

ON FOREST ENTHEOGEN

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The article describes the red toadstool, *Amanita muscaria*, in the mirror of history, natural medicine, content of substances, and toxicity, as well as within the context of shamanic, ritual, and religious practices. Based on scientific reasons, a strong warning against any experimentation with the consumption of the mushroom itself, or preparations prepared from it, is delivered.

Keywords: red-and-white toadstool, fly agaric, fly amanita, *Amanita muscaria*, soma, toxicity, hallucinogen, solubility, log P

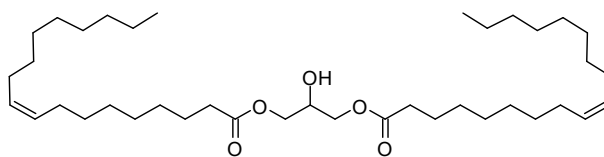
It all started a long, long time ago. A body of archaeological evidence suggests that humans have tended to use psychedelic drugs in a religious and/or healing context since prehistoric times. Evidence of such use of psychomimetic mushrooms includes paintings and sculptures depicting, among other things, stylized humanoids with mushroom-like features¹. Some time after the last ice age, in the northern forest zone, among birch trees, our ancestors found the preferred mycorrhizal symbiont of this tree – beautiful toadstools with red and white caps (red toadstool *Amanita muscaria* var. *muscaria* (L.) Lam. (Amanitaceae), Fig. 1, ref.²).

After observing that the mushroom had an interesting effect on reindeer, which, when they ingested it, went into a kind of trance, they tried it too. Thus began the religious, mystical and recreational use of this psychedelic



Fig. 1. *Amanita muscaria* var. *muscaria* (L.) Lam. (Amanitaceae), ref.²

mushroom, which continues to the present day in several regions of the world^{3,4}. From the circles of Finno-Ugric shamans, the knowledge spread to Vedic, Tibetan, Buddhist and other ceremonies, among others, as the drink of the gods, soma (from Sanskrit squeeze, crush). In our regions, however, more prosaically, housewives took caps of mushrooms, which they soaked in sweet water or milk and sprinkled with sugar. The sweet delicacy then attracted flies, which were poisoned by its ingestion; that is why in Czech the mushroom is called "muchomůrka", because it kills flies (moucha). It should be noted that however tempting the Czech spelling (for Czechs) of the mushroom name "mochomůrka" (after the word pattern Vochomůrka), it is correctly⁵ only "muchomůrka". Another theory claims that the 1,3-diolein (2-hydroxypropane-1,3-diyl-di(9*Z*)-octadec-9-enoate) in the mushroom attracts insects⁶.



1,3-diolein

But back to history, the ancient Indo-Europeans called toadstool, or its leachate "maga" (a great gift, supposedly from this word derive the terms as magic and magician), Rigveda the oldest classical text of ancient Indian knowledge, dating from about three and a half thousand years ago (Rig Veda 8.48.3) then says about it^{7,8}:

We have drunk Soma and become immortal;

We have attained the light, the Gods discovered.

Now what harm may foeman's malice do to harm us?
then (Rig Veda 8.68.1):

This here is Soma, ne'er restrained, active, all-conquering bursting forth, Rishi and Sage by sapience. All that is bare he covers o'er, all that is sick he medicines: The blind man sees, the cripple walks.

During the ceremonies and use, it was experimentally found that it was possible to achieve the desired intoxication by ingesting the urine of individuals who had ingested toadstool, and the urine could be recycled up to five times in this way, which "mystical" wisdom was known to both users, especially to the shamans of Siberia⁹, who were originally told it by the mythical Great Raven (Quikinnáqu), creator of the universe¹⁰, to the Vikings, as well as to some North American Indians and many other cultures, including Chinese, Japanese¹¹, all the way to Asia-Minor¹². Shamans and priests have also found that, in turn, some of the emetic constituents contained in toadstools are metabolized after passing through the body, and therefore recycled urine is to some extent more useful than the toadstool itself or its original leachate. By donating urine, they then bound unwitting fellow tribesmen to themselves. Recent sources suggest that the reason for the "quality" of the urine is metabolically induced decarboxylation of ibotenic acid¹³.

The efficacy of toadstool extract was known to Vedic priests, where such intoxication is associated in ancient literature with the mythical drink "soma (also amrita, haoma)", the nectar of immortality, to which the magical properties of alchemical medicine are attributed. A drink that induces feelings of divinity (entheogen)¹⁴, which has a strong psychotropic effect with a feeling of 'immortality', euphoria and flying. Ancient texts explicitly link the ingestion of toadstools with levitation. Toadstools were allegedly ingested before battle by warriors of the European north (Berserks), who then supposedly felt no pain and in their state of uncontrollable frenzy were immune to fire and metal¹⁵, or, as the Old Persian Yasna¹⁶ also says (about haoma):

... Haoma grants to racers who would run a course with span both speed and bottom (in their horses). ... grants to those (how many!) who have long sat searching books, more knowledge and more wisdom ...

The classicist defines¹⁷ psychedelic drug as an agent which, without causing physical dependence or craving, serious physiological disturbances, delirium, disorientation, or amnesia, more or less reliably produces thoughts, moods, and changes of perception otherwise rarely experienced except in dreams, contemplative and religious raptures, flashes of vivid involuntary fragments of memory, and acute psychosis. The toadstool, according to many, approaches this ideal. Legend has it that September toadstools are narcotic, and August toadstools are visionarily psychedelic.

Mika Waltari¹⁸, or Lewis Carroll (Charles Lutwidge Dodgson)¹⁹, write interestingly about (their) experiences with toadstools. The well-known drug experimenter Jiří Glos, *alias* Freud^{20,21}, *vulgo* Obrázek, has also spoken at length about the psychoactivity of toadstools. He dreamed that the toadstool, "could be such a Czech LSD" if only the

emetic substances could somehow be removed; it wasn't enough that smoking marijuana was quite anti-emetic, he wanted to get it neat, which he probably wouldn't have been able to do, because muscimol itself is a terminal sedative (although it's a very strong GABA_A agonist), it's intoxicating, hallucinogenic but also induces a somatic reaction involving nausea and vomiting²² and he didn't know the urine trick.

Jiří Glos (*1947), is said to have brought "pervitin" (methamphetamine) to the Czech scene in the middle of the last century. Although allegedly a half-educated geologist, he had such a knowledge of chemistry in his youth that he could have passed a college exam in advanced organic chemistry and pharmacology. Of his writings, reportedly, physicians said with a sigh that he was twenty years ahead of them in research on psychoactive substances because, while he was experimenting on humans, they were experimenting on rabbits.

Like all things, it has a flip side. However, ingestion of toadflax or toadflax extracts also produces other symptoms, including sweating, nausea, muscle twitching, and auditory or visual hallucinations, and the toxic and potentially fatal properties of the muscarinic mushroom are significant¹⁴. A further problem is that ingestion of hallucinogens can lead to what is known as a 'bad trip' (a state of experiencing (very) unpleasant sensations after taking a hallucinogen) or a state of delirium or recurrent perceptual disturbances (a flashback in which a person acts as if a past situation (intoxication) or unpleasant event is happening again)²³.

However, as we wrote in our article on nutmeg²⁴, Andrew T. Weil²⁵ used to say: "Persons who use narcotics are often willing to suffer extreme discomfort along with the pleasurable effects produced by (narcotic) drugs".

It should be added that from the current perspective, psychedelics are not narcotics, among other things because narcotics are usually addiction triggers, which psychedelics are not, and there is usually no extra significant discomfort after their administration. However, the negative aspects of the effects of toadstools can be eliminated to some extent. We've already mentioned body passage and marijuana, let's look further. The classics state that it is necessary to macerate the dried mushroom, or rather the mushroom cap itself, preferably with as much of the white remains of the sheath as possible. "Preferably" the dried cap is macerated in water, milk or fruit juice. Drying the same is recommended¹² on a moderate heat, 35–50 °C, until the material is completely dry (it breaks and crumbles easily), which is said to radically change the chemical composition of the mushroom, resulting in an aromatic product with a sweet, pleasant taste, which is fully usable and easy to store. It is then stored in good packaging for 2 to 3 months before use. Of course, one branch of toadstool processing leads to an "ideal" usable substance to induce a hallucinogenic state, the other to a harmless, fragrant food.

A recipe for preparing "edible" toadstools quotes Pearson²⁶: To prepare *Amanita muscaria* for safe eating (modified): (1) carefully peel the cap and remove each piece of the cortex; (2) cut into small pieces; (3) place the pieces in boiling water and boil for exactly five minutes; (4) drain the water thoroughly and boil again in fresh, boiling water for another five minutes; (5) remove the water and prepare the mushroom in the usual manner. (For safety reasons, the author advises careful disposal of the water used for extraction.) The chemist is puzzled that he does not indicate the amount of water or whether the "pre-cooked" toadstool had any biological activity other than mushroom smell and taste. Probably not, since dream seekers value the red cortical layer (exocarp) the most. Preparing toadstool without its major alkaloids seems quite realistic, given the solubility of the essential constituents. We did not find aqueous solubilities in the literature, so we modelled them using the ACD/ADMET Profiler program²⁷: muscarinic 129 mg ml⁻¹ (logP=2.93), ibotenic acid 467 mg ml⁻¹ (logP=0.85), muscimol 1000 mg ml⁻¹ (logP=0.92), muscazone 305 mg ml⁻¹ (logP=0.60).

The classical procedure for preparing soma involved three stages²⁸: sun drying, extraction and filtration through the organism. The well-known pharmacoe ethnographer František Šita²⁹ writes in his treatise on soma: *The process of preparation (of soma) began with purifying the drug (toadstools) with water, crushing it between stones and pouring water over the pulp. This procedure was repeated several times. Then the liquid was poured off, the residue squeezed out, and the liquid thus obtained was added to that previously obtained. Now came the climactic moment. The combined crude macerate was filtered through a cloth. The bright yellow filtrate, on its appearance, represented the revelation of the entire deity. The liquid obtained was mixed with milk, water or melted butter with honey, or a decoction of the fireweed or rosebay willowherb (*Epilobium angustifolium*, a plant widely used to make a stimulating infusion in Russia before the advent of tea culture) or the juice of the bog blueberry (*Vaccinium uliginosum*, a drug known for inducing psychomotor restlessness and feelings of dizziness or mild hallucinogenic effects; however, it is thought that the major contributor to the effects is not the plant itself but the metabolic products of the parasitic downy mildew fungus (*Sclerotinia megalospora*) that invades it³⁰). Let us add a quote from Feeney's work³: Because of the difficulty of dissolving ibotenic acid in cold water, an extract in cold water may have a lower concentration of this acid than an extract in hot water, and thus the risk of vomiting is reduced.*

Šita then goes on to give us the chronology of the effect of the toadstools; it is such an interesting text that we present it unchanged, however much it may be commented upon: *The dose of red toadstool which causes poisoning in an average healthy person is about 20–40 g. At least two people in a hundred die of poisoning. The contents vary depending on the location of the mushroom. We therefore strongly warn against rash experiments with*

the mushroom, which are very likely to have the most serious consequences. Let us describe the course of toadstool poisoning in the lucky survivors. Let's look for motives that agree with or contradict the description of soma poisoning... The first symptoms of poisoning appear, on average, half an hour to two hours after the mushroom is ingested. The sufferer feels dryness in the throat and mouth, has difficulty swallowing, and has a feeling of "breathlessness". Nausea and pressure in the stomach follow, similar to overeating. A sensation of heat, even unpleasantly intense, appears. The sufferer longs to cool down. The heart begins to pound violently. Perceptual disturbances occur. Distance vision is unusually sharp and clear, even in low light. The image is seemingly plastic, black and white. However, yellow, blue or violet vision may also appear. Nearby objects appear to be magnified. At close range, vision becomes increasingly blurred, the sufferer is unable to write. Hyperacusis sets in: the sufferer believes, for example, that he hears the sound of a clock from the next room. Disturbances of touch appear. Tingling in the limbs, then numbness. Food and drink seem tasteless. This description of poisoning is consistent with the peripheral effects of the toadstool's contents. The effect of the poisons on the central nervous system develops further. The beginning is a headache, tinnitus and a feeling of emptiness in the head, then revolving vertigo. The limbs seem "lighter than paper", some poisoned persons feel as if they are being lifted or propelled forward by an unknown force, and a sensation of flying is experienced. At the same time, loss of muscular strength occurs. The sufferer cannot even hold light objects in his hands. The muscles of the limbs and trunk twitch. The intoxicated person is constantly in contact with his surroundings, is aware of the reality of his condition, is in an excited mood, is verbose, and often repeats words or whole sentences he has heard in the surroundings. The agitation increases, and the sufferer loses consciousness and contacts with his surroundings. What he experiences from this point on in the form of dreams he can usually describe only partially or not at all. One sufferer said that he 'existed in the form of two persons, one of whom observed what the other was doing' – this stage of poisoning sometimes ends in a delirious image in which he may even act aggressively towards his surroundings. After exhausting his strength, the patient becomes delirious and then falls into unconsciousness rather than sleep. He lies still, his body temperature falls, and his breathing is rapid and laboured. Bruising appears. This is where death is closest. The fantastic nature of the dreams of the poisoned is captured by statements such as "You know, I'm back from the dead, I'm alive" or "So I'm back, I've been to the world beyond". The imaginary return from beyond the grave is often depicted. Another sufferer felt himself placed in a large white sphere spinning at breakneck speed between rotating red orbs. The poisoning lasts about 24 hours. The period of recovery begins with awakening, the sufferer having no recollection or consciousness of having passed through

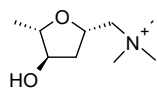
a severe dream state. He feels headache, flaccidity, and depressed mood. Visual disturbances may last for several days. The most common cause of death in red toadflax poisoning is – among many other complications – heart failure or bronchopneumonia.

Research into the contents of the red toadflax was begun as early as 1869 by Schmiedeberg and co-workers³² and in 1875 they published the structure³³ and a year later the synthesis³⁴ of the first isolated substance; they obtained a poisonous substance which was later named muscarine. When injected subcutaneously, 1–3 mg caused salivation, a sensation of pressure in the head, changes in the heartbeat, nausea, flushing in the face, dizziness, anxiety, sweating, and convulsions. The hallucinogenic effect did not manifest itself even when the doses were increased to 100–200 mg, at which point dangerous intoxication was already developing. The lethal dose is higher than 300 mg. It was only a century later that Eugster and colleagues in Switzerland³⁵ and Takemoto and colleagues in Japan³⁶ described the discovery of another active substance from the red toadflax. This was ibotenic acid and its breakdown product muscimol. The pharmacological effect of both substances is very close. After a dose of 10–15 mg, volunteers described confusion, disorientation in space and time, magnified vision of objects, visual and auditory hallucinations, tremors and even muscle spasms. They eventually fell asleep. The picture of toadflax poisoning is thus a synthesis of the effect of muscarinic acid, ibotenic acid with muscimol, and the state of the organism on which the mushroom acts. It cannot, therefore, be accurately reproduced by experimental administration of pure isolated substances. Then in 1967, both Eugster and Takemoto laid the

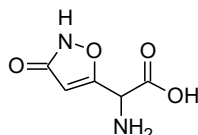
foundation for the nomenclature of fly agaric content³⁷.

Donald E. Teeter's¹² description of intoxication is interesting, similarly detailed to Shulgin's descriptions³⁸: *I purchased several dried samples of Amanita muscaria via mail order. On opening the bag, I was struck by a most pleasant aroma. An old switch clicked somewhere in my body as if my body had previous experience with what was in my hands. The test confirmed that the drug tasted as good as it smelled. It wasn't bitter or nasty at all, but sweet, tasty actually.*

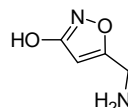
I ingested about 1.75 g. The effects were very mild; mild euphoria; slight increase in ambient light, these pleasant effects lasted about 3 hours. A week later I ingested 3.5 g. More pronounced effects: general inner calm, very soothing; visual illusions of colour, blue being particularly brilliant; undulating field of vision; slight difficulty walking; changing colour patterns with eyes closed. After about 2 hours: drowsiness, had to lie down with my eyes closed; extraordinary visual illusions; inner sense of peace; 4.5 hours after ingestion I feel rested and back to normal. A week later, 7 g. Much more pronounced effects with faster onset: darkened room is luminously brilliant, I walk like a drunk and have to lie down. After about 2 hours: see intense Persian carpet patterns behind closed eyes, have a great sense of inner peace, feel some auditory sensations. One week after that I ingested 14 g, very quick onset, only a few minutes. After about 1 to 1.5 hours, I had to lie down: extreme inner peace; indescribable illuminated visions; extremely complex auditory effects, from audible narration of visions to complex "sayings or teachings", I can't express it better. The experience was not quite the same as perceiving the spoken word; I knew the answers to questions; then



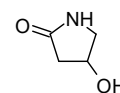
muscarine



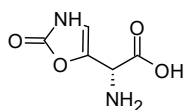
ibotenic acid



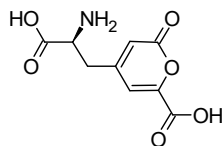
muscimol



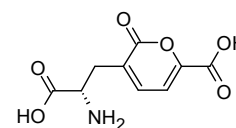
4-hydroxypyrrolidine-2-one



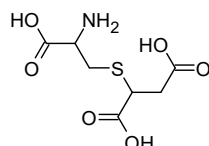
muskazon



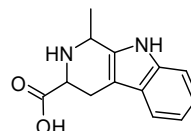
stizolobic acid



stizolobic acid



2-amino-3-(1,2-dicarboxylethylthio)propanoic acid



tetrahydroharman-3-carboxylic acid

sometimes the visions illustrated the answers! At some point, I spiritually went to a place I can only refer to as a kingdom. Everything I saw was illuminated by an inner light. This vision was a cohesive whole, with a beginning, middle and end. The visual and auditory effects subsided after about 4.5 hours. In 6 hours after ingestion, I felt refreshed and physically rejuvenated. This feeling of physical well-being lasted for about 14 days after application. Teeter further describes that he was relieved of several ailments after application, including joint pain.

Let's take a look at the main substances contained in the mushroom^{22,39–41}. The main substances include the highly toxic muscarine (LD₅₀ (mouse) 0.23 mg kg⁻¹)⁴², which is a parasympathomimetic, in simple terms it affects acetylcholine levels, acts on muscarinic receptors to cause smooth muscle spasms of the intestines, uterus, bladder and bronchi, sweating, salivation, lacrimation, stomach pain and urge to vomit; however, its content in toadflax is low, around 0.002–0.02 % of the dry weight of the fruiting bodies.

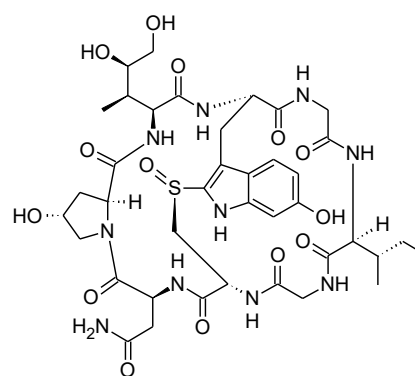
Furthermore, ibotenic acid (LD₅₀ (rat) up to 129 mg kg⁻¹, content in the dry weight of the cap around 1 %) ⁴³, which is soluble in water and decarboxylates during drying⁴⁴ to muscimol also originally contained in the drug. Ibotenic acid is a substance that crosses the blood-brain barrier and is then decarboxylated. In the brain itself, it acts as a potent neurotoxin. It is structurally related to glutamic acid and activates NMDA receptors, but it does not appear to have the psychoactive properties of toadstools.

Muscimol (agarine, pantherine, about 0.09 % content in the dry weight of the cap), is a GABA_A receptor agonist (LD₅₀ (rat, p. o.) 45 mg kg⁻¹), probably most associated with psychoactive and psychedelic effects and functions as a primary inhibitory neurotransmitter. The action is similar to that of alcohol, in addition to being hallucinogenic.

The other substance muscadone is apparently formed by a photochemical reaction from ibotenic acid, some authors believing it to be an isolation artefact; however, we fear that this is not the case; converting the 1,3-oxazol-2-one-5-yl derivative to 1,2-oxazol-3-one-5-yl by mere water extraction seems to us most unlikely. Its toxicity LD₅₀ is estimated ACD/Percepta²⁷ at 180 mg kg⁻¹ (mouse s. c.; lowest figure); its psychoactivity is low. Also found are stizolobic acid, stizolobic acid, tetrahydroharman-3-carboxylic acid, and 2-amino-3-(1,2-dicarboxyethylthio) propanoic acid. In addition, the antibacterial and antifungal 4-hydroxypyrrolidin-2-one, several beta-glucans, especially the immunomodulatory AM-ASN, antioxidant tocopherols, traces of tropane alkaloids, traces of highly toxic amatoxins and phallotoxins (typical substances especially for *A. phalloides*), bufotenin (5-hydroxy-*N,N*-dimethyltryptamine), dyes, amino acids, etc. The main component of the cap is approximately 90% water. Muscimol is drawn, in accordance with its name, as an oxazole enol; like the other derivatives, we can imagine it, depending on the conditions, in both forms and the

existence of some in zwitterionic form. We adhere to the usual literary form.

Several authors report that mycotoxins, such as α -amanitin (α -amatoxin), contribute to the toxicity of the above mentioned mushrooms, and *A. muscaria* included, although their content in the (presumably fresh) mushroom is less than 1 mg kg⁻¹, which, at a mean lethal dose of 0.5–1 mg kg⁻¹ (ref.^{45,46}), means that if one wanted to poison oneself with α -amanitin from *A. muscaria*, one would have to eat a big mushroom scrambled egg fry. The mycotoxin content of other toadstools is much higher, and the toxicity of *A. muscaria* is relatively low in this respect⁴⁷.



α -amanitin

Experienced users caution against the simultaneous ingestion of carbonated drinks, as it is thought that ibotenic acid, which is decarboxylated during drying into muscimol, which can be converted back by the action of carbonic acid¹² which is a tempting idea, but to the chemist at least a strange one, but nature is a powerful sorceress. However, the toadstool should be warned against again, because even if the intoxication subsides without major health problems, there are still a number of complications that can occur later: respiratory and cardiovascular problems, kidney failure, rhabdomyolysis or cancer⁴⁸.

Erowid lists 30 articles on the toadstool *Amanita muscaria*⁴⁹. SciFinder provides 3494 articles on the query "amanita", which, when refined by another query "muscaria", is reduced to 803 citations, with the frequency starting to increase in the 1950s. There are also many sources of dubious "grey" literature, such as the materials of the so-called Czech Psychedelic Society, which according to the commercial register has 4 officers and a total of 4 members, and many other groups and associations. With this article, we try to contribute to the knowledge of reality, drawn mainly from the professional literature. We also bring this paper as another contribution to a series of teaching texts describing various interesting aspects of the chemistry of natural substances^{50–52} also because we wish to respond in this way to the many fictions, half-truths and nonsense that are being spread about natural compounds today. It is clear that exploring

natural substances as substances from renewable sources is one way to contribute to the general good simply and effectively^{53,54}.

In conclusion, we agree with ChatGPT's statement⁵⁵, where we asked for their opinion on the issue described above, "It is important to note that consuming toadstools can be dangerous and can lead to serious health problems. Many individuals experience nausea, vomiting, severe abdominal pain and dizziness after consuming toadstools. Further, it can be dangerous to underestimate the effects of the mushroom and succumb to hallucinations, which can lead to risky behaviour and injuries. For these reasons, toadstool consumption is not recommended and should be left only for research purposes under the supervision of experienced scientists and physicians."

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