# Wild Mushrooms and Lichens used as Human Food for Survival in War Conditions; Podrinje - Zepa Region (Bosnia and Herzegovina, W. Balkan)

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## *Abstract*

*During 2002-2005, research has been conducted within eastern Bosnia, on the use of mushrooms and lichens and their effect on people's survival in war shelters and on isolated guerilla fighters in the area during the war in Bosnia and Herzegovina (1992-95). 51 adults have been contacted for this research, including former soldiers who were holed-up in the enclave during the siege between April 1992 and June 1995, when free territory was overtaken. At that time, residents of the area escaped and a number of defense soldiers formed guerilla groups.*

*Using the method of "ethnobotanical" interview, 25 species of mushrooms and 7 species of lichens were used by interviewees during the siege. The most used mushrooms were: Agaricus campestris, Boletus edulis, and Cantharellus cibarius. The most used lichens were Evernia prunastri (oak lichen) and Usnea sp. (Old Man's Beard), used for porridge and for lichen flour.*

***Keywords:*** *food shortage, biodiversity, human behavior, human ecology, survival*

## Introduction

Besides chronic and acute hunger caused by different economic and social issues (WHO 2000; FAO/WHO 2002; Allen et al. 2006) in some countries, common causes of hunger are war, exodus and ghettoes. Such patterns of human interaction are, unfortunately, becoming more present. (Goto et al. 1958; Guggenheim 1982; Smith Fawzi et al. 1997; Huxley et al. 2000). One example of such an occurrence is the four-year long war (1992-1995) in Bosnia and Herzegovina (B&H) followed by exoduses of civil victims (ICMP 2007), a constant lack of food, drinking water and medicines (Redzic et al. 1997).

A particularly difficult and incertitude situation was in the occupied and completely blocked Sarajevo, as well as isolated enclaves in eastern Bosnia — Zepa and Srebrenica, as well as in other places where humanitarian aid wasn't distributed.

Wars, exoduses and ghettoes around the world are causes of malnutrition in all residents, including soldiers. A number of syndromes are direct result of malnutrition. It was noted that these situations can lead to a growth in cases of di-

abetes (Goto et al. 1958), reproductive problems (Wynn and Wynn 1993), a decrease of body mass index in children (Redzic and Hadzihalilovic 2007) and a high number of miscarriages (Redzic 1999).

Circumstances during the war were extremely tough. It was particularly difficult to accept them as conditions in which one could organize an ordinary life. After a certain period of time, some kind of hidden instinct and urge to struggle for life emerged. Among the population, certain psychoecological patterns in approach and concept of living were developed. With time, people even became used to living with bombshells and everyday explosions. In the next phase, a form of "war syndrome as survival necessity" appeared. During the initial few months, people's weight loss was significant, sometimes up to 30kg. Mass undernourishment developed (Smaijkić et al. 1995). Afterward, people developed a stronger instinct for living and desire for survival. The first reaction to the new conditions was to search for food in the immediate environment (Redzic 1993).

The lack of conventional food during was emphasized in urban areas, especially in surrounded Sarajevo (Redzic 1993; Vespa and Watson 1993-95). Besides the lack of food, there were huge shortages in dietetics and medicines, which mostly influenced elderly and chronic patients (Redzic 1999a). Therefore, a plan of obtaining additional nutrition from the natural environment was used (Redzic 1993), including gathering medicinal plants in free territories that were used as dietetics products (Redzic et al. 1997).

Conditions in villages were slightly different. Residents were oriented toward nature and natural food sources, toward surviving in difficult everyday conditions. Despite that, reserves of conventional food were exhausted in time and the population suffered from severe hunger. Hunger influenced civilians and soldiers to find ways to use available food. An especially difficult situation was in the occupied and surrounded area of Podrinje, in a town called Zepa. People from this area were under siege for three and half years, and were forcibly expelled in June 1995. Several thousand people sought refuge toward free territories through nearby cliffs, while haunted by panic and hit by severe hunger. For some of them, this fight for survival lasted up to six months. People ate anything. Centuries long held myths about wild food, especially about mushrooms and lichens, and some small animals, were disregarded. It is all about prejudices. People have rather died of hunger than reached after food from the wilderness. They preferred to consume either beech bark or shoe soles than to look after the alternative food sources in nature. In general, mushrooms were considered to be dangerous and poisonous, which is why they were avoided in human nutrition. Thus, many species of high nutritional values, such as those from genera *Coprinus, Boletus, Russula* and others, have not been used at all. Even today, one can hear the stories about killing of unwanted persons with mushrooms (women used to poison spouses they didn't like or daughters in law used to poison their mothers in law). For some of the mushrooms, such as *Morchella* genus, it is common belief that they increase sexual potential in men. Therefore, young women used to keep pulverized mushrooms, hidden away from other household's members, and to administrate it in secret to their husbands, just before going to bed. And if they have found *Phallus impudicus*, girls believed that it was a sign how well equipped would be their future spouse.

Even though mushrooms were very unpopular in conventional nutrition in these areas due to genuine fear of poisonous mushrooms, the situation during the war was completely different. Increased interest was not only toward two or three previously known species (*Agaricus, Lactarius* and *Morchella*) but toward a number of other species. This improved the human protein intake that they were lacking. Previous research on the use of mushrooms in human nutrition, especially on their nutritive and curative aspects, proved without doubt that mushrooms are extremely important (Grlic 1980; Miles and Chang 1997; Manzi et al. 1999; Mattila et al. 2000; Pieroni et al. 2005; Ruan-Soto et al. 2006). Mushrooms are also known to be a very healthy food and good as a dietetic and medicine (Breene 1990; Johl et al. 1995-96; Falandysz et al. 2001; Dabour and Takruri 2002; Hossain et al. 2003; Dursun et al. 2006). For these reasons, more attention has been given to mushrooms. This is particularly due to the fact that a great number of mushrooms are still unknown biologically in relation to their nutritional and medicinal value.

As wars and other catastrophes are followed by lack of conventional food, greater attention is given to the discovery of new food sources (Ertug 2004; GRIN 2005; PFAF 2006; Tardio et al. 2006; Redzic 2006a). Such sources could be found in already known, as well as still unknown, plants, mushrooms and wild animals (CBD 2005). If compared to wild plants, mushrooms have much better nutritive advantages, as a good source of proteins, minerals and fats. (Petrovska et al. 2001; Savage et al. 2002).

Lichens or lichenized fungi are important but a still poorly affirmed source in human nutrition. There are cases where people would rather die from chronic hunger than eat a wild plant, animal or lichen (Vracaric 1977). Unlike plants and mushrooms, lichens are not poisonous or are far less poisonous and therefore are more suitable for human use. According to recent studies, lichens are an extraordinary source of nutrients, dietetics and medicines (Gorin and Iacomini 1984; Esimone et Adikwu 1999; Gulcin et al. 2002).

Most recent results in food science studies have indicated an extraordinary importance on a global level of an in-

creased need for new sources of food and new means of food preparation. (Pieroni et al. 2005; Luczaj and Szymanski 2007).

Wild mushrooms and lichens, in particular, are still fairly unknown and poorly affirmed in human nutrition, especially in extraordinary conditions such as war. This study gives special attention to such biodiversity with the goal to promote them as new sources in production of different dietetics, both in war and peaceful situations. Previous experience in these areas showed that only a few plants are known as supplements for flour (Vracaric et al. 1967; Vracaric 1977; Redzic 2006a). In this aspect, lichens are additional and important resources.

The main goals of this study are:

(i) to provide an inventory of mushrooms and lichens used by humans as a food source during the war in eastern Bosnia;
(ii) to offer ways of preparation, preservation and storage of these food sources;
(iii) to identified original nutrition patterns in cases of food shortages during war and in occupied areas and shelters;
(iv) and to investigate changes in behavior of affected individuals and amplitudes of their adaptation on a given environmental conditions.

## Material and Methods

### Study Area

The study area is located in eastern Bosnia on the border with the Republic of Serbia (19˚ – 20˚ E and 43˚30' – 44˚30' N (Figure 1)). This territory includes about 1550 km$^2$. It is inhabited by approximately 25,000 residents. The Zepa area is a valley encircled with mountains. The elevation of Veliki Stolac, 1673 meters, on the east side, elevation of Devetak is on the west, and elevation of Veliki Zep, 1537 meters, is on the north. Very steep cliffs surround this gentle valley (at some spots over 60 degrees). The altitude varies between 230 meters at the shores of the river Drina to about 1000 meters at the edge of the valley. In the near proximity is the canyon of the river Drina, surrounded by limestone cliffs. The depth of the canyon in this area is the highest, about 1300 meters. The canyon is very inaccessible and wild. This area hides a large number of caves, safely hidden from the wild world (Redzic et al., 2003).

The vegetation is very dense and diversified, including oaks and hornbeam forests in the lowest parts (*Querco-Carpinetum*). The northern mountains are covered with Moezian beech forests (*Fagetum moesiacae*). The warmer areas, with shallower soil and carbon geological foundation, are covered with forests and bushes of oak (*Quercus pubescens*), black hornbeams (*Ostrya carpinifolia*) and black maple (*Fraxinus ornus*). The canyon area is covered with a number of endemic species. Most significant are forests of lime and Bosnian maple *Aceri obtusti- Tilietum "mixtum"*, forests of black maple *Seslerio-Ostryetum* and many others. Special attention is drawn by steno-endemic unions in ruptures of rocks and cliffs. Endemic spruce (*Picea omorika*) grows in higher areas. Places where forests are suppressed are covered by vegetation of karsts terrain of *Scorzonero-Chrysopogonetalia*, thermophilic meadows of *Brometalia erecti*, and mesophitic meadows of *Arrhenatheretalia* (Redzic 1999b, 2003; Redzic et al. 2003). Smaller surfaces have been planted with vegetables (onion, cabbage, peppers, potatoes, tomatoes, mangel), or cereal crops (barley, oats, wheat, rye). In the close proximity of villages, orchards of plum trees, apple trees and pear trees are planted (Redzic 2006b).


**Figure 1.** Study Area
(Source: http://enrin.grida.no/htmls/bosnia/soe/maps/index.htm)

### Population

In the pre-war period, the majority of the population was Bosnian Muslims (about 90%). The rest were Bosnian Orthodox. The majority of the population was involved in agriculture — cattle breeding and fruit-growing. Due to isolation from main roads, communication and large distances from bigger urban centers, a large number of residents have immigrated to other areas. However, the majority has remained connected to their area of origin (Redzic 2006a).

Most of the people maintain behavior they used to have in the previous social surroundings, including the dialect, which makes them easily recognizable. Besides, they used local names for plants and mushrooms that were not common in the new social milieu and kept using some plants and mushrooms in the way they used to do it at their childhood while helping on the land or with the cattle (Redzic, 2010).

**Circumstances**

After the start of aggression in B&H, in the spring of 1992, Serb forces occupied large areas and established full control over them. Areas that were not occupied were surrounded and kept in total blockade and isolation with the intention of attenuating local residents and eventually occupying the territory (WP 2007a). That region included several villages in Podrinje in eastern Bosnia, in particular, the town of Zepa. About 10 000 people lived there at that time. As time went by, a circle around the city was tightened. Living conditions deteriorated and it became increasingly dangerous. Food reserves were drained more and more every day. By the fall of 1992, reserves of conventional food were already minimal. Lack of flour was significant. Most of the people turned toward alternative sources of food. They were finding their own ways to survive. Fortunately, among residents there were some more educated people who were able to recognize edible plants, mushrooms and animals. Special attention was given to avoid poisonous mushrooms. Natural instincts were particularly dominant in such cases as the struggle for life was at its peak. In the end, no residents were poisoned with natural food. The hardest days for this eastern Bosnian enclave were in the summer of 1995. The territory was occupied and the people were forced to find shelter (WP 2007b). During that period, people used wild fruits and mushrooms such as chanterelle, etc.. However, a number of people, mostly men, escaped to the deep and inaccessible canyon of the Drina river. Some of them spent up to three months in this wilderness. As reserves of conventional food were extremely low, their only option was to turn toward natural sources. Besides wild plants, they used mushrooms and lichens.

**Field Work**

The research on the use of mushrooms and lichens in these areas was conducted during the period 2004-2006 in different seasons. Contact was made with people that spent several months in the total wilderness of the canyon of the Drina river and its confluents. They played a key role in marking the territories which were inhabited by people during the war and exoduses. In addition, they went through the whole area with the author and showed him the mushrooms and lichens they consumed. The interviews took place in the spring of 2004, in the summer, fall and early winter of 2005 and in the spring and summer of 2006.

The main method in gathering information was direct interview with surviving residents, mostly above 50 years of age. A total of 51 people were interviewed (32 men and 19 women). All of the interviewees were Bosnian Muslims. Samples of mushrooms and lichens collected by the author were shown to the interviewees, who identified these as species that they used during the war. Lichens species were identified with a 100% certainty.

The information gathered in the field also included the names of mushrooms and lichens consumed, the usable parts, harvest time, means of preservation and use of nutritive products, time of interviews, names of people interviewed, age and sex, level of education, area (name of location) and biotope (forest, meadow, karsts terrain, others).

**Informed Consent**

All people voluntarily agreed to participate in this research without any special conditions. On the contrary, they were all very friendly and willing to contribute to this research, especially the members of the "Kokić" family. This family led the author to the most inaccessible terrain in the canyon of the Drina were they hid for several months after their exodus from the Zepa area.

**Laboratory Work**

The gathered and preserved material of mushrooms was finally determined by using literature sources (Vracaric 1977; Grlic 1980; Focht 1990) and of lichens or lichenized fungi, using keys for determination (Kusan 1953; Murati 1992a, 1992b). Nomenclature of species and genus was conducted in accordance with Index Fungorum (IF 2010). Upon determination, voucher specimens were stored in the Herbarium of the Center for Ecology and Natural Resources, Faculty of Sciences, University of Sarajevo (CEPRES HERB).

Types of habitat were determined on the basis of species' ecological inclination toward certain a plant community, according to the methodology of Braun-Blanquet (1964). Determination of ecological conditions was carried out according to the author's judgment and syntaxonomy according to Oberdorfer (1983) and Redzic (2003).

## Results

**Citation of Mushrooms and Lichens**

Table 1 shows the 25 species of wild mushrooms and seven species of lichens that were used during the war by local residents and soldiers. The most mentioned mushrooms (over 80%) were: *Agaricus campestris, Lactarius piperatus* and *Morchella conica*. *Boletus edulis, Cantharelus cibarius*, and *Lactarius delicious* have been quoted 61-80% of the

*Table 1*. Edible Wild Fungi and Lichens/lichenized Fungi Consumed in the Region of Podrinje in the Canyon of Drina River (Bosnia and Herzegovina)

| Scientific Name / (Voucher) | Local Name | English Name | Family | Frequency of Citation | Season of Fructification | Habitat/ Community* | Mode of Consumption |
|---|---|---|---|---|---|---|---|
| **FUNGI** | | | | | | | |
| *Agaricus campestris* L. 1753 (F20101) | Rudnjaca, pecurka | Field Mushroom | Agaricaceae | 45 | Jul-Oct | Arrh, Be | Baked, raw |
| *Agaricus macrosporus* (F.H. Møller & Jul. Schäff.) Pil·t 1951 (F20102) | Velika rudnjaca | Meadow Gigant Mushroom | Agaricaceae | 27 | Jul-Sep | Arrh, Be | Baked, raw |
| *Agaricus silvaticus* Schaeff. 1774. (F20103) | Sumska pecurka | Wood Mushroom | Agaricaceae | 15 | Aug-Sep | V-P, Fag | Baked, raw |
| *Armillariella mellea* (Vahl) P. Karst. 1881. (F20201) | Mednjaca | Honey Fungus | Physalacriaceae | 6 | Aug-Nov | Fag, V-P, Qp | Baked, cooked |
| *Boletus aereus* Bull. 1789 (F20301) | Vrganj zuti | Queen Boletus | Boletaceae | 9 | Aug-Nov | Fag, V-P | Fried, soup, dried |
| *Boletus edulis* Bull. 1782 (F20302) | Vrganj pravi | King Boletus | Boletaceae | 35 | Jul-Oct | Fag, V-P | Fried, soup, dried |
| *Calocybe gambosa* (Fr.) Donk 1962 (F20202) | Durdevaca | St George's Mushroom | Lyophyllaceae | 14 | April-Jun | Arrh, Be, Ps, V-P | Baked |
| *Calvatia gigantea* (Batsch) Lloyd 1904 (F20401) | Velika puhara | Gigan Bovista | Agaricaceae | 6 | Jun-Sep | Be, Arrh | Baked, raw |
| *Cantharellus cibarius* Fr. 1821 (F20501) | Lisicarka | Cantarelle | Cantharellaceae | 35 | Jun -Nov | Fag, V- P, Qp | Baked, fried |
| *Coprinus atramentarius* (Bull.) Fr. 1838 (F20601) | Jarcici | Common Ink Cap | Coprinaceae | 5 | May-Oct | Ono, Fag, Ps, Ch | Baked, fried |
| *Coprinus comatus* (O.F. M¸ll.) Pers. 1797 (F20602) | Gnjoiötarka | Lawyer's Wig | Coprinaceae | 9 | Jul-Nov | Ono, Fag, V-P | Baked, fried |
| *Hydnum repandum* L. 1753 (F20701) | Jeûevka | Wood Hedgehog | Hydnaceae | 5 | Jul-Oct | Fag, V-P | Baked, cooked |
| *Kuehneromyces mutabilis* (Schaeff.) Singer & A.H. Sm. 1946 (F20801) | Panjevaca | Honey Fungus | Strophariaceae | 7 | Jul-Nov | Fag, Qp | Baked, fried |
| *Lactarius deliciosus* (L.) Gray 1821 (F20901) | Jesenka | Milk Autumn Mushroom | Russulaceae | 37 | Aug-Dec | Fag, V-P, Pter, Junip | Baked, fried |
| *Lactarius piperatus* (L.) Pers. 1797 (F20902) | Mlijecnica | Milk paper mushroom | Russulaceae | 46 | May-Oct | Fag, V-P, Qp | Baked, fried |
| *Lactarius volemus* (Fr.) Fr. 1838 (F20903) | Prjesnac | Milk Fresh Mushroom | Russulaceae | 25 | Jun-Oct | Fag, V-P | Baked, fried, raw |
| *Lycoperdon perlatum* Pers. (F20402) | Puhara | Bovista plumbea | Agaricaceae | 9 | Jun-Nov | Arrh, Be | Baked, fried, raw |
| *Macrolepiota procera* (Scop.) Singer 1948 (F201001) | Suncanica | Parasol Mushroom | Agaricaceaee | 22 | Jun -Oct | Qp, Fag | Baked, fried, dried |
| *Macrolepiota rhacodes* (Vittad.) Singer 1951 (F21002) | Velika suncanica | Shaggy Parasol | Agaricaceae | 14 | Jul -Oct | Fag, Arrh, Junip | Baked, fried, dried |
| *Marasmius oreades* (Bolton) Fr. 1836 (F21101) | Vilin klincic | Fairy Ring Mushroom | Marasmiaceae | 9 | May -Oct | Arrh., Be | Baked, fried |
| *Morchella conica* Pers. 1818 (F11201) | Smrcak | Morel | Morchellaceae | 47 | Apr-Jun | V-P | Baked, fried, dried |
| *Pleurotus ostreatus* (Jacq.) P. Kumm. 1871 (F21301) | Bukovaca | Oyster mushroom | Pleurotaceae | 21 | Sep-Dec | Fag, V-P | Baked, fried |
| *Polyporus squamosus* (Huds.) Fr. 182 (F21401) | Skripavac | Forest mushroom | Polyporaceae | 7 | Apr -Sep | Fag | Baked, cooked |

*Table 1*. Edible Wild Fungi and Lichens/lichenized Fungi Consumed in the Region of Podrinje in the Canyon of Drina River (Bosnia and Herzegovina) (continued)

| Scientific Name / (Voucher) | Local Name | English Name | Family | Frequency of Citation | Season of Fructification | Habitat/ Community* | Mode of Consumption |
|---|---|---|---|---|---|---|---|
| **FUNGI (continued)** | | | | | | | |
| *Ramaria flava* (Schaeff.) Quél. 1888 | Koralka | Pale-yellow calvarias | Gomphaceae | 8 | Jun-Sep | Fag | Cocked, baked |
| *Tricholoma terreum* (Schaeff.) P. Kumm. 1871 (F20203) | Redusa | Grey Knight | Tricholomataceae | 21 | Sep-Nov | Ph-n, V-P, Fag | Baked, fried |
| **LICHENS/LICHENIZED FUNGI** | | | | | | | |
| *Bryoria fuscescens* (Gyeln.) Brodo & D. Hawksw. 1977 (L10101) | Lisaj, masina | Horsehair lichen | Parmeliaceae | 5 | Sep-Dec | Fag, Qp At the bark of *Fagus, Quercus* | Mush and lichen bread |
| *Cetraria islandica* (L.) Ach. 1803 (L10102) | Islandski lisaj, Islandska mahovina | Iceland moss | Parmeliaceae | 12 | Jun-Dec | Be, Junip | Salad (young thallus), mush and lichen bread |
| *Pseudevernia furfuracea* (L.) Zopf 1903 (L10103) | Konjski rep | Horsehair lichen | Parmeliaceae | 9 | Jun-Dec | Fag, Qp In forests (mainly on *Fagus, Betula* and *Quercus*) and on isolated trees | Mush and lichen bread |
| *Evernia prunastri* (L.) Ach. 1810 (L10104) | Hrastov lisaj | Oak's lichen | Parmeliaceae | 12 | Jun-Feb | Fag Manly on *Prunus* sp., trees | Mush and lichen bread |
| *Lobaria pulmonaria* (L.) Hoffm. 1796 (L10201) | Plucni lisaj | Lungwor | Lobariaceae | 10 | Jun-Feb | Fag, V-P Corticolous, mostly on old *Fagus*, and *Quercus* trees | Mush and lichen bread |
| *Ramalina farinacea* (L.) Ach. 1810 (L10301) | Viseci lisaj | A lichen | Ramalinaceae | 5 | Jun-Feb | Fag on all kinds of deciduous trees, in open or in forest conditions | Mush and lichen bread |
| *Usnea barbata* (L.) Weber ex F.H. Wigg. 1780 (L10105) | Djedova brada | A lichen | Parmeliaceae | 11 | Jun-Jan | Fag On any kind of deciduous trees in forests | Mush and lichen bread |

**Legend:**
*Habitat/Community:
Arrh - *Arrhenatheretalia* (mesophilous grasslands); Be - *Brometalia erecti* (dry grasslands); V-P - *Vaccinio-Piceetalia* (dark coniferous forest); Fag - *Fagetalia* (dark deciduous and beech forest); QP - *Quercetalia pubescentis* (light and dry oak forests); Ps - *Prunetalia spinosae* (law scrubs and living fens) Ono - *Onopordetalia* (neglected habitats with high concentration of nitrogen compounds); Ch - *Chenopodietalia* (more arable and neglected habitats) Pter - *Pteridietalia* (heaths with Pteridium aquilinum); Junip - *Juniperetalia* (law scrubs coniferous vegetation with Juniper); Ph-n - *Pinetalia heldreichii-nigrae* (light coniferous forests with black pine)

time. In the category of 41-60% was *Agaricus macrosporus, Boletus aereus, Lactarius volemus, Macrolepiota procera, Pleurotus ostreatus* and *Tricholoma terreum*, in 20-30% was *Agaricus silvaticus*, Calocybe gombosa and *Macrolepiota rhacodes*, and less than 20% was *Lycoperdon, Coprinus, Marasmius, Ramaria* and others (Table 1).

It is interesting to emphasize that the earlier knowledge of mushrooms and their appearance in a biotope are determining factors for their usage in human food. Therefore, just based on the fact that *Coprinus comatus*, otherwise a very tasty mushroom of high quality, found in rather remote areas is very rarely consumed, while the species *Lactarius piperatus* (quality wise rather behind *Coprinus*) is used frequently as it is found in a clear forest habitats. Also, as an example, the size of the fruiting body could be a limiting factor in the use of mushrooms. People are reluctant toward species *Agaricus macrosporus* or *Calvatia gigantea* simply because they have a "giant" fruiting body and therefore "they could be poisonous". The color of the mushrooms is even more important in the popular decision of which mushrooms are edible. In general, mushrooms with clearer colors are less desirable for food.

Regarding lichens (lichenized fungi), seven species have been consumed, especially for making lichen flour at the times of severe lack of products for bread. People considered lichens as non-poisonous "plants". They were gathered from everywhere, in particular those with bigger biomass and those that are found on the bark of trees. As shown in Table 1, the most used species were *Evernia prunastri*, widely spread in these areas, *Pseudevernia furfuraceaa, Lobaria pulmonaria, Usnea barbata* and *Cetraria islandica*.

## Preparation and Preservation

The edible part of the mushrooms is the aerial part (fruiting body), where the cap is the most popular part. However, during some periods people used the whole aerial part, particularly in young specimens. That is the case of *Calvatia* and *Lycoperdon* that are used while very young, before the spore season. In lichens, the whole talus is used.

Mushrooms were prepared in a very simple way. Most often they were fried, grilled, boiled, dried, etc (Table 2). A total of 23 species were grilled on an open fire or on a plate. About 17 species are fried with fat, alone or along with other species of mushrooms. Some were boiled and prepared in a very tasty stew, while some species were used in preparing soups. Six species were used raw, particularly the species *Agaricus* and *Lactarius volemus*. Some were dried, especially *Morchella* and *Boletus*.

*Table 2*. Preparation and Usage of Mushrooms

| No | Preparation/ Kind of Use of Fungi | Number of Species | Proportion (%) | | |
|---|---|---|---|---|---|
| 1 | Baked mushrooms | 22 | 40.1 | | |
| 2 | Fried mushrooms | 16 | 29.09 | | |
| 3 | Raw mushrooms | 6 | 10.91 | | |
| 4 | Cooked mushrooms | 4 | 7.27 | | |
| 5 | Dried mushrooms as a food or condiment | | | 5 | 9.09 |
| 6 | For the soups | 2 | 3.84 | | |
| **Total:** | **55** | **100** | | | |

Most mushrooms were used fresh. Drying was the only way of preservation, either the whole fruit bodies (*Morchella conica*) or the pieces or just dangling them on a string (*Boletus*). Mushrooms preserved in such manner can be consumed throughout the year.

Lichens or lichenized fungi are used in native form. First they are soaked in cold water over night, and then boiled. In such a process, lichens lose their native bitterness and acerbity. They are then used for stews, soups, or as additives for other meals. In addition, dried and boiled lichens are used for making bread. They are added to flour, soups, and mashes, mostly mixed with some other herbs. During winter, they were mostly mixed with *Nasturtium officinale* and *Oxalis acetosella* (Redzic 2006a).

## Seasonal Dynamics

The seasonal dynamic of mushrooms is in close co-relation with the semi-continental climate of this area. The climate's characteristic is of four seasons. Rather cold winters, sunny and wet falls, rather warm springs and very warm summers. In such conditions, most mushrooms fruit in early fall (in August 20 species, in September 23 species and in October 19 species (Table 1)). Some mushrooms, such as *Lactarius deliciosus* and *Pleurotus ostreatus* fruit in December. Out of all registered mushrooms, the first to appear are *Morchella* and *Calocybe*. It is important to emphasize that in this region, mushrooms are available almost 9-10 months and could significantly assist in overcoming shortages of proteins and food in general.

As the air in this area is very clean, lichens are abundant and productive. A maximum of biomass production is reached in summer and fall. Some are available during winter, in particular *Lobaria pulmonaria* and *Evernia prunastri.* In that period they had a significant role in the production of the so-called lichen flour, as well as in other products used in the nutrition of people and cattle.

## Taxonomic Diversity of Mushrooms and Lichens/lichenized Fungi

Registered mushrooms belong to 15 families. The most available are Agaricaceae with 7 species, Russulaceae with 3 species, Boletaceae and Coprinaceae with two species each. Eight families are represented with one species (Table 3). Most species are Basidiomycota, while only the genus *Morchella* is Ascomycota.

Out of seven species of lichens, four belong to the family Parmeliaceae. The families Ramalinaceae and Lobariaceae are represented with one species each (Table 3). All identified lichens are from the class Ascolichens.

*Table 3*. Systematics of Wild Edible Mushrooms and Lichenes

| No | Family | Number of Species | Proportion (%) | |
|---|---|---|---|---|
| 1 | Agaricaceae | 7 | 21.89 | |
| 2 | Boletaceae 2 | 6.26 | | |
| 3 | Cantharellaceae | 1 | 3.12 | |
| 4 | Coprinaceae | 2 | 6.26 | |
| 5 | Gomphaceae | 1 | 3.12 | |
| 6 | Hydnaceae 1 | 3.12 | | |
| 7 | Lobariaceae | 1 | 3.12 | |
| 8 | Lyophyllaceae | 1 | 3.12 | |
| 9 | Marasmiaceae | 1 | 3.12 | |
| 10 | Morchellaceae | 1 | 3.12 | |
| 11 | Parmeliaceae | 5 | 15.63 | |
| 12 | Physalacriaceae | 1 | 3.12 | |
| 13 | Pleurotaceae | 1 | 3.12 | |
| 14 | Polyporaceae | 1 | 3.12 | |
| 15 | Ramalinaceae | 1 | 3.12 | |
| 16 | Russulaceae | 3 | 9.38 | |
| 17 | Strophoariaceae | 1 | 3.12 | |
| 18 | Tricholomataceae | 1 | 3.12 | |
| **Total:** | **32** | **99.99** | | |

## Habitat and Community

Determined mushrooms grew in 11 different habitats. They belong to 11 different plant communities (Table 4). Most of the mushrooms are found in deciduous forests of oaks and beeches, order Fagetalia (19 species) and in dark conifer forests, order *Vaccinio-Piceetalia* (15 species). Five species are found in thermophilic forests of pubescent oaks, order *Quercetalia pubescentis* and one species are found in black pine forests, order Pinetalia heldreichii-nigrae. Many mushrooms (13 species) grow in two different kinds of meadows, orders *Arrhenatheretalia* and *Brometalia erecti*. A significantly lesser number of species is found in other habitats (Table 4).

*Table 4*. Habitat and Communities of Mushrooms and Lichenes

| No | Habitat/Community | Number of species | Proportion (%) | |
|---|---|---|---|---|
| 1 | Arrhenatheretalia | 7 | 4.27 | |
| 2 | Brometalia erecti | 6 | 3.66 | |
| 3 | Chenopodietalia | 1 | 0.61 | |
| 4 | Fagetalia 19 | 11.59 | | |
| 5 | Juniperetalia | 2 | 1.22 | |
| 6 | Onopordetalia | 2 | 1.22 | |
| 7 | Pinetalia heldreichii-nigrae | | 1 | 0.61 |
| 8 | Prunetalia spinosae | 2 | 1.22 | |
| 9 | Pteridietalia1 | 0.61 | | |
| 10 | Quercetalia pubescentis | 5 | 3.05 | |
| 11 | Vaccinio-Piceetalia | 15 | 9.15 | |
| **Total:** | **61** | **100** | | |

Most lichens are epiphytic. They develop on the bark of different species of trees. From an ecological aspect, most are members of groups of deciduous forests, order *Fagetalia* and *Quercetalia pubescentis*, and dark conifer forests *Vaccinio-Piceetalia* (Table 1). The lichen *Evernia prunastri* is very often found on plum trees, where it grows on the bark of the bole. Some lichens are terricolous, such as *Lobaria* and *Cetraria*.

## Discussion

### Nutritional Value of Lichens and Mushrooms and Possibilities for Use in Human Nutrition

*Lichens/Lichenized Fungi*

Lichens contain a number of nutritive substances, particularly carbohydrates, and are considered a good and healthy food. Some species, such as the lichenized fungus *Ramalina*, contain different glucanes (α- and β-) and galactomannans (Stuelp-Campelo et al. 2002). Different kinds of polysaccharides appear in the species *Ramalina usnea* and *Cetraria islandica* (Gorin and Iacomini 1984) and those of the genus *Cladonia* (Carbonero et al. 2001). Some species of genus *Ramalina* contain very specific junctures such as galactosphingolipid (Machado et al. 1997) and glucanes (Stuelp et al. 1999), which gives them additional nutritive values.

Besides prime metabolites, many lichens contain active secondary metabolites, such as usnic acid [2, 6-diacetyl-7, 9-dihydroxy-8, 9b-dimethyl-1, 3(2H, 9bH)-dibenzo-furandione], which has become the most extensively studied lichen metabolite and one of the few that is commercially available. Usnic acid is found in lichens only, and is especially abundant in genus such as *Alectoria, Cladonia, Usnea, Lecanora, Ramalina* and *Evernia* (Ingolfsdottir 2002). For this reason, lichens have found a huge use in pharmacology and cosmetology.

In addition, many lichens have a rather high level of digestibility, which gives them special comparative advantages to other sources of natural food of biological origin. Studies on the nutritive value of some terricolous lichens for reindeers in winter, showed a very high digestibility *in-vitro*, in the case of *Cetraria islandica* is 66-77% of dry matter (Storeheier et al. 2002).

Unlike many other plants, this high digestibility makes lichens a very important food during the winter season, especially due to the shortage of other sources of food in this period. That is the case of some other lichens used during winter in the researched area for making the so called lichen flour. Besides their nutritive value, many lichens have important medicinal properties. Some species are used in the prevention of many diseases, since they have shown significant anti-oxidant activities. Researches have proved that *Cetraria islandica* is an important anti-oxidant (Gulcin et al. 2002), which additionally increased its nutritive values.

Some other species of lichens, used in this area, such as *Usnea barbata* and *Ramalina farinacea* have shown significant antimicrobial activities (Esimone and Adikwu 1999), and their use during winter season have a special preventive role. However, some species expressed important antifungal activity that comes from lichen acid activities (Halama and van Haluwin 2004), while the species *Lobaria pulmonaria* commonly used in the researched area have expressed significant anti-inflammatory and anti-ulcerogenic effects (S¸leyman et al. 2003). The methanolic extract of *Umblicaria esculenta* has expressed antithrombotic activity (Kim and Lee 2006). Some species have anti-viral (Esimone et al. 2005) and even cytostatic or anticancerigenic role in humans (Bezivin et al. 2003). This shows that lichens are an enormous, but still under-researched, resource as healthy food and also as an important product in pharmacology and cosmetology. This can be applied to certain species of lichens,

such as *Evernia prunastri, Pseudevernia, Bryoria, Ramalina* and *Usnea*, which develop a vast biomass in the researched area. Similar possibilities exist in other regions of BiH, where lichens are available in large quantities due to ecological advantages such as clear air. They represent an important resource for human and animal food and as pharmaceutical material. Compared to mushrooms, lichens advantage is that they are less poisonous.

**Mushrooms**

Most mushrooms are very nutritive and yet their use in nutrition is not proportional to their importance in nature. This particularly applies to wild mushrooms. Their number is still questionable, but it is believed that there are tens of thousands of species. Even though mushrooms are one of the most numerous nexus organisms, only a few are used in nourishment and only in some areas. However, in special conditions, such as war and struggle for life, people start using mushrooms believing that they would be able to supplement certain proteins that are not available in other plants. That is why mushrooms are known as "forest meat" in some areas. Mushrooms contain high proportions of proteins (19-35%), including all essential amino acids, and a low amount of fats (Grlic 1980; Foht 1990). They also contain relatively high amounts of carbohydrates and fiber (51 to 88%), or 4-20 % of dried mass (Miles and Chang 1997; Breene 1990) and significant amounts of vitamins, namely thiamin, riboflavin, ascorbic acid and vitamin D2, as well as minerals. Especially valuable are hytines and beta-gluconats (Manzi and Pizzoferrato 2000). Many of the edible mushrooms contain significant amounts of very high quality proteins, such as *Pleurotus ostreatus, Tricholoma terreum* and *Agaricus macrosporus* (Dabbour and Takruri 2002). All those mushrooms are found in the researched area. One of the most popular mushrooms in the enclave is *Cantharellus cibarius*. It contains high concentrations of vitamin D2 (12.8 ng/100g). Although very well known, it was not consumed before the war. Besides their nutritive values, many mushrooms are also expressing significant antitumor, anticancerigenic, antiviral and hypo-lipidemic activity (Mattila et al. 2000).

Owing to their high and unique nutritive importance, mushrooms were considered as "Food of the Gods" by Romans, while old Chinese appreciated them as good medicines naming them the "Elixir of Life" (Johl et al. 1995).

Mushrooms are also a great source of minerals. *Morchella esculenta*, a very popular species in the researched area, contains high concentrations of magnesium, up to 5254.9 mg/kg. Similar concentrations of calcium can be found in species of the genus *Coprinus*, and a higher level, 9973.8 mg/kg in the species *Polyporus squamosus* (Kalac and Svoboda 2000; Dursun et al. 2006). That is significantly higher than concentration of calcium in some edible wild plant, such as *Plantago major, Polygonum bistorta, Lathyrus tuberosus* and *Chenopodium album* (Yildrim et al. 2001).

Ectomycorrhizal mushrooms, such as *Boletus edulis*, *Cantharellus cibarius, Lactarius deliciosus*, contain soluble and insoluble oxalate (Savage et al. 2002), significant amounts of sodium (Vetter 2003), up to 38 elements as in some wild mushrooms in Poland (Falandysz et al. 2001), and a very complex structure of nutritive and curative substances (Longvah and Deosthale 1998)

As with lichens, many mushrooms expressed extraordinary anti-oxidant traits, in particular the genera *Morchella*. Some contain a huge amount of phenols and also expressed anti-oxidant activities (Cheung et al. 2003). Some species, such as *Pleurotus ostreatus* have regulated the flow of fats in experimental animals (Hossain et al. 2003) and the species *Agrocybe aegerita* expressed cyclooxigenasa inhibitory activity and antioxidant capabilities (Zhang et al. 2003).

It is important to emphasize that no mushroom in the researched area is used as medicine. However, it is a common belief that the fried fruiting bodies of *Morchella* and the powder of dried mushrooms enhance men's sexual power and desire. The species of this genus (*Morchella conica*) is the most respected species of mushrooms in the area but it should not be over used, since it can cause nausea, dizziness, and intoxication. In addition, species *Ramaria flava* causes diarrhea and it is used as a purgative.

Most of the mushrooms used are very nutritive, and the consumption of even one fruiting body a day could decrease the need for other sources of protein in these difficult conditions. Therefore, mushrooms could bear at least some credit for the fact that the residents of the researched area successfully overcame food shortages during three years of siege and several months of exodus.

Table 5 shows the nutritive and caloric values of some edible wild mushrooms and lichens that can be found in the surveyed area. It can be seen that the highest caloric values are found in the fruiting bodies of the species *Calocybe gambosa*, followed by *Macrolepiota procera* and *Boletus* sp. Most of the species contain significant quantity of proteins, carbohydrates and lipids. This illustrates that the consumption of mushrooms could compensate for a human daily calories intake.

As a result of the relatively high caloric content of these mushrooms and wild plants, it was possible to survive through the difficult time of war. This applies both to the residents and the isolated guerilla groups. They survived for several months with a very small amount of conventional food but a great use of wild flora and fungi. Such nutrition helped to avoid significant malnutrition of people in this area, which is a common occurrence in conflict situations (Rossi et al.

*Table 5*. Nutritive Values and Calories of Some Edible Mushrooms from this Geographical and Ecological Area (from Vracaric, 1977, modified)

| | Contents (in 100g of Mushroom Biomass) | | | | |
|---|---|---|---|---|---|
| **Scientific Name of Mushrooms** | **Water** | **Proteins** | **Carbo-hydrates** | **Lipids** | **Number of Calories (in 100g)** |
| *Agaricus campestris* L. 1753 | 92 | 4.2 | 1 | 0.4 | 20 |
| *Calvatia gigantea* (Batsch) Lloyd 1904 | 82 | 4 | 9.2 | 1.3 | 60 |
| *Lactarius piperatus* (L.) Pers. 1797 | 90 | 2.5 | 4.4 | 1 | 35 |
| *Lactarius deliciosus* (L.) Gray 1821 | 92 | 2.8 | 3.8 | 0.6 | 29 |
| *Macrolepiota procera* (Scop.) Singer 1948 | 84 | 7.3 | 4.6 | 0.7 | 47 |
| *Boletus* sp. | 85 | 4.2 | 7.2 | 0.8 | 48 |
| *Cantharellus cibarius* Fr. 1821 | 89 | 1.9 | 5.6 | 0.9 | 36 |
| *Morchella conica* Pers. 1818 | 91 | 2.8 | 4 | 0.3 | 28 |
| *Lycoperdon* sp. | 91 | 3.5 | 3.8 | 0.2 | 27 |

2006), and could lead to significant problems in human reproduction (Wynn and Wynn 1993), or manifestation of diabetes mellitus such as in Japan (Goto et al. 1958) or in the U.S. Army (Marble 1949) during the World War Two, or "hunger disease" that affected children in the ghettos during the Holocaust (Hercshlag-Elkayam et al. 2003; Shasha 2002), or a decrease in the reproduction capabilities of females and increased proportion of miscarriages that affected Sarajevo population during the war (Redzic 1999a).

Residents' use of wild mushrooms and lichens in the researched area, as well as the use of wild plants (Redzic 2006a) decreased the risk of chronic malnutrition that was dominant in some other parts of B&H, such as Sarajevo, where most of the residents were malnourished during the war (Vespa and Watson 1995).

A similar situation existed amongst the refugees in the Tuzla, mostly from the researched area of Podrinje. In those period, significant decreases in the body mass index of boys has been determined. (Redzic and Hadzihalilovic 2007). Particularly difficult conditions were during 1993-1994 affecting all age groups with serious malnourishment (Watson et al. 1995). Malnourishment in the human population results from lack of food and uniformity in nutrition. That was particularly reflected in the population of Sarajevo during the 1425 days of siege, where the available amounts of food were insufficient to cover daily needs in calories. According to Smajkic et al. (1995), prescribed calories in this area for adult people was 2700 kcal per day. However, those needs are significantly higher in soldiers.

Although successful survival required the consumption of several kilograms of the fruiting bodies of mushrooms, the available plants replaced the daily needs in calories and proteins. Due to the available nutritive diversity in wild mushrooms, lichens and plants it was possible to survive in the occupied area of Podrinje, without significant health consequences, since wild mushrooms and lichens contain a large spectrum of nutritive and curative substances (Johl et al. 1995-96; Esimone and Adikwu 1999; Mattila et al. 2000; Petrovska et al. 2001; Storeheirer et al. 2002). They could be used not only during vegetative periods, but also during winter when the residents had at their disposal most species of lichens, dried mushrooms, vitamin species of needles and young cropping of "spruce" (*Picea abies*), "Pancic spruce" (*Picea omorika*), watercress (*Nasturtium officinale*), and the fringes of hazel (*Corylus avellana*) as supplements for flour. All of them are significant and effective replacements for conventional forms of necessary food (Redzic 2006a).

Even though the use of wild mushrooms in human nutrition is relatively modest, the results of this research are remarkable and can lead to the expansion of new possibilities in nutrition ecology and anthropology. This is especially true for the Mediterranean region where a relatively small number of wild species are currently used for human food (2.300 species), compared to significantly higher number of wild plants available in this heterogeneous area (Rivera et al. 2006). Similar trends exist in the medical real of this region where nutritive flora provides massive possibilities in generating acceptable pharmacological substances and dietetics. (Redzic and Grujic 2003; Simopoulos and Gopalan 2003; Redzic 2006b, 2007).

## Endnotes

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