

Morel Mushroom Toxicity: An Update

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Abstract: Morel mushrooms (*Morchella* species) are widely considered excellent and delicious culinarily by foragers and chefs alike. Most would be surprised to learn that morel mushrooms can be toxic. This is no “urban legend.” The aim of this article is to clear up what is fact and fiction about morel toxicity, with references to scientific study of morel-related disorders from experiences and case studies in Spain.

Key words: Cerebellar syndrome, *Morchella*, Neurological toxicity, Toxic effects

Introduction

Although it may be surprising to speak of toxicity in the case of well-known edible mushrooms like morels, the truth is that in recent years news about possible health disorders caused by these ascomycetes has been spreading. Eight years ago I published an extensive review in a mycological journal (Piqueras, 2013). Since that time confusion and misunderstanding of morel toxicity has persisted, and worse, a serious poisoning occurred in Valencia, Spain in 2019, attributed to morels. For these reasons I have decided that this topic is deserving of review and an update.

Morels are a group of ascomycete fungi belonging to the genus *Morchella* of the *Morchellaceae* family. They generally fruit in spring and are characterized by having a honeycombed “hat” and a hollow “foot” (Figure 1). Some species have been successfully cultivated and can be seen in markets, mostly from China (see “Morels Are Growing Up,” elsewhere in this edition of FUNGI). These mushrooms have a high gastronomic value, and they are very popular and highly appreciated in many parts of the world. Proof of this is the considerable number of



Figure 1. Wild Morels (*Morchella elata*), courtesy P. Iglesias.

names with which they are known: Arigany, Cagarrias, Calves, Colmenillas, Crespillas, Crispas, Gallardas, Guchi chiau, Guchhi, Huhtasienet, Karraspinas, Morcheln, Morels, Morilles, Morronglas, Murgues, Múrgules, Pantorras, Rabassoles, Spugnole, Xirupatos. Morels lend themselves perfectly to drying, so it is very common to see them dried and for sale in markets in Spain and elsewhere (Figure 2).

In all the places where consumption of morels is popular, it is well-known by most that these mushrooms should never be eaten raw or undercooked. This is justified because they are said to contain heat-labile toxins—hemolysins—which can cause the breakdown of red blood cells. These toxic compounds do not withstand the heat of cooking. However, if consumed raw, a number of disorders may occur. Besides hemolysis, gastroenteritis and neurological symptoms are known.

Morel hemolysis: myth or reality?

By now, who has not heard of the possible hemolytic consequences that may occur as a result of consuming raw or undercooked morel mushrooms? In practically all the books on mushrooms, the chapter on ascomycetes mentions that morels possess substances capable of destroying red blood cells. Heat destroys these substances, it is said, so the rule should be to always eat them well-cooked. This information seems to be passed down from one author to the next. But is this true? I must confess that I myself have written in the past on more than one occasion that “they contain poorly identified thermolabile hemolysins” (Piqueras, 1996).

Although there are many who are convinced of the existence of this hemolytic power of morels, when we ask them to refer a specific case of patients who have suffered from this problem,

it turns out that they do not know any firsthand. This caught the attention some years ago of my good friend and colleague Dr. Pepe Elizalde, who in an internet forum posed the question in the following terms: What level of evidence is there for the presence of thermolabile hemolysins in the genus *Morchella*? Can anyone cite specific cases with symptoms attributed to these hemolysins? Analyzing the matter, there is no doubt that hemolysis by ascomycetes in general, and *Morchella* in particular, is a compelling topic, since it is mentioned and repeated in many books and in numerous articles. And although the idea that it was due to “helvellic” acid (which in some texts, perhaps referring to Swiss mushrooms, was called “helvetic” acid) was overcome long ago, the need to cook morels well is still a general rule as there is unanimous agreement that raw they can be toxic.

References that we find on toxicity due to raw or undercooked morels refers to digestive and cardiocirculatory disorders but not hemolysis (Lindgren, 1997; Gracia and Juyol, 1999; Beug et al., 2006). Even so, I suppose that some degree of harmless hemolysis sometimes occurs with their consumption. This would explain the popular saying that many years ago Ramón Menal had noted in some places in Catalonia (Spain): “*Qui menja murgules, pixa fosc*” (he who eats morels, has dark urine).

In the Spanish medical literature, there is a citation about a family that, after eating vastly undercooked mushrooms, suffered from acute gastroenteritis, followed by mild liver dysfunction and hemolysis. This intoxication, which resolved spontaneously in three weeks, was attributed to the consumption of *Morchella esculenta* (Fusté et al., 1979). However, there is no doubt that there was an error in the identification of the mushrooms and that, in fact, it was the false morel, *Gyromitra esculenta* (Figure 3). Although they belong to different genera, they share some morphological characters, are found in similar habitats, and both occur in the spring (Huffman and Tiffany, 2001), which would explain the confusion. However, the clinical presentation was the typical one of the intoxication by hydrazines present in *Gyromitra*. Again last spring a poisoning by this species occurred in the Catalan Pyrenees of Spain (Escoda et al., 2020),



Figure 2. Dried morels, courtesy J. Piqueras.

with symptoms very similar to that of the article by Fusté et al.

To summarize: There is evidence that raw morels (maybe even cooked) produce some degree of hemolysis. But this does not appear to be the main mechanism for its toxicity in raw. Furthermore, some mushrooms may look similar to morels and may also be toxic.

The toxicity of raw or undercooked morels

Contrary to what modern gastronomic trends promote—the consumption of “mushroom carpaccio” as if it were a delicate dish for demanding palates—the reality is that mushrooms should never be eaten raw. On the one hand, the cell walls of mushrooms are made of carbohydrates (chitin) that are hardly degradable by our digestive enzymes. (Similar substances are present in the exoskeleton of insects which are also difficult to digest.) And, on the other hand, it is also a bad idea to

consume any raw mushrooms because this has been associated with the subsequent development of allergies and intolerances to mushrooms.

Mushrooms of the *Paxillus involutus* group (Figure 4) that, when consumed raw or undercooked, can produce a sensitization to some of their antigens, which can lead, upon subsequent ingestion, to the development of a serious condition of hemolysis—potentially fatal—produced by the deposition of antigen/antibody complexes on the surface of red blood cells (Flammer, 1983; Winkelmann et al., 1986). During times of food and fuel shortages such as during the Second World War, people have consumed mushrooms out of desperation. Deaths occurred due to this immunohemolysis syndrome after the repeated consumption of undercooked *Paxillus* mushrooms. As fate would have it, the victims were two eminent mushroom scholars, one German, Julius Schäffer



Figure 3. *Gyromitra esculenta*, courtesy P. Iglesias.



Figure 4. *Paxillus involutus*, courtesy P. Iglesias.

in 1944, and the other an Austrian, F. Neumann, in 1945 (Gibon, 1996).

Thus all edible mushrooms, even the most appreciated ones, must undergo some type of cooking prior to consumption. The disorders produced by consuming mushrooms raw may not extend beyond GI problems in some cases, but there are species that contain substances that are highly irritating to the digestive tract or even toxic. In the case of morels, consuming raw or undercooked morels may produce symptoms of moderately intense gastroenteritis, along with the usual cluster of indigestion symptoms.

In many parts of North America, the appreciation and fondness for morels leads many to celebrate; there are annual festivals. Many families take part in excursions into the country (Schaechter, 1997). Therefore, it can be expected that sporadically some disorders will be attributed to the consumption of wild morels. Indeed, in the poisoning registry of the North American Mycological Association (NAMA) through 2005, 129 cases out of a total of 1,641 correspond to morels (Beug et al., 2006). Most of the time, digestive symptoms are reported and in more than half of the cases “raw *Morchella* spp.” are referenced. An

episode that took place in Vancouver, British Columbia on June 8, 1991, stands out; 77 adults fell ill at a banquet where they were served raw morels (and other mushrooms) in a salad (Lindgren, 1997). All presented with mild digestive disorders, nausea, and vomiting.

Based on the cases presented, the presence of thermolabile toxins in these mushrooms is certain. The mild toxins act on the digestive system, producing gastroenteritis symptoms—but have never endangered the lives of patients.

Neurological toxicity and “cerebellar syndrome”

My first suspicions about a neurological toxicity of morels arose from some sporadic episodes that were reported in the 1990s in some publications (journals, newsletter, and a mycology book) about mushrooms as well as through personal communications. I will describe the most significant of these anecdotes.

In May 1991, in Asturias, Spain, four people consumed morels (*Morchella esculenta* var. *vulgaris* and var. *rotunda*). The following day two of them presented with tremors, motor incoordination, and dizziness. The symptoms, which disappeared that same day, were described by Dr. Rubio Domínguez (1997)—one of those affected—as typical of a “cerebellar syndrome.” The following year, a married couple in Cantabria, Spain, ate well-cooked mushrooms (*Morchella vulgaris*) (Figure 5). The next day they both presented ataxia, instability, and a “feeling of dizziness” that lasted for several days. In addition, they had tremors, especially of the hands, which persisted for a month (Ruiz Fernández, 1997). A year later, the husband collected *Morchella esculenta* var. *rigida*. Although he had trepidations, he ate them for dinner—but this time only a small portion. The next day he had the same symptoms as before, but with less intensity. A friend who was offered some mushrooms later commented that he had been very nervous and shaky all week, especially in his hands.

In the spring of 1993 a group of ten people from Bilbao, Spain, dined on an abundant harvest of morels. The seven adults and three children consumed between 4 and 6 kilograms of fresh morels, possibly *Morchella rotunda* var. *rigida*. The mushrooms were boiled for



Figure 5. *Morchella vulgaris*, courtesy D. Merino.

a long time and then well-cooked. Four of the adults presented the next day with a mild neurological disorder, loss of balance, and tingling in the hands (Meléndez Arranz, 2003).

In 1996, this time in San Sebastián, Spain, three people consumed *Morchella* sp. boiled and then prepared in an omelette. The next day one of them presented with severe dizziness when standing up and instability. These symptoms lasted for two days.

A year later, again in Asturias, Spain, three people consumed freshly harvested morels. Although they were cooked properly, within a few hours they presented with mild neurological symptoms (dizziness and instability), along with symptoms of digestive upset (Rubio Domínguez, 1997). Later that year (April 17, 1997), the Mycology Section of the Aranzadi Society of Sciences of San Sebastián, published an alert in the *Egin* newspaper about the danger that these spring mushrooms can pose if they are consumed fresh and, especially, undercooked (Anonymous, 1997a). Pedro Arrillaga, president of the Society at that time, recalled a case that occurred in the 1970s when several members of the Aranzadi Mycology Section “acted as guinea pigs by consuming the morels they had collected fresh and in omelette. They all had the same symptoms the next day: dizziness and lack of stability when standing up, similar to those experienced by people who have drunk too much.”

In that publication, the following was given as a possible solution to avoid these disorders: “*The solution, dry them.*” Three days later, in a new warning published in the *Diario Vasco* they insisted that the morels had to be “*dried and hydrated*” (Anonymous, 1997b). We have to assume that such an assertion is based (apart from what happened to his partners 20 years ago) on three other cases treated at the Nuestra Señora de Aránzazu Hospital and some episodes compiled by Juan Sánchez-Ocaña from the Société Mycologique du Béarn bulletin (in the French Pyrenees), always associated with the consumption of fresh morels (Rubio Domínguez, 1997).

What do we know about “cerebellar syndrome?” At the end of the 1990s, we knew that sporadically, in the north of Spain and in the south of France, the ingestion of morels had been the cause of a surprising and previously undescribed toxicity. Provisionally, in my review of mycotoxicology in 1999 I called it “the cerebellar syndrome due to morels” (Piqueras, 1999), because, as Dr. Rubio had pointed out a few years before, the symptoms of this “new” disorder corresponded to those of the cerebellar syndrome of medical neurology (Rubio Domínguez, 1997). Four years later, some aspects of this “new” syndrome were published by me in an article for the *Lactarius* magazine in Jaén (Piqueras, 2003): “*It is a set of dizziness, tremors and lack of stability when standing or walking,*

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similar to what suffer from people who have drunk too much. In general, it occurs the day after consuming morels (*Morchella spp.*). In some cases it is mild and temporary, and in others it is disabling and can last for several weeks." Shortly thereafter, I picked up other references to similar phenomena, always coming from the north of our country and in which, curiously, they also spoke of hallucinations. For example, in a mycological forum (Micolist), on March 20, 2003, Roberto Fernández Sasia commented that "*Morchella rigida var. esculenta*, the most common in the riverside forests of that area, had caused cases of intoxication with dizziness, hallucinations and gastrointestinal disorders." And on April 21, 2004, again in Micolist, the following was read, referring to morels: "An Asturian friend ate them fresh a week before and says that the next day it was as if he had taken diazepam. And the following day he slept so soundly that he was an hour late for work. He did not hear the alarm clock." On the subject of hallucinations, it should be noted that in the fall of 2002 my good friend, the Madrid mycologist Mariano García Rollán, had included *Morchella vulgaris* in a talk on hallucinogenic mushrooms. As we will see later, hallucinations in cerebellar morel syndrome are very rare. In the case reported by Roberto Fernández Sasia it was about a man who had the sensation that the road was widening and things acquired disproportionate sizes.

For a time it seemed that this strange syndrome was a fairly local phenomenon, restricted to northern Spain and the French region of the Pyrenees. In fact, the first episode presented in a National Toxicology Congress in Spain, in the spring of 2004, corresponded to that geographical area (Pinillos et al., 2004). But very soon we were going to know that this neurological toxicity was neither so infrequent nor was it limited to the north of Spain and the French Pyrenees.

In the spring of 2006, at the Center for Anti Poisons in Angers (France), Dr. Patrick Harry twice treated groups of people apparently intoxicated by "*morilles*" with clear neurological symptoms. Intrigued, he searched a bibliography on similar events and found two articles in mycological journals: one from 1962, German, and

another from 2003, Spanish (Nothnagel, 1962; Piqueras, 2003). The following year, at the Congress of the European Association of Poison Centers and Clinical Toxicologists (EAPCCT), a team from Munich reported six more cases of "cerebellar *Morchella* involvement," which occurred in Germany (Pfab et al., 2007). All this prompted Drs. Patrick Harry and Philip Saviuc to study the databases of the French CAP (Centers for Anti Poison). They found records of 129 people who had suffered neurological syndromes caused by *morilles* over a period of 30 years. The first case dated from 1976. They analyzed all these cases and, after a brief communication at the 45e Congrès de la Société de Toxicologie Clinique in Bordeaux (Harry et al., 2008), they published a detailed and complete work for the French Coordination Committee of Toxicovigilance in January, 2008 (Saviuc and Harry, 2008). Hallucinations are mentioned in only two of the episodes recorded in the French files. For this reason I consider them exceptional. After extensive review of the bibliography for their report, although they do not mention Pinillos' communication in Mallorca (2004), they find a quote from A.E. Alder (1956), prior to that of Nothnagel from 1962, in which a Swiss doctor collected in 1953 around 3 kilos of morels that were prepared the next day (by boiling) and consumed as a family for lunch and dinner. About 9 hours later, the parents began to experience intense vertigo. The doctor could barely stand up, as if he were drunk. The symptoms disappeared after three days. The children who had eaten few mushrooms did not get sick. In this same article, Alder mentions the case of a man who, years ago, the morning after an abundant dinner of morels suffered an affliction that forced him to stay in bed for a day. Likewise, Alder mentions a paper from 1930 (J. Jaccottet: *Die Pilze in der Natur*; translated from French [Jaccottet, 1925]) in which it was said that in Algeria the consumption of *morilles* is sometimes associated with a light and transitory inebriation. Due to a certain similarity with other neurotoxic syndromes, Alder thought that morels would have a toxin similar to the one that was (wrongly) supposed to be responsible for the toxicity of

Amanita muscaria: "pilzotropin." In a later publication he maintained this hypothesis (Alder, 1960).

In June 2007, a woman ate a good quantity of fresh but well-cooked morels, bought in a Barcelona market. After having dinner and going to bed, she woke up the next day with a mild neurological disorder, ataxia, postural instability, and some tremors. The syndrome was short-lived; I did not witness the morels, so there was no record of the responsible species. That was the first case in my personal experience as a physician of morel cerebellar syndrome. In December of that same year, Salcedo Larralde and García Alija (2007), in a report on *Morchella vulgaris*, mention the following: "They should not be eaten fresh because even if we boil them for a long time (one hour) and throw away the cooking water, they can produce intoxication that generates tremors, nervousness, instability, lasts several days, remitting spontaneously in most cases, this is what Dr. Piqueras calls cerebellar syndrome."

In 2008 several things happened. First of all, a Munich medical team published in detail the six cases of their communication from the previous year, at the EAPCCT congress. Apart from those six cases (four women and two men), they reported two other episodes (Pfab et al., 2008). One report described eight people showing cerebellar neurological symptoms, 6–8 hours after eating *Morchella esculenta* that they had collected. One of them also had hyperacusis and two others suffered from diarrhea. In the second report, two people collected and consumed fresh morels (*Morchella esculenta* or *M. conica*), then developed the following day a set of vertigo, unsteady gait, and blurred vision. It is obvious that the bibliographic review of these authors was not as deep or extensive as that of my colleagues from the French CAPs. Pfab et al. say, literally, that "*in the medical literature (searching PubMed) these neurotoxic effects have not been published before.*" Pfab et al. also failed to mention my two publications on the subject of 1999 and 2003.

Is there a link between the morel species and the symptoms? Returning to the case of Pinillos et al. (2008), the species could be correctly identified as

Morchella rotunda var. *rigida*, a species belonging the group of the “blond” or yellow morels. The mushrooms (Figure 6) were collected next to a creek, close to ash trees, and consumed three days later after cooking for 20 minutes.

Hemolysis was completely ruled out and the predominant symptoms (dizziness, dysarthria, unsteadiness, incoordination of gait, tremor, nystagmus) were those typical of a cerebellar syndrome. The amount of mushrooms each patient consumed was considerable. In the episode reported by López Castillo et al. (2008), from Granada, Spain, which was possibly the first report for Spain outside the more popular morel habitat of the North and the Pyrenees, there were three adults who consumed mushrooms for dinner, among them were *Morchella esculenta* var. *rigida* and *Morchella esculenta* (Figure 7). The habitat for collecting the mushrooms was the bank of a mountain stream with a grassy bank understory between poplars and ash trees. The mushrooms were not dried. They were frozen after previously boiling and consumed after a month and a half. Each diner ingested approximately 300 grams of morels. Only two of them drank wine but the symptoms were similar in all of them: instability, dizziness, lack of balance, tremors, motor incoordination, and vision disorders. One of the people, the mother of a nine-month-old girl, breastfed her at midnight, after eating the mushrooms. The next day the girl “was abnormally calm and with incoordination in her usual movements and gestures, such as her inability to clap. When asked to do so, she crossed her hands at the wrong time, being unable to bump into one another as she usually did.” For this reason they deduced that “the possible neurotoxin can be conveyed by breast milk, producing alterations in the movements and behavior of the infant.”

Méndez Meléndez et al. (2008) report two episodes that occurred in April 2008 in Asturias, which occurred on two consecutive days with morels collected in forest areas near a river and well cooked. The patients (one and two victims, respectively) presented similar symptoms (dizziness, tremor, instability) which were classified as CSM (cerebellar syndrome by morels).

From the detailed analysis of



Figure 6. *Morchella rotunda* var. *rigida*, courtesy P. Iglesias.



Figure 7. *M. esculenta*, courtesy P. Arrillaga.

the various communications and publications on this neurological affection caused by the consumption of morels, it was evident that its symptoms were not limited to those of a cerebellar syndrome. Indeed, hallucinations, agitation, headache, muscle cramps, dysarthria, confusion and drowsiness are not typical of this syndrome. In fact, Saviuc et al. published a review in *Clinical Toxicology* (2010), based on their extensive report in 2008, in which they called this toxicity NS (neurological

syndrome) and comment that it is very different from the usual gastroenteritis syndrome that occurs after ingestion of undercooked morels and it is not limited to a cerebellar syndrome. Even so, the term “cerebellar syndrome due to morels” continues to be used by most authors and researchers who have addressed the subject to date.

Recently, there has been much discussion regarding possible neurotoxicity due to morels, especially in internet forums, from Spain and

elsewhere. In some cases, the association of hallucinations was mentioned but in general the symptoms described were the usual ones of cerebellar syndrome. As an example, Manuel Becerra Parra reported in the Micolist mycological forum that “several people in Arriate (Malaga) have suffered the effects of these mushrooms the morning after their consumption presenting motor incoordination and pseudo-drunkenness.” He mentioned three factors present in all these cases: harvested under ash trees, consumption of the mushrooms on the same day (usually at dinner), and diners had “binged” on morels. He adds that there is a belief that the morels of the ash trees are responsible for dizziness symptoms.

In November 2012, I visited Jimena de la Frontera (Los Alcornocales Natural Park, Cádiz), invited by the Chantarella Mycological Society, and I had the opportunity to talk with some members of that society, who reported cases of their acquaintances who had suffered from syndromes of that type, and apparently they continued to “suffer” when they have the great fortune of abundant morel harvests. In the spring of the following year, new cases of cerebellar syndrome were reported in the Micolist forum, this time in Asturias. It so happened that they were fresh mushrooms cooked a year before, and immediately frozen. In this case the drying process was missing again. Also

in 2013, Santiago, Elizalde, Jean-Luis, and myself, published in the magazine *Emergencias* two episodes from the Emergency Service of the Complejo Hospitalario of Navarra (Pamplona, Spain). In the first, it was a 45-year-old woman who, the day after eating a dish cooked with morels collected at the edge of a stream, presented a cerebellar syndrome, without hallucinations. She was admitted for observation, treated, and discharged 24 hours after the onset of the affliction. In the second episode, a couple and their 32-year-old daughter, who ate a stew of morels collected on the bank of a creek and cooked for about 20 minutes; the next day presented with a florid cerebellar neurological syndrome in the case of the daughter and the mother, along with the presence of horizontal nystagmus and Romberg’s sign. A milder affliction in the case of the father, with instability and trembling of the hands. They were discharged after 24 hours practically asymptomatic. It is worth noting that their daughter, who had a baby, breastfed him three times that night and the infant did not present any symptoms (Santiago et al., 2013).

As a simple anecdote, I would like to point out that in the 750-page encyclopedic book *Mycologie Médicale*, coordinated by the mycologist Christian Ripert, Saviuc (2013) points out that the first reference to neurological toxicity by morels comes from the year 1899. In fact we can also find reference to this in the

article on NS (neurological syndrome) by Saviuc et al. (2010). In this article, after commenting that NS could be related to storage in poor condition, they point out that in 1899 Roumeguère reported the role of defective storage or the poor condition of the specimens at the time of collection (very old specimens). To date, that would be the oldest reference I have been able to find on possible morel toxicity. As I have not been able to access the original article from 1899, I have my doubts that it really referred to a neurological or cerebellar syndrome, or to some type of inebriation due to morels. So for now we can continue to consider Jaccottet as the author of the first reference to this type of toxicity.

López Castillo (2020) recently recounted an experience similar to the one I had in 2012. It was in Los Alcornocales Natural Park, in the White Villages around the Sierra de Grazalema, (El Bosque, Villamartín, Ubrique, Benamahoma), where there is a great tradition of consuming *Morchellas* or “cagarrias,” as they are usually called. The vast majority of the locals do not dry them, but cook them when fresh. During the 2018 and 2019 “Day of the cagarria,” he collected testimonies from locals who jokingly recounted their episodes of “drunkenness” after consumption of abundant morels.

And one last report. In April 2017, again in the Micolist forum there are reports of new cases of cerebellar syndrome due to morels. First it was Pablo Alvarado who reported the case of three people who consumed morels collected in the same area where he had collected and described *Morchella fluvialis* (figure 8) (stream banks with ash trees in Asturias). The mushrooms were not dried. One woman ate a large amount and developed dizziness, inability to walk, and poor hand coordination. She was treated at the Cabueñes Hospital (Gijón). The symptoms remitted the same day. That same month, Dr. Miguel Angel Pinillos reported the case of three people who, after collecting some fresh morels on the river bank, cooked them for 20 minutes and then ate them, without consuming alcohol. The one who ate the most, at 10 am presented with dizziness, instability, and stiffness of the limbs, for which she was admitted to the Hospital Complex of Navarra. After several hours in hospital,



Figure 8. *Morchella fluvialis*, courtesy P. Iglesias.

she was discharged. The other two, who ate fewer mushrooms, remained asymptomatic. That same year, at the 37th Congress of the EAPCCT held in Basel, a team of French doctors from various centers (Bruneau et al., 2017) reported that among the 772 mycetisms collected in 2014, 23 corresponded to a neurotoxic syndrome caused by morels, so that this type of toxicity was already well known outside my country.

Are there interactions of morels with alcohol?

We have all heard of coprinic syndrome, an unpleasant reaction that occurs if consuming *Coprinus atramentarius* along with alcohol. This interaction with ethanol is not exclusive to *Coprinus atramentarius*; it has been reported for *Clitocybe clavipes*, *Boletus luridus*, some *Morchella* spp., other *Coprinus* and randomly in some people with some chemicals and medications. Christensen, in his book *Molds, Mushrooms and Mycotoxins* (1975), mentions that some morels can give reactions similar to those of the *Coprinus*, and Groves (1964) had warned of the danger of consuming some morels (specifically *Morchella angusticeps*) together with alcoholic beverages. In fact, this species appears in the database of the North American registry of poisonings by mushrooms as the cause of five poisonings in the 1990s (Cochran, 2000). Among NAMA records, Beug (2006) has mentioned some cases of toxicity associated with alcohol consumption caused by *Morchella* spp. The syndrome seems to be superimposable to the classic coprinic syndrome (for review, see Piqueras, 1981). Until 2012, I was unaware of any such cases between morels and alcohol in my country. But in October of that year, an interesting episode occurred in Catalonia in which six out of fifteen diners presented with symptoms 30 minutes after ingesting the mushrooms that were offered as a first course in a restaurant (morels stuffed with zucchini and gratin with grated cheese). The six who drank wine were the only ones who developed cutaneous erythema, a sensation of lip swelling, palpitations, and in some of them vomiting and hypotension. I could not study the mushrooms but I received some photos of the dried morels. There



Figure 9. *Morchella conica*, courtesy R. Blasco.



Figure 10. *Morchella sextelata*, courtesy T. Conca.

were two or maybe three species of *Morchella*, possibly *M. esculenta* and *M. conica* (Figure 9).

Can morels kill? ... a curious case

On Saturday, February 16, 2019, to celebrate his birthday, a 44-year-old man, along with his 46-year-old wife and 12-year-old son, went to the Riff restaurant of chef Bernd H. Knöller (awarded a Michelin star), in Valencia. Like most of the diners, they enjoyed the tasting menu. Menus of this type include numerous dishes in rather small quantities, to give the opportunity to

taste various foods. One of these dishes was a rice with morels.

In the afternoon all three suffered nausea, vomiting and diarrhea. Symptoms lasted overnight from Saturday to Sunday. The father and son recovered but the woman, following profuse vomiting, died at dawn on Sunday at her home. The Ministry of Health launched an investigation. As a result, it was found that seven other diners at the restaurant also were sickened but recovered. When the survey was extended to the previous three days, it was confirmed that a total

of 30 people who ate at the restaurant between February 13 and 16, including the family of the deceased woman, suffered from mild gastroenteritis, but no further consequences. In the one case of death, the autopsy showed that she died from bronchial aspiration during vomiting. Word got out and everyone was suspicious of the mushrooms. The other foods on the tasting menu were not considered, as is often the case, mushrooms were the “usual suspects” blamed in the media (Anonymous, 2019; Eustachewich, 2019; Ayuso, 2019). On February 18, the food safety inspectors made a visit to the establishment in order to examine its hygienic and sanitary conditions. Likewise, samples of foods and ingredients that were part of the tasting menu were collected for analysis. Mycologist Javier Marcos Martínez used DNA analysis to confirm that the morels served on the menu were *Morchella sextelata* (Figure 10). This morel, the sixth phylogenetic species in the *Morchella elata* clade (O'Donnell et al., 2011), is virtually identical morphologically to other species of that clade (*M. septimelata*, *M. brunnea*, *M. angusticeps*, and *M. septentrionalis*) (Kuo et al., 2012). This excellent edible species is widely cultivated in various parts of China, and can be seen in the markets in spring,

imported from that country. Curiously, the label on the box of mushrooms found in the restaurant indicated that they were wild mushrooms collected in Spain, sent by an authorized dealer in Castilla y León. But in actuality they were cultivated and imported from China which launched an investigation by Public Health. Nothing was ever determined conclusively, but a chemical additive was most likely the source of illness, not the mushrooms. Since it is not uncommon for the pesticide metaldehyde to be applied to mushrooms in order to prevent their deterioration on their trip from China, it was thought that this could have been the cause of the gastroenteritis outbreak.

At the beginning of December of that same year, a similar episode occurred in Argentina. On December 4, I received an email from Rodrigo Bustamante, from the Río Negro Province Ministry of Health, requesting my advice on a case that occurred in the city of San Carlos de Bariloche (Río Negro province, Argentina). It was about a family that purchased and consumed dried morels native to the area, then prepared them in tomato sauce. The family consisted of a 47-year-old man, along with his wife and daughter. The man, who was the one who ingested the greatest amount of mushrooms (about 10 specimens

approximately), suffered from vomiting and diarrhea 30 minutes after ingestion. A few hours later, he presented with muscle weakness in the lower and upper limbs, loss of consciousness, seizures, and cardiorespiratory arrest. He was admitted to a nearby hospital and died within 36 hours. The wife suffered only vomiting and diarrhea; while her daughter, who ingested a small amount of mushrooms, had no symptoms. Rodrigo Bustamante sent me photographs that I shared with some other experts of *Morchella*. In López Castillo's opinion, they appear to be from the *Distantes* section, close to *M. tridentina* (formerly *M. elatoides*) (Figure 11).

No other food was suspected other than the morels. Two hypotheses were that either the mushrooms were indeed toxic (though of an unknown toxic) or that the mushrooms had picked up some poison, either from the soil where they grew, contamination, or deterioration along the way. Samples of gastric lavage from the deceased patient were analyzed. The Department of Environmental Health collected four bags of mushrooms from the market, as well as the leftover mushrooms in the family's possession, and sent them for analysis by CIEFAP laboratories. The results showed that nearly a third of the specimens were deteriorated and moldy, and some with evidence of damage by insects. As with the Valencia case, I believe that the toxicity was not caused by morels. In my opinion, the poor condition of some of the mushrooms could point to food poisoning. López Castillo offered advice about drying mushrooms: for proper desiccation humidity must be below 10% to avoid any type of microbiological contamination. It is common to see insufficiently dried morels in the markets (López Castillo, 2019).

Summary about cerebellar syndrome due to morels

1. This syndrome is a set of disorders that sometimes can appear after ingestion of mushrooms of the genus *Morchella*. There may be a latency period of 8 to 12 hours; onset of symptoms may not begin until the following morning after ingestion. The most common symptoms are dizziness, instability, dysarthria, incoordination of motor skills,



Figure 11. *Morchella tridentina*, courtesy J. A. Cañestro.

tremors, and ataxia. Sometimes other alterations of the senses can be associated, from hyperacusis to pseudo-hallucinatory pictures. In some cases digestive symptoms are associated. Nystagmus is relatively common on examination.

2. There is no real treatment, since neither the toxin nor its mechanism of action is known. Patients should be kept under observation for a period of 12 hours. In the case of significant digestive symptoms, it may be necessary to administer antiemetics, anti-diarrheals, and plenty of fluids. It is important to reassure patients; make it clear that the symptoms will resolve spontaneously within hours or at most days, and that there have been no deaths from this intoxication. In this sense, Bruneau et al. (2017) applied the Poisoning Severity Score (PSS) to 23 cases of neurological syndrome due to morels collected in 2014; 20 scored PSS1, the other 3 merited PSS2 (very mild and moderate), and no case was deemed PSS3 or PSS4 scores (severe and very severe forms).
3. From the detailed analysis of all the cases published or known at the present time, some characteristics or circumstances typical of this syndrome can be inferred:
 - The morels were nearly always fresh, not dried; in one case they were canned mushrooms and another two were dried. It is recommended that the desiccation be as complete as possible.
 - The afflicted usually noted that the amount ingested was generally high, usually more than 300 grams (10.5 ounces).
 - Often a positive ID of morel species is not certain; in many cases *Morchella rotunda* var. *rigida* was involved.
 - In almost all cases the morel collectors noted “the proximity of rivers, streams, and creeks” (riparian forests).
 - In many cases the morel collectors noted ash trees (*Fraxinus* spp.) nearby.
 - Alcohol does not seem to play a role in this intoxication.
 - Freezing morels does not eliminate their toxicity.

- There are conflicting reports over the possibility that the neurotoxin is excreted in human milk.
- Anyone may have a personal intolerance to morels. As with other foods, the consumption of morels, even if properly cooked, can cause GI problems for those with a sensitivity. This does not imply toxicity, since it is an idiosyncratic reaction that only affects certain subjects.

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