Wild-gathered fungi for health and rural livelihoods

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Fungi are a good source of digestible proteins and fibre, are low in fat and energy and make a useful contribution to vitamin and mineral intake. In terms of current dietary advice, 80 g fungi represent one portion of vegetables. Dried fungi and concentrated extracts are also used as medicines and dietary supplements. Some species show strong anti-tumour and antioxidant activity by enhancing various immune system functions and lowering cholesterol levels. Nevertheless, there are also some safety concerns. Edible species might be mistaken for poisonous ones, high heavy-metal concentrations in wild edible fungi (WEF) are a known source of chronic poisoning and the consumption of WEF can contribute markedly to the radiocaesium intake of human subjects. Some regions of Europe have a strong WEF tradition, especially eastern Europe. In the UK the consumption of wild fungi is considered of minor importance. Only one-third of adults consume fungi (cultivated species and WEF) throughout the UK; the average intake of fungi in the UK is estimated to be 0·12 kg fresh weight *per capita* per year. At least eighty-two species of wild fungi are recorded as being consumed in the UK, although certain species (e.g. chanterelle (*Cantharellus cibarius*), cep (*Boletus edulis*), oyster mushroom (*Pleurotus ostreatus*)) are favoured over others. Although WEF are not essential components in the daily diet, they are a nutritionally-valuable addition to the range of vegetables consumed, and their role in helping to avert food shortages in less-favoured areas should be definitely considered.

Wild edible fungi: Medicinal fungi: Nutrition: Safety: Health

Wild edible fungi (WEF) are a natural resource with a high nutritional and economic value. Although collection is often regarded as a hobby, recent studies confirm that they are an important source of food and income in both developing and developed countries (Hosford *et al*. 1997; Wong *et al*. 2001; Boa, 2004).

Attitudes towards WEF are very different around the world. According to Boa (2004) about 1200 species of fungi are used in eighty-five different countries for their gastronomic value and/or medicinal properties. China, Japan and eastern European countries are particularly enthusiastic collectors and consumers, and have developed a robust marketing network in order to satisfy the high demand. In northern and western Europe and North America WEF have traditionally been mistrusted, although trends vary among countries. In central America some wild fungi are revered as sacred objects (Wasson, 1968). Studies in Africa reveal that the knowledge and use of WEF is widespread (Yorou & De Kesel, 2001; Kuyper, 2002).

The most remarkable WEF species in terms of world trade are the black truffle (*Tuber melanosporum*), which is exported from France, Italy and Spain, the matsutake (*Tricholoma matsutake* and relatives), which is sent to Japan from the USA, Canada, Mexico, China and neighbouring countries, and the boletes (*Boletus* spp.) and chanterelles (*Cantharellus cibarius*), which are widely appreciated.

In terms of nutrition WEF are rich in protein and have considerable value as a source of dietary fibre because of both their high fibre content and their unique fibre composition (Cheung, 1997). Some medicinal species are widely used in traditional and alternative medicines to heal a broad range of diseases; *Ganoderma lucidum*, for example, is especially esteemed in China and Japan (Molitoris, 2002).

The present paper gives a global perspective on the nutritional and medicinal value of WEF, addresses safety concerns and describes their consumption and role in rural livelihoods worldwide.

The nutritional value of fungi

Many studies have been undertaken on the nutritional composition of cultivated edible fungi and WEF (for a summary of the most informative of these studies, see Table 1 and for further information, see Mukhiibi, 1973; Seeger et al. 1983; Coli et al. 1988; Mattila et al. 1994; Outila et al. 1999; Vetter, 1999; Ilievska & Petrovska, 2000; Caglarirmak et al. 2002; Sadler, 2003; Sanmee et al. 2003; Yildiz et al. 2005).

In general, edible fungi contain 850–950 g water/kg fresh weight and (g/kg dry weight (DW)) 160–350 protein, 20–60 fat and 280–399 carbohydrate. However, the wide variety and abundance of minerals are the most characteristic features of fungi; they are useful sources of Cu, Fe, K, Mg, Se, P and Zn in the human diet and are very low in Na. They are a source of unsaturated fatty acids (particularly oleic and linoleic acids), contain high amounts of dietary fibre and are low in energy (1·42–5·46 MJ (340–1310 kcal)/kg). The proportion of protein, the amino acid index and the quantity of minerals appears to be greater in the cap than in the stem (Coli et al. 1988). In terms of current dietary advice, 80 g fresh fungi is equivalent to one portion of vegetables (Sadler, 2003) and a serving (100 g) of fungi guarantees 9 (fresh Agaricus bisporus)–40 (dried Boletus spp.) % RDA for dietary fibre (Manzi et al. 2001).

The nutritional value of proteins is usually very high in the majority of fungi (Ilievska & Petrovska, 2000), and fungal proteins are considered to be of equal quality to those of animal origin (Longvah & Deosthale, 1998). León-Guzmán et al. (1997) have shown that the protein contents (g/kg) of fresh Amanita rubescens, Boletus frostii, Lactarius indigo and Ramaria flava collected in Mexico are higher (190–350) than those of wheat (132) or milk (252). Some exceptions exist; in Lentinula edodes or Termitomyces spp. the protein quality is inferior to that of grain legumes and cereals, but is still comparable with that of many vegetables (Mukhiibi, 1973; Longvah & Deosthale, 1998).

Some species, such as Termitomyces umkowaani and T. sagittaeformis, contain all the essential amino acids (Botha & Eicker, 1992). Other species lack one or more of the essential amino acids; in T. reticulatus four essential amino acids (isoleucine, leucine, methionine and cytosine) are severely limiting (Botha & Eicker, 1992); in Hericium erinaceus methionine and tryptophan are absent (Eisenhut et al. 1995). In the fungi analysed by Agrahar-Murugkar & Subbulakshmi (2005) phenylalanine was found to be the limiting amino acid and leucine the most abundant amino acid. León-Guzmán et al. (1997) have recorded high levels of free lysine in Amanita rubescens, Boletus frostii, Lactarius indigo and Ramaria flava, making these species valuable additions to the human diet. Tricholoma terreum and T. portentosum are particularly rich in glutamic acid (220 mg/g total amino acids), like many other fungi (Díez & Álvarez, 2001). The high concentrations of glutamic acid in T. terreum and T. portentosum probably contribute most to their characteristic flavour. Another possible source of the precursor flavour compounds would be the presence of unsaturated fatty acids, particularly linoleic acid (Díez & Álvarez, 2001).

Several studies have confirmed that fungi make a useful contribution to vitamin intake, particularly the B vitamins and vitamins D and K, and in some cases vitamins A and C (Sadler, 2003; Sanmee et al. 2003). Mattila et al. (1994) have shown that Cantharellus cibarius and C. tubaeformis contain high amounts of ergocalciferol (128 and 298·2 µg/kg fresh weight respectively), possibly because in the genus Cantharellus the pileus and gills are often more effectively exposed to light than they are in other species of fungi. The influence of illumination conditions in determining ergocalciferol content is a factor that should be taken into account in the case of cultivated fungi. Outila et al. (1999) have shown that human subjects can easily absorb ergocalciferol from lyophilized and homogenized Cantharellus tubaeformis. Thus, for some groups, for example vegetarians or individuals allergic to fish, fungi can be an important dietary source of vitamin D.

Fungi rank amongst the vegetables with the lowest Na content (Seeger et al. 1983). The Na contents of plants vary between 200 and 2000 mg/kg, while in some meat and meat products Na contents range from 10 000 to 22 000 mg/kg. The fruit bodies of Agaricus species contain on average 396 mg Na/kg (Vetter, 2003b), which is of great nutritional benefit to the consumer.

The nutritional value of fungi can be affected by the method of preservation. Manzi et al. (2001) have compared the nutritional value of Agaricus bisporus (fresh, canned and deep-frozen), fresh Pleurotus ostreatus and dried Boletus spp. Cooked dried Boletus spp. were found to have the highest nutritional value, although this effect is essentially a result of insufficient rehydration. On the other hand, cooked deep-frozen Agaricus samples have lower amounts of protein (19 g/kg) and fat (2·6 g/kg) than fresh (protein 20·1 g/kg, fat 4·5 g/kg) or canned (protein 20·4 g/kg, fat 4·2 g/kg) Agaricus. It is probable that the structural damage to the cells, occurring during the deep-freezing process, promotes nutrient loss and causes the small post-cooking yield (Manzi et al. 2001).

Individual species appear to have similar nutrient concentrations in different forest ecosystems (Rudawska & Leski, 2005). Sanmee et al. (2003) have found that the chemical and nutritional composition of WEF collected in sub-tropical forests of Thailand are within the same order of magnitude as that measured in fungi collected in more temperate regions.

Finally, fungi can also have a role as functional foods, known as 'nutraceuticals', which are those materials that are beneficial, but not absolutely vital, for the human body (Tudge, 2001). Modern diets are based on relatively few domesticated plants, which in terms of biochemical composition tend to be blander than their wild counterparts, and some theories suggest a return to more primitive eating habits, much closer to those of man's hunter–gatherer ancestors (Tudge, 2001).

Table 1. Summary of the data published to date on the nutritional composition of wild and cultivated edible fungi

Reference	Species	Protein (g/kg DW)	Fat (g/kg DW)	CHO (g/kg DW)	Fibre (g/kg DW)	Minerals	Amino acids	Fatty acids	Energy
Agrahar-Murugkar & Subbulakshmi (2005)	Calvatia gigantea, Cantharellus cibarius, Russula integra, Gomphus floccosus, Lactarius quieticolor, Clavulina cinerea, Ramaria brevispora	6–12*	0·712*			mg/250 g FW: 287 Ca, 9·3 Fe, 3·72 Zn, 0·077 Na	µg/kg: Phe 9, Leu 7040		
Alofe (1991)	Termitomyces robustus, Tricholoma lobayensis, Volvariella esculenta					Zn five times more abundant than Cr, Co or Ni	All contain the essential amino acids		
Alofe et al. (1996)	Lentinus subnudus, Psathyrella atroumbonata, Termitomyces striatus					Good sources of Mg, Zn, Fe			
Bokhary & Parvez (1993)	Terfezia claveryi	160	20†	280	40‡		Twenty-nine detected (ten essential, nineteen non-essential)	Nine saturated, four unsaturated	
Botha & Eicker (1992)	Termitomyces umkowaani, T. sagittaeformis, T. reticulatus						Ten essential, eight non-essential		
Díez & Álvarez (2001)	Tricholoma terreum, T. portentosum	160	60		450§		Sixteen detected; rich in Glu (220 mg/g total amino acids)	Oleic and linoleic acids account for 75 g/100 g total fatty acids	
Eisenhut et al. (1995)	Hericium erinaceus					mg/kg FW: 2540 K, 1090 P, 80·4 Na, 67·0 Ca	All essentials detected, except Met and Trp		
León-Guzmán et al. (1997)	Amanita rubescens, Boletus frostii, Lactarius indigo, Ramaria flava	190–350					High amounts of free Lys		
Longvah & Deosthale (1998)	Schizophyllum commune, Lentinula edodes	160–230	20					Oleic and linoleic acids the most abundant	
Manzi et al. (2001)	Agaricus spp. Boletus spp.								1·42–5·46 MJ/kg
Rudawska & Leski (2005) Solomko et al. (1984)	In general Pleurotus ostreatus	175	29	399				56 g oleic acid/100 g total fatty acids	
Vetter (1994) Vetter (2003b) Vetter (2005)	In general Agaricus spp. In general					8·21 g P/kg DW 396 mg Na/kg 10–60 µg Li/kg			

DW, dry weight; FW, fresh weight; CHO carbohydrate.
*g/250 g FW.
†Crude fat.
‡Crude fibre.
§Dietary fibre.

The value of fungi as medicines

Fungi are well known for their medicinal properties. From ancient times Oriental traditional medicine has stated that medicine and food have the same origin. Amongst the many species used in medicine, the most common are *Claviceps purpurea*, *Cordyceps sinensis*, *Ganoderma lucidum*, *Laricifomes officinalis*, *Lentinula edodes* and *Trametes versicolor* (Molitoris, 2002).

Fungi are a good source of digestible proteins and fibre in the form of chitin, which has potential in lowering cholesterol (Sadler, 2003). The intake of fungi has also been shown to be effective in cancer prevention. Ikekawa (2001) has reviewed studies of the anti-tumour activity of fungi undertaken at the National Cancer Research Institute of Japan since 1966. Several anti-tumour polysaccharides have been isolated, the most important of which is lentinan, a β-1,3-glucan isolated from *Lentinula edodes* (shiitake), which is used clinically in Japan. Lentinan may enhance various immune system functions, such as increasing production of T-helper cells and macrophages (Sadler, 2003). Other popular edible fungi, such as *Flammulina velutipes* (enokitake) and *Hypsizygus marmoreus* (bunashimeji), also have high anti-tumour activity and a preventive effect in tumour metastasis (Ikekawa, 2001). An epidemiological study carried out in the Nagano Prefecture, Japan, has indicated that the death rate from cancer among farmers producing *Flammulina velutipes* as a main occupation is markedly lower than that of the other subjects studied. The cancer prevention effect of *Hypsizygus marmoreus* has been investigated in a bioassay with mice injected with a carcinogen. Of the thirty-six control mice twenty-one were found to have developed tumours, whereas only three of the thirty-six mice that had been fed on *H. marmoreus* were found to have tumours (Ikekawa, 2001).

Antioxidant activity of WEF has also been recorded. In a study by Lakshmi *et al*. (2004) the four fungi examined, *Phellinus rimosus*, *Pleurotus florida*, *Pleurotus sajor-caju* and *Ganoderma lucidum*, were reported to show antioxidant activity. Cellular damage caused by reactive oxygen species has been implicated in several diseases, and hence the antioxidant properties of fungi may play an important role in human health.

Other studies that have focused on the medicinal properties of fungi include that of Ling *et al*. (1990), who have found that *Flammulina velutipes* is protective against increased serum cholesterol level and promotes the formation of Hb in rats. Ooi (2001) has focused on the effects of selected Chinese medicinal fungi, i.e. the immunomodulation and anti-tumour activity of *Tricholoma giganteum*, the blood pressure-lowering action and mechanism of *Volvariella volvacea* and the liver protective effect of *Trametes versicolor*.

Safety concerns when eating wild edible fungi

Although the benefits of eating wild fungi are clear, there are also safety concerns that have to be taken into consideration.

It is clearly of great importance that edible species are not mistaken for poisonous ones. In most cases only mild poisoning occurs, with stomach upsets and sickness. Nevertheless, in a few cases the consequences may be fatal, as in the case of *Amanita phalloides*, *A. verna*, *A. virosa*, *Cortinarius orellanus* or *Galerina marginata*. Some mushrooms contain natural toxins, such as nitrosamines, which are particularly abundant in *Boletus edulis*, and haemaglutinins, which are destroyed by cooking (Sadler, 2003). Some fungi are thus poisonous when raw, but edible when cooked properly, such as *Morchella* spp. or *Gyromitra* spp. Other fungi are only poisonous when consumed together with alcohol, e.g. *Coprinus atramentarius*. Psycho-active fungi, e.g. *Amanita muscaria* or *Psilocybe* spp., can have adverse effects on brain chemistry and mental health and can produce other toxic symptoms in the body (Sadler, 2003).

High heavy-metal concentrations in WEF are also a known source of chronic poisoning, although peeling and washing caps and stalks can reduce their heavy metal contents by about 30–40% (Zrodowski, 1995). Saprophytic species usually show higher concentrations of heavy metals than mycorrhizal species (García *et al*. 1998; Melgar *et al*. 1998; Alonso *et al*. 2000, 2003), while fungal species growing on wood tend to have lower concentrations of heavy metals than those growing on soil (Alonso *et al*. 2003). Cultivated species accumulate lower concentrations of heavy metals than wild species because their mean life span is shorter (Zrodowski, 1995; Alonso *et al*. 2000). The hymenophore shows higher metal concentrations than any other part of the fruit body (Melgar *et al*. 1998; Alonso *et al*. 2000, 2003), and the heavy-metal concentration of the cap exceeds that of the stipe (Svoboda *et al*. 2000; Zimmermannova *et al*. 2001).

Some fungi are well known to accumulate high concentrations of Hg; *Agaricus* and *Macrolepiota* have been shown to contain 2·92 mg/kg DW, and *Lepista* (3·02 mg/kg DW) and *Lycoperdon perlatum* (2·94 mg/kg DW) could also fall into this category (Vetter & Berta, 1997). It is important to note that the recommended maximum Hg intake for an adult is, according to the WHO standard, 0·03 mg/kg food consumed (Vetter & Berta, 1997).

The genus *Agaricus* is not only an efficient bioaccumulator of Hg, but also of Cd (Melgar *et al*. 1998) and Ag (Falandysz *et al*. 1994). *Agaricus macrosporus* has been shown to have the highest concentrations of Cd (68·96 and 36·84 mg/kg DW for the hymenophore and the rest of the fruiting body respectively) among thirteen WEF species collected in Spain (Melgar *et al*. 1998). *A. campestris* and *A. augustus* have also been reported to contain the highest concentrations of Ag among wild-grown fungi studied in northern Poland (35 mg/kg DW and 2·0–6·9 mg/kg DW respectively; Falandysz *et al*. 1994).

Alonso *et al*. (2000) have analysed the Hg content of eight species of fungi from Spain: four mycorrhizal species (*Boletus pinicola*, *Cantharellus cibarius*, *Lactarius deliciosus*, *Tricholoma portentosum*); four saprophytes, two cultivated (*Agaricus bisporus* and *Pleurotus ostreatus*) and two from the wild (*Agaricus campestris* and *Macrolepiota procera* var. *procera*). Of the samples 90·2% were found to exceed the limit established by legislation, although

70% of the toxicity of Hg was reported to disappear with cooking. In order to avoid a risk for human health, Alonso et al. (2000) have recommended the elimination from the diet of the hymenophore portions of *Boletus pinicola* and *Macrolepiota procera* var. *procera* and have suggested that *Agaricus campestris* should not be consumed at all.

In the study by Falandysz et al. (2004) in Poland *Leccinum rufum* was shown to have accumulated the greatest concentrations of Hg among the WEF analysed. The concentrations of Hg for all WEF studied were found to exceed the human tolerance limit set for dried plant foodstuffs; when expressed on a fresh weight basis, the concentrations were found to be below the tolerance limit for four of the fifteen species analysed. However, these data must be interpreted cautiously. The rates of WEF consumption in Poland have been estimated at 7 kg fresh weight per household per year, with a maximum of 10 kg/year for some individuals (28 g/d). An estimate of the daily intake of Hg from WEF consumption indicates that the flesh of WEF may not pose hazards to human health even at a maximum consumption rate of 28 g/d.

Considerable contamination of most WEF from a heavily-polluted area in Slovakia has been observed mainly for Hg and Cd (Svoboda et al. 2000). Many of the WEF were found to exceed the Slovak food statutory limits for Cd, Hg, Pb and Cu content set at 2, 5, 10 and 80 mg/kg DW respectively. Thus, the authors have recommended that some WEF species from the polluted area should not be consumed at all. Samples of WEF fruiting bodies have also been collected in an emissions area for a Hg and a Cu smelter in Slovakia (Zimmermannova et al. 2001). In this case Slovak food statutory limits were reported to have been surpassed by 93·3, 82·0, 15·3 and 9·8% for Hg, Cd, Pb and Cu respectively. In Poland Cd contamination has been found to be particularly high for fresh *Cantharellus cibarius* collected from all regions; dried *Boletus edulis* and *Boletus scaber* were also found to exceed the permitted limits of 1 mg/kg DW (Statkiewicz & Gayny, 1994). Pb concentrations in *Xerocomus badius* (5·4 mg/kg DW) have also been reported to exceed both Polish (2 mg/kg DW) and European (3 mg/kg DW) tolerance limits (Rudawska & Leski, 2005). In north-west Russia the fungi growing over an area of ≤ 3000 km^2 around a smelter complex have been declared unsuitable for human consumption because of the elevated Ni concentrations caused by the smelter dust emissions. The fungi gathered in the polluted forests were found to contain fifteen to forty times more Ni than the background level (Barcan et al. 1998).

García et al. (1998) have analysed the Pb content in WEF collected from north-west Spain, and have found that *Coprinus comatus* contain the highest concentrations, reflecting the effects of traffic pollution; this species could, therefore, be considered an indicator of Pb contamination. It was recommended that wild fungi, especially saprophytes, should not be consumed within an approximate distance of 50 m from the main roads. Isiloglu et al. (2001) have confirmed that the effects of traffic pollution are mainly reflected in the Pb contents of fungi. Nevertheless, Svoboda et al. (2000) have suggested that no single species of fungi can be considered as a precise indicator of environmental pollution with heavy metals, but fruiting bodies can be useful for distinguishing between polluted and unpolluted sites.

The Cd, Pb and Hg contents of twenty-four WEF species collected in primary forests of Latin America have been shown to be surprisingly similar to those found in fungi collected in polluted urban areas in Europe (Michelot et al. 1999). These results suggest long-distance dry or wet deposition of heavy metals across the globe.

Not all studies indicate that consumption of WEF poses a risk in relation to the intake of heavy metals. In the UK a survey of the concentrations of twelve metals and other elements in WEF has concluded that the estimated dietary exposures are within relevant guidelines on safe exposures (Joint Food Standards and Safety Group, 2000). In Spain Cu and Zn contents have been determined for twenty-eight species of fungi (Alonso et al. 2003). The highest metal concentrations were found in *Calvatia utriformis*, *Macrolepiota procera*, *Agaricus macrosporus* and *Lactarius deliciosus*, but when the Cu and Zn concentrations were compared with levels set by legislation, it was concluded that the consumption of these fungi poses no toxicological risk.

Another risk that should not be overlooked is that the consumption of WEF can contribute markedly to the radiocaesium intake of human subjects, because radiocaesium concentrations in fungi are higher than those in other foodstuffs. Higher radiocaesium activity usually occurs in mycorrhizal species as compared with saprotrophic or parasitic species (Barnett et al. 1999).

Giovani et al. (2004) have shown that since the Chernobyl accident in 1986 the average concentration of ^{137}Cs in wild fungi does not seem to be decreasing markedly over time, but the radionuclide physical decay is moving from fungi with more superficial mycelia to those with deeper mycelia. After the Chernobyl accident Vasser et al. (1992) recommended that Ukrainians should stop picking WEF because the levels of radioacaesium in WEF were very high. Surprisingly, in an online questionnaire carried out by Druzhinina & Palma-Oliveira (2004) among fungi pickers from different regions in Europe, respondents from eastern European countries were found to have a higher perceived global contamination of WEF and a higher perception of the Chernobyl global influence, but to show the highest rates of collection and consumption of WEF, while possessing the lowest perception of possible personal harm.

In contrast, in countries not affected by the Chernobyl accident the radiocaesium intake related to WEF consumption does not constitute a risk, because the dose associated with consumption of fungi is below the recommended limit (Italy, Giovani et al. 2004; Spain, Baeza & Guillén, 2004; UK, Barnett et al. 1999). For France it has been reported (Kirchner & Daillant, 1998) that most of the samples of WEF collected have detectable levels of radioactive Cs, but radiation doses to individuals resulting from WEF consumption are dominated by ^{210}Pb for the majority of WEF sampled.

One last safety concern is the negative consequences derived from some methods of preservation of fungi that diminish their nutritional value (Vetter, 2003a). The

extremely high Na levels in canned fungi, 20–30-fold higher than in fresh fungi, is a potentially hazardous factor to some groups of consumers, particularly patients with high blood pressure and generally in consumers with cardiovascular problems. There is also an increase in the concentrations of Ni, Cr and Hg. In contrast, the amounts of K, a nutritionally-beneficial mineral, show a 40–80-fold decrease in canned fungi. The most widespread method of preservation of fungi, drying, does not cause any loss of nutritional value, and is thus preferred to canning.

Trends in consumption of wild edible fungi

Populations in eastern Europe and Russia have a stronger tradition of collecting fungi from the wild than populations from western, northern and central Europe (Wasson & Wasson, 1957; Druzhinina & Palma-Oliveira, 2004). Germanic populations have never been great fungi eaters, in contrast to Romans and Slavs (Kardell, 1980).

In the UK the consumption of WEF has always been considered of minor importance. In a survey carried out by Barnett *et al*. (1999) the median intake rate was found to be 0·75 kg fresh weight *per capita* per year, and 60 % of the respondents reported consuming only one species, generally *Agaricus campestris*. Extrapolation of the results of the questionnaire would suggest that the average intake of WEF in the UK is 0·12 kg fresh weight *per capita* per year. According to the respondents of the questionnaire eighty-two species of WEF are being consumed in the UK, although certain species (e.g. chanterelle (*Cantharellus cibarius*), cep (*Boletus edulis*), oyster mushroom (*Pleurotus ostreatus*)) are clearly favoured over others. The survey of Byrom *et al*. (1995) has reported that fungi (cultivated and wild species) are eaten by only 37·3 % of adults throughout the UK. In the study of Fulker *et al*. (1995) carried out in Cumbria 40·3 % of the participants were reported to consume fungi.

Nevertheless, trends are now changing. In the UK fungi hunters are required to obtain licenses for collecting in Epping Forest, north-east London, because of the increase in commercial picking (Morris, 2002), and similar legislation has been introduced for the New Forest, Hants. In Sweden >50 % of the population gathers fungi. The custom of eating fungi in Sweden was imported from France and was adopted by the nobility, although not initially by the general public. During years of near-famine there was still a refusal to eat fungi. It was not until the 20th century, when there was migration to the cities and the consequent awareness of other eating habits, that the Swedes began to consider the wild fungus to be worth harvesting and eating (Kardell, 1980).

Trends are also changing in Spain. Basques and Catalans have always been eager fungi consumers, but now interest in picking and eating WEF has spread throughout the country, and populations from other regions where traditionally there was no interest in WEF are now looking forward to the fungi season each year (de Román & Boa, 2004).

Increasing numbers of the French population have become interested in picking WEF (Berelle, 2002). Fungi pickers can be a serious nuisance in the forest, and in some regions some measures have been taken, such as the establishment of legal regulations for the harvest of WEF, the introduction of a license system for fungi pickers and distribution of leaflets and posters to raise public awareness about good harvesting practices and the threats of overexploitation.

In contrast, the tradition of gathering and consuming WEF among rural populations in countries such as India is on the decline because of growing urbanisation and the associated changes in food habits. It has become necessary to document the nutritional quality of traditionally-consumed WEF in order to retain this valuable information (Agrahar-Murugkar & Subbulakshmi, 2005).

Some ethnomycological studies have shown that in Africa knowledge about fungi is widespread and extensive, although it varies between regions. However, this widespread knowledge does not imply a high social valuation of fungi or a high consumption (Yorou & De Kesel, 2001; Kuyper, 2002). Although WEF could be useful in helping to overcome extreme food shortages in this continent, there appears to be only one report of the use of fungi as an emergency food (Wilson *et al*. 1989), even though they are routinely used at times of low food availability in countries like Malawi.

An overview of the uses and importance of WEF to global populations has been published by Boa (2004), in which there are records of 1200 species being consumed in eighty-five countries and more detailed information on the consumption of WEF worldwide.

Concluding remarks

Fungi have a balanced and high nutritional value, are rich sources of protein and fibre, are low in fat and make a useful contribution to mineral and vitamin intake. They have potential as a food source in situations of food shortage and as nutritional additions in the daily diet. It is anticipated that, in the future, fungi will have increasing importance in medicine and biotechnology because of their unique biosynthetic capabilities and metabolic products. Most safety concerns can be overcome by exercising caution when eating WEF. The present paper provides evidence of the considerable potential of WEF as a food source that should be given more consideration, particularly by nutritionists.

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