered sensibly. The answers were based on the imbibers visions. The Koryaks believed that the mushroom was endowed with particular power and the harmful beings, called *nimvits*, were believed to be controlled by Shamans after consuming the mushroom. Communication with these beings took place only at night, in total darkness, by the use of the plant. After the Shaman consumed the mushroom, he fell into a trance. When the Shaman awoke he would relate his visions to those around him, often reporting that he entered the next world and arranged meetings with dead kinsmen who instructed him. However, all men could eat the mushroom, whether or not they were Shamans, to find out why they might be ill, to explain a dream, or merely to reveal aspects of the upper or lower universe. The Koryak believed that when a person is intoxicated by the plant, he does what the spirits who reside within the plant tell him to do (Wasson and Wasson 1957).

The Chukchee believed that the mushrooms actually constituted another "tribe". Intoxication brought to the user visions in the form of men (Bogoras 1910). Among the Yurk Samoyed, the forest magicians knew the custom of eating fly-agarics when they were dry and fully grown. Like the Chukchee, these people reported man-like creatures who appeared before them in a dream.

Among the Ugrian fold peoples, when the mushrooms were eaten in an ordinary manner various precautionary rules were invoked because of their toxicity. However, when a Shaman eats the mushroom, the act takes on cultic significance. This is so because by eating the mushroom the Shaman creates helpers for himself. Among the Vasyugan tribe, music played an important part in the mushroom ritual. Magicians under the intoxication by the mushroom attempted to communicate with the spirits and obtain the information they needed in divining the future. Another Siberian tribe, the Ostyaks, had different types of fly-agaric ceremonies. A hut was filled with smoke of a resinous tree bark. A Shaman took three to seven fly-agaric caps, after fasting all day, and then slept for a while. Afterward he rose, shouting, walking about, his body trembling with excitement, to report what the spirits were revealing to him through his emissaries. The mushroom told him which spirit would be propitated, how to regain good luck, and so forth. After these emissaries had told everything and left the Shaman would sink into deep sleep until morning (Wasson and Wasson 1957). In olden days, Siberian Shamans used to appear in complete animal disquise, with fur covering their bodies and antlers on their heads. Such symbolic dress may have signified the debt of the Shaman to the humble reindeer,

whose delight in human urine may have been the vehicle through which knowledge about augmenting drug effects in human beings was acquired (Dobkin de Rios 1984). Wasson (1972) has propounded a compelling thesis that the legendary *soma* (the god-narcotic of ancient India) described and deified in Sanskrit texts (Vedas) of the second millenium B. C., was in fact *Amanita muscaria.* Of the 1028 hymns of the Vedas, 120 are focused on the plant god soma. But the use of this plant and subsequently its very identity, faded with time. Numerous speculations have been made as to its identity, ranging from Cannabis to the ephedrine-containing herb mahuang. These speculations were obviously casual and made little or no attempt to match these substances with Vedic descriptions of soma (McDonald 1978). According to Wasson (1968) the material that is soma should be small and leafless with fleshy stalks. Its preparation should require only a day, or at most a few days. Perhaps most significantly, it should have rather unique characteristic that its active ingredient passes into the urine of the user, so that another person may obtain similar experiences by drinking that urine. *A muscaria* fits the Vedic descriptions of soma in all these details. Moreover ceremonial urine drinking is also mentioned in the Rig-Veda. The significance of this argument, if it is true, is that one of the largest of the world's religions may be a direct outgrowth of the use of an hallucinogenic drug. This argument has been favourably received by many anthropological authorities (La Baree 1972). Despite the impressiveness of the anthropological and linguistic evidence presented by Wasson (1968), there are some weak links in the theory. First, how a drug of this sort, so often described in the most ecstatic terms could have fallen so completely into disuse and its very identity have been forgotten ? In only a few regions of the world today is it still in use, primarily by primitive tribes in Siberia. The first post-Vedic published reference to its continued use in that region was made in 1730 by a swedish army officer who spent 12 years there as a Russian prisoner of war (Wasson 1968), and only long after this was the use of *A. muscaria* generally recognised. Second, apparently quite different descriptions of the mushroom's psychological effects exist. If one accepts the identify of *A. muscaria* as soma, one might well wonder why it apparently achieved little popularity in the many other parts of the world where it commonly grows (Mc Donald 1978). There is some question about how the mushrooms were originally used. Wasson (1968) indicated that they were usually either eaten raw or squeezed, mixing the juice with water, milk, curds, or honey. There are also Vedic references to their being dried and eaten either dry or after soaking in water. According to Brekhman and Sam (1967) *Amanita muscaria* is normally ingested in the natural state. It is either swallowed whole in a slightly desiccated condition or drunk in an infusion after soaking for 5 or 6 days in water which are sometimes taken with *Epilobium angustifolium* The exact method of preparation is unknown and other drug additives may at least occasionally have been used. The usual suggestions as to

the quantity are rather vague, referring to a mushroom, one or two mushrooms, or several mushrooms. The ancient Chinese drug of immortality, *Chih*, may have been the same. The remnants of Fly-agaric shamanism followed the early settlers as they crossed the Bering Strait into the Americas, as a result, it is not surprising that religious use of this mushroom has been found among the native Indians in north western Canada and on Lake Superior of Michigan (Schultes and Hofmann 1979) Use has also been suspected among the maya of highland Guatemala, who refer to its scared power as'evil or diabolical mushrooms' (Schultes and Hofmann 1979). *Amanita muscaria* is normally ingested in the natural state (Brekhman and Sam 1 67 ; Wasson 1972). It is swallowed whole in a slightly desiccated state. Other methods use infusions, after soaking for five to six days in water, which are sometimes taken with *Epilobium angustifolium*, the French willows ; the latter mixture is boiled to produce a thick, sweet liquor to which, in modern times, underproof vodka is often added.

Amanita muscaria is the most notorious member of the poisonous *Amanita* genus although several other members are considerably more toxic. Toxicity is related to the presence of peptidic toxins, however it is interesting that *Amanita citrina*, the yellow mushroom, contains bufotenin and other hallucinogenic indoles (Wieland 1968) but there is no evidence that this mushroom has ever been used for intoxicating purposes, while early reports of the presence of bufotenin in *Amanita muscaria* have now been largely discounted (Eugster 1969).

(b) *Morphological Characters*

Habitat—Widespread throughout the world except for the tropic zones, growing preferably under fir or beech trees.

Habit-mycorrhizal

Fruitbody—15-25 cm in height and an average specimen weighs 60-75g, young one appear as eggshaped cap with maturity the cap bursts open the outer shell and the surface becomes brilliant red with the residue which remains as white spots irregularly distributed over it.

Pileus—8-25 cm in diameter, convex to flattened in mature specimens, viscid, orange to bright red in colour and ornamented with white warts (remnants of white universal veil) scattered all over the pileus surface but more concentrated at the centre, with maturity the colour slightly fades to yellowish and the warts mostly disappear ; flesh-firm, white throughout.

Gills—white, crowded, free, broad with minutely hairy edges.

Spores—subglobose, thinwalled, white in print, no amyloid reaction, 9—12×7—10 μm.

Annulus—concentric, pendulous, white.

Stipe—8-20 cm long, 18-30 mm thick enlarging (bulbous) towards base, white to pale yellow.

Volva—white, membranous, in mature fruit bodies the only remains of volva are 2 or 3 concentric rings.

Diagnostic features of Amanita muscaria

Family	Amanitaceae	C.J. Shepherd, C.T. Totterdoll (1988)
Botanical name	*Amanita muscaria* (L. ex. Fr.) Hook	Wasson (1972)
Common or native name	Fly agaric, soma	
Native area of growth	Asia, Europe Africa and Central America	Siegel (1984) Brimblecombe and (1975)
Active Principles	Muscimole, Ibotenic acid and Muscazone	Eugster (1967)
Onset of symptoms	30 min - 2hour	Lincoff and Mitchel (1977)
Common symptoms	Dizziness, uncoordination, staggering (intoxication) ; muscular cramps and spasms ; hyperkinetic activity ; comalike deep sleep and "visions"	Lincoff and Mitchel (1977)
Treatment and duration of recovery	Physostigmine O.5-2 mg slowly i.v. repeated hourly as needed for anticholinergic symptoms. Do not give atropine unless definite cholinergic symptoms are present. Recovery in 4-24 hours.	Lincoff and Mitchel (1977)

(c) *The Active Principles of Amanita muscaria*

The parasympathetic stimulant muscarine was discovered by Schmiedeberg and Koppe in 1869 from *Amanita muscaria*, but this discovery concealed for almost

a century the true nature of the centrally active principles of *Amanita muscaria* (Eugster 1967, Wilkinson 1961). Muscarine is present in only very low concentrations, less than 0.0002 percent of the fresh mushroom and its weak activity on oral administration clearly ruled out its candidacy as hallucinogenic principle. Other substances such as atrophine and hyoscyamine have also been detected in very small amounts that exclude them as possible causes of hallucinogenic effects. The mushroom also contains very small quantities of unidentified indole derivaties, but it is clear that the centrally active components are the isoxazole derivaties, muscimol, ibotenic acid and muscazone. Ibotenic acid, which is the zwiterion of α-amino-α-(3-hydroxy-5-isoxazolyl) acetic acid, is present to the extent of 0 03-0 1 percent of fresh *Amanita muscaria* and it can be regarded as the precursor of muscimol by decarboxylation, and muscazone by photochemical rearrangements.

Muscimol may be the hallucinogenic principle of the fly-agaric and in recent years pharmacological investigations of mushroom have focused on this very polar and extremely water soluble enolbetaine. Both ibotenic acid and muscimole are found in human urine within 1 h after ingestion of *Amanita*. Thus the early experimentation by man led to the highly efficacious use of this ancient hallucinogen. In animals, muscimol is about 5 10 times more potent than either of amino acids in producing hyperthermia, catalepsy, sedation and mycolonic cramps (Waser 1967, Theobald *et al* , 1968 ; Scotti de Carolis, 1969). Indeed the original bioassay for the centrally active principles of *Amanita muscaria* were based upon the narcosis-potentiating effects of the extracts. Experiments in man have confirmed these results and duplicate the ethnopharmacological reports of Wasson. Higher doses of muscimol produce severe intoxication in man with painful muscular twitching, considerable agitation and vivid hallucinations. Similar doses of ibotenic acid or muscazone were virtually without hallucinogenic activity but showed only some unpleasant effects on the peripheral circulation. Muscimol can be detected in the urine of human subjects, again providing confirmation of Wasson's studies in Siberia. However there is no experimental report yet on the comparative study of animal and human metabolism of the compound. Furthermore it is yet to be ascertained as to whether muscinmol reaches the brain.

(d) *Chemical constituents of A. muscaria*

Various pharmacologically active substances from *A. muscaria* have been only partially determined (Eugster 1969) and additional constituents continue to be found (Chilton and Ott 1976 ; Catalfomo and Eugster 1969). The psychoactive agents present in *A. muscaria* include the isoxazole amino acid ibotenic acid, its decarboxylation product muscimol and its ultraviolet irradiation derivative

muscazone. The chemistry of these compounds was elucidated independently and simultaneously by Bowden *et al.* (1965). Takemoto *et al.* (1964) and Muller and Eugster (1965). All thse substances have been examined singly as pure substances in both animals and man (Johnson *et al.* 1968 ; Koenig-Bersin *et al.* 1970 ; Theoblad et. al. 1968 ; Waser 1961). These isoxazoles are not distributed uniformly in the mushroom but in *A. muscaria* they occur in highest concentration in the yellow tissue immediately below the skin (Catalfomo and Eugster 1970) Although the dry mushroom is psychoactive, the content of ibotenic acid gradually diminishes with time (Benedict *et al.* 1966). Both ibotenic acid and muscimol may be detected in human urine within 1 h of ingestion of *A. muscaria* (Lampe 1978). Muscimol is though most likely responsible for the central excitement in actual intoxications on the basis of its concentration and potency. Intoxicants with *A. muscaria* have more recently become far more common as the result of deliberate attempt by individuals to employ it for inducing hallucinatioms. This is possibly due to the ethnomycological studies of Wasson (1968) who refers to this species as the ' Divine Mushroom of Immortality" Special recipes are even now appearing for ways to prepare a broth from this mushroom so that one can retain its psychoactive properties but eliminate the gastroentric irritants also present (Lampe 1978). The irritant snbstances have not been identified. *A. muscaria* contains trace quantity of parasympathetic stimulant muscarine. Since muscarine is present in very low concentration so the muscarinic effects are rarely seen during intoxications. Furthermore, since muscarine does not enter the brain in clinically significant amounts, it cannot be responsible for either the psychoactive or central neurological action of *A. muscaria.*

Wasson (1968, 1970) describes the effects of soma as follows :

(a) The effect appear within 15-20 minutes and last for several hours.

(b) The soporific action induces a 2 hours sleep from which the subject cannot be roused but in which he is still aware of sounds-hallucinations and coloured visions appear in this halfsleep, which are apparently susceptible to self-manipulation.

(c) Upon waking, a feeling of elation often lasts for 3-4 hours and the subject is capable of both performing and enjoying feats of extraordinary physical effort.

There is no mention in Wasson's description of any undesirable effects.

Schultes and Hoffman (1980) describe the effects somewhat differently and report that the response may vary greatly from person to person. Their description is as follows :

"Ingestion of from one to four mushrooms is said to be sufficient to induce an intoxication, which begins 15 minutes to an hour after ingestion with twitching, trembling and slight convulsions of the limb. The feet become number. A euphoria characterized by happiness, lightness of the feet and a desire to dance gives way to coloured visual hallucinations. Macropsia is common. Religious overtones frequently occur. Occasionally violence and mad rushing about takes place until exhaustion leads to a deep sleep".

Mc Donald (1978) reported the following effects after self adminstration of 12 g of dried powder of *A. muscaria.*

(a) a marked nausea that tapered off over the first 3 hour,

(b) a conspicuous absence of reflective thought combined with a sense of tiredness.

(c) a slight transient euphoria around the fourth hour that alternated with and finally overwhelmed by a general sense of fatigue.

McDonald (1978) also reported that the above mentioned experience of self-administration of *A. muscaria* was not at all inspiring and initial nausea was so great that he neither had a desire to repeat it nor could he associate his experiences with the glories of soma. Later on he studied the effects of self-administration of different doses of *A muscaria* by six volunteers. All volunteers reported nausea, tiredness, increased salivation, deterioration in their grammatical sense. auditory distortions but none reported the desire to repeat the experience. McDonald (1978) however reported that the results on so few subjects cannot be definitive ; however given the primary results that they obtained it would probably be unethical to attempt to gather more data without changing the route of administration to be less offensive or providing some evidence that specimens from different regions might be less noxious.

Despite some tentative proposals, the fact is that the major ingredients of *A. muscaria* is not fully known. For a long time it was believed to be muscarine, but we know now that the amount of muscarine in *A. Muscaria* is very low (2 to 3 mg kg of fresh mushroom) to account for its effect (Eugster 1967). Belladona alkaloids (atropine, scopolamine) and Bufoltenine were also suggested, but these are present in small quantities if at all (Eugster 1967). According to Aaronsom and Osmond (1970) the three principle ingredients of *A muscaria* are muscarine, atropine and bufotenine. Since atropine and muscarine are rather antagonistic in effect, Aaronson and Osmond (1970) speculate that their relative proportions might determine the effect but as they are present in very low quantities, this speculation is highly untenable.

A more useful line of investigation is initiated by Eugster (1967) and others into the substances ibotenic acid, muscimole and muscazone. The pharmacological

and psychological effect of ibotenic acid and muscimole was studied by Theobald *et al* (1968) and Waser (1967). Muscimole is formed by decarboxylation and loss of water from ibotenic acid, which according to Eugster (1967) is the primary active ingredient. The relative quantities of these substances may vary with the type of material ingested-whether fresh, dried or rehydrated. Eugster demonstrated that muscazone can be produced by UV-irradiation of ibotenic acid-and that ibotenic acid acts as a precursor for muscazone. He believes that the relative toxicity of various specimens of *A. muscaria* results from fluctuations in the ibotenic acid-muscazone ratio. Current researchers emphasize the importance of ibotenic acid and muscimole. Waser (1967) self-administered these agents and his reports hardly match the description of soma intoxication. He did not have obvious hallucinations or report macropsia or micropsia, which are so often reported by native users, and in Vedic descriptions. One can conclude that neither ibotenic acid nor muscimole on their own c n account for the effects of the classical soma. We are not aware of any self administration reports on muscazone.

Muscimole has been the subject of abundant literature directly related to its interaction with brain membranes. Studies on the effects of the isoxazole on the firing of central neurons have been done on the basis of structural analogy between muscimol and GABA (γ-amino butyric acid). Both muscimole and GABA are powerful inhibitors of spinal interneurons and Renshaw cells in cats while ibotenic acid is a more powerful excitant than L-glutamic acid (Johnston *et al* 1968). It is not possible at present to decide whether muscimole produces its hallucinogenic effects by stimulation of inhibitory GABA receptors or by a serotoninergic mechanism.

In this context, it must be remembered that the Fly mushroom has been widely and is stilly used in certain regions as a fly-killing agent. In an experiment conducted by Singer (1970) at Leningrad, the flies were at first immobilized and eventually killed (at least many of them) then feeding on an infusion of one carpophore in milk. These observations were, in a more sophisticated setting were confirmed by French scientists (Bazante 1965, and Locquin-Linard 1968). So it is now obvious that the fly-killing properties of *A. muscaria* are not a myth as had been assumed by Wasson and Wasson (1957).

CONCLUSION

The hallucinogenic mushroom belong to a very special category of psychotropic fungi. In order to avoid misunderstanding, it must be noted that a hallucinogenic mushroom may at the same time be a poisonous mushroom either because an overdose may cause serious sickness or because such sickness or even death may

be caused by the presence of additional poisonous substances present in the fungus tissue together with hallucinogenic alkaloids (or other psychotropic substances). Even if we disregard the possiblity of overdose or misidentification of *A. muscaria*, any experiment on self-administration by insufficiently trained persons with hallucinogenic mushrooms collected from the field should be discouraged. Furthermore, the unauthorised use of hallucinogenic mushroom is prohibited by law in certain countries like USA, Mexico and Australia. The scientific progress, although punctuated by some brilliant biochemical work, has no doubt been discontinuous and still not fully satisfactory. Future work should take into account that the fly-agaric group of mushroom is taxonomically complex, and concentrations of chemical substances may be variable in different populations, races and stages of the growth of mushroom.

ACKNOWLEDGEMENTS

The first author (MKB) would like to thank the Department of Botany, The Australian National University for award of Visiting Fellowship and for providing necessary facilities for writing of this paper.

For technical assistance the help of Mrs B.O. Austin Mrs N. Plovanic, Mrs E. Magro, Mr K.P. Herbert, Roger Heady, Mieczystaw Ciszewski are sincerely appreciated.

Authors sincerely thank Miss J. Perks for her great patience in typing the manuscript

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(Accepted for publication 21 April 1990)