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COLLECTION, MARKETING AND CULTIVATION OF EDIBLE FUNGI IN SPAIN

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ABSTRACT

We report a total of 61 species of wild edible fungi collected and eaten in Spain. It may no longer be considered a mycophobic country. A tradition of wild edible fungi has existed in Cataluña and País Vasco for many years, but now includes significant consumption and marketing of *Boletus* spp., *Cantharellus cibarius* and *Lactarius deliciosus*, and others, from Aragón, Castilla-León, Madrid, Andalucía and Valencia. The most successful attempts cultivating edible ectomycorrhizal fungi, have been made with *Tuber melanosporum* Vitt., the black truffle. Its cultivation involves the inoculation in the nursery of seedlings of *Quercus ilex* L., *Q. faginea* Lam., *Q. humilis* Miller and *Corylus avellana* L. Truffles appear 8-10 years after the seedlings are planted in fields, and are harvested with the aid of trained dogs. The average annual production of black truffle in Spain is 22,400 kg, and prices range from 100 €/kg to 360 €/kg paid to the collector. The success with *T. melanosporum* encouraged mycologists to try to grow other edible ectomycorrhizal fungi to guarantee a stable production able to meet the increasing demand of these products.

Key words: Edible fungi, non-timber forest products, collection, marketing, cultivation, black truffle, *Tuber melanosporum*, Spain.

INTRODUCTION

France and Italy are frequently thought of as the leading mycophilic countries in Europe,

each with a long and strong tradition of collecting a wide range of wild edible fungi (WEF). In one of the few and possibly only general account of WEF in Europe, Wasson

and Wasson¹⁶ confirmed the traditions in France and Italy, though they also pointed out important regional differences within the two countries. In marked contrast, Spain is described as mycophobic, with the notable exceptions of Cataluña and País Vasco.

In the last 10-15 years a series of reports^{6,7,10}, most of which are poorly known outside Spain, has revealed that consuming and marketing WEF extends to other regions, a fact also confirmed by our own observations. The purpose of this paper is to summarise the published data and to clearly distinguish which species of WEF are eaten, that is used as food, and focusing exclusively on fungi gathered from the wild, because, as it is widely known, there is also world trade of cultivated saprobic species, such as *Agaricus bisporus* and *Pleurotus* spp.

As a second aim of this paper, we have considered necessary to provide an overview of the cultivation and marketing of the black truffle in Spain, because it is one of the topics typically related to Spain when dealing with edible fungi. The cultivation of *Tuber melanosporum* arose as a response to reductions in 'natural' harvests and is now becoming better established as a viable alternative for farmers who have to cope with fewer and smaller subsidies for traditional crop production. In contrast with saprobic species, which can be easily grown, ectomycorrhizal fungi are far more difficult to cultivate, and *Tuber* species have proved to be nearly the only ectomycorrhizal fungi successfully grown after being inoculated under controlled conditions.

It is of general mycological interest to know that a greater variety of WEF species are being collected and consumed in Spain, but we have a particular concern in highlighting their wider economic importance. As collection and marketing

increase so does the concern about sustainable harvests and there are new debates about the steps needed to ensure wise use of natural resources².

COLLECTION AND MARKETING OF WILD EDIBLE FUNGI

Although Spain can now be described, in general, as mycophilic, there have traditionally been great differences from region to region. País Vasco and Cataluña, where the first exhibition of fungi in Spain took place in 1931⁸, are the leading mycophilic regions, while those of Celtic origin, such as Galicia, Asturias and Cantabria (**Fig. 1**), have traditionally regarded the fungi as something harmful or just not worthy of attention¹. The increasing interest in the collection of fungi has led to the establishment of numerous mycological societies all over the country. Every autumn they organise several field trips, workshops and gastronomical events in which fungi are the focus of attention.

Plenty of information on the toxicity or edibility of fungi is available for the amateur mycologist, but it is necessary to make a distinction between 'edible', a property of a species, and 'food,' indicating use. WEF species exist around the world and are often reported to be edible, yet in many countries it is far from clear whether they are actually consumed². Therefore, we have started to gather data on the fungi which are actually eaten in Spain. So far, in this preliminary report, we mention 61 species and the region they are consumed (**Table 1**). It is also necessary to point out that only confirmed records of actual consumption are presented here, and that the lack of a record does not mean that the species is not eaten in that region. According to these data, there are some

Table 1. Main wild edible fungi collected in Spain, showing the regions in which they have been recorded to be eaten and whether they are collected to be sold or not^{4,6,7}. Authorities according to www.indexfungorum.org. “Collect to sell” indicates that a given species is sold at least in one region in Spain.

Scientific name	Regions where people eat it					Collect to sell
	Castilla-León	Cataluña	Navarra	País Vasco	Other regions	
<i>Agaricus arvensis</i>	+	-	+	+	-	No
<i>Agaricus campestris</i>	+	-	+	+	-	No
<i>Agrocybe aegerita</i>	-	-	+	+	-	No
<i>Amanita caesarea</i>	+	-	+	+	Andalucía, Extremadura	Yes
<i>Amanita ponderosa</i>	+	(Salamanca)	-	-	Andalucía	Yes
<i>Armillaria mellea</i>	-	-	+	-	Aragón, Madrid	No
<i>Boletus aereus</i>	+	+	+	+	Aragón	Yes
<i>Boletus aestivalis</i>	+	+	+	+	Aragón	Yes
<i>Boletus edulis</i>	+	+	+	+	Aragón	Yes
<i>Boletus pinophilus</i>	+	+	+	+	Aragón	Yes
<i>Boletus regius</i>	+	+	+	+	-	No
<i>Calocybe gambosa</i>	+	-	+	+	-	Yes
<i>Cantharellus cibarius</i>	+	+	+	+	-	Yes
<i>Cantharellus lutescens</i>	+	+	+	+	-	Yes
<i>Cantharellus tubaeformis</i>	+	+	+	+	-	Yes
<i>Clitocybe geotropa</i>	-	+	+	+	-	No
<i>Clitocybe nebularis</i>	+	-	+	+	-	No
<i>Coprinus comatus</i>	+	+	+	+	-	No
<i>Craterellus cornucopioides</i>	+	+	+	-	-	Yes
<i>Helvella leucomelaena</i>	-	-	+	+	-	No
<i>Helvella monachella</i>	+	-	-	-	-	No
<i>Hydnum repandum</i>	+	+	+	+	-	Yes
<i>Hydnum rufescens</i>	-	-	+	+	-	Yes
<i>Hygrophorus eburneus</i>	-	+	-	-	-	Yes
<i>Hygrophorus latitabundus</i>	-	+	-	-	-	Yes
<i>Hygrophorus olivaceoalbus</i>	-	+	-	-	-	No
<i>Hygrophorus russula</i>	-	+	-	-	-	Yes
<i>Lactarius deliciosus</i>	+	+	+	+	-	Yes
<i>Lactarius sanguifluus</i>	+	+	+	+	-	Yes
<i>Leccinum aurantiacum</i>	-	+	-	-	-	Yes
<i>Leccinum lepidum</i>	-	+	-	-	Valencia	Yes
<i>Lepista nuda</i>	+	-	+	+	Madrid	Yes
<i>Lepista personata</i>	+	-	+	+	Madrid	Yes
<i>Leucopaxillus candidus</i>	+	-	+	+	-	No
<i>Leucopaxillus lepidoides</i>	+	-	+	+	-	No
<i>Macrolepiota procera</i>	+	-	+	+	-	No
<i>Macrolepiota rhacodes</i>	+	-	+	+	-	No
<i>Marasmius oreades</i>	+	-	+	+	-	Yes
<i>Morchella esculenta</i>	-	-	+	+	-	Yes
<i>Pleurotus eryngii</i>	+	-	-	-	-	Yes
<i>Pleurotus nebrodensis</i>	+	-	-	-	-	No
<i>Pleurotus ostreatus</i>	+	+	+	+	All regions	Yes
<i>Ramaria botrytis</i>	-	+	+	-	-	Yes
<i>Rhodocybe truncata</i>	+	-	-	-	-	No
<i>Russula cyanoxantha</i>	-	+	+	+	-	Yes
<i>Russula virescens</i>	-	+	-	+	-	Yes

Table 1. Continued

Scientific name	Regions where people eat it					Collect to sell
	Castilla-León	Cataluña	Navarra	País Vasco	Other regions	
<i>Suillus bellinii</i>	+	+	-	-	-	Yes
<i>Suillus bovinus</i>	-	+	-	-	-	Yes
<i>Suillus granulatus</i>	+	+	-	-	-	Yes
<i>Suillus luteus</i>	+	+	-	-	-	Yes
<i>Suillus variegatus</i>	-	+	-	-	-	Yes
<i>Terfezia arenaria</i>	+ (Ávila, Salamanca)	-	-	-	Andalucía, Extremadura	Yes
<i>Terfezia claveryi</i>	+ (Ávila, Salamanca)	-	-	-	Andalucía, Murcia	Yes
<i>Terfezia leptoderma</i>	+ (Ávila, Salamanca)	-	-	-	Extremadura	Yes
<i>Tricholoma equestre</i>	+	+	+	+	-	Yes
<i>Tricholoma goniospermum</i>	+	-	+	+	-	No
<i>Tricholoma portentosum</i>	+	-	+	+	-	Yes
<i>Tricholoma terreum</i>	+	+	+	+	-	Yes
<i>Tuber aestivum</i>	+ (Soria)	-	+	-	Aragón, Valencia	Yes
<i>Tuber brumale</i>	+ (Soria)	-	+	-	Aragón, Valencia	Yes
<i>Tuber melanosporum</i>	+ (Soria)	-	+	-	Aragón, Valencia	Yes

species which are widely eaten, such as *Boletus* spp., *Cantharellus* spp., *Lactarius deliciosus*, *Pleurotus ostreatus* and *Tricholoma terreum*. Others are restricted to a given area: *Armillaria mellea* is eaten in Aragón, Madrid and Navarra, while in other regions it is considered to be poisonous; *Calocybe gambosa* and *Clitocybe nebularis* are especially appreciated in Castilla-León, País Vasco and Navarra; *Hygrophorus* spp. are only consumed in Cataluña; *Pleurotus eryngii* is typically eaten in Castilla-León; and *Suillus* spp. are only collected to be eaten in Castilla-León and Cataluña, whereas in other areas they are regarded as tasteless.

Although most of the wild fungi are collected for personal consumption, there is also a developing market, especially for *Boletus* spp., *Cantharellus cibarius* and *Lactarius deliciosus*, among others. **Table 1** indicates whether the species collected to be eaten are also sold or not. Cataluña is the leading region in marketing wild fungi, but most come from other areas, especially Lugo (Galicia) with ca. 2,000 tons and Cuenca (Castilla-La Mancha) and Soria (Castilla-León) with more than 1,200 tons each¹⁰. We

can also affirm that Palencia (Castilla-León) is one of the most important sources of wild edible fungi, especially in the case of *L. deliciosus*. Palencia has drawn the attention of buyers coming from all over Spain who then sell the mushrooms mainly in Barcelona (**Fig. 2**), but also in Valencia and Mallorca (Balears). In fact, *L. deliciosus* has appeared only in Palencia since the native *Quercus pyrenaica* forests, which grew there, were replaced with the more productive (in terms of wood) *Pinus nigra*, giving rise thus to an unexpected harvest of edible fungi. An average of 4,000 kg of *L. deliciosus* at ca. 2 €/kg are marketed every day of the season in Palencia, a figure which shows that the area is extremely productive and that mushroom pickers can earn good money. During the mushroom season, wild fungi are available in many retailer stalls, which usually sell fruits and vegetables at the markets (**Fig. 2**). **Table 2** shows the wild edible fungi recorded in retailer stalls in several cities and their prices, when available. It is obvious that prices have increased considerably at this step of the market chain. The most expensive fresh wild fungi are *Boletus* spp., which are sold for up

Table 2. Prices of several wild edible fungi recorded in retailer stalls in Barcelona (Cataluña) in November 2002, and in Pamplona (Navarra) in November 2003. Fungi are sold fresh unless otherwise stated.

Scientific name	Price €/Kg	
	Barcelona	Pamplona
<i>Boletus</i> spp.	Fresh: 25	28-30
	Dried: 130	
<i>Cantharellus cibarius</i>	25	
<i>Cantharellus tubaeformis</i>	8.90	12-15
<i>Clitocybe nebularis</i>		12
<i>Craterellus cornucopioides</i>	13.90	
<i>Hydnum repandum</i>	9.90	
<i>Lactarius deliciosus</i>		
	1 st class 13	16
	2 nd class 6	10.5-12
	3 rd class 3	6
<i>Lepista nuda</i>		12
<i>Morchella esculenta</i>	Dried: 320	
<i>Ramaria botrytis</i>	9.90	
<i>Tricholoma terreum</i>	9.90	



Fig. 2. Stall with plenty of *Lactarius deliciosus* for sale at La Boquería market in Barcelona.

in order to find out more data on the amounts of wild edible fungi marketed in Spain, it is obvious that the collection and marketing of this non-timber forest product is an enjoyable and profitable task which falls within the concept of sustainable development, and it can be an extremely important source of income in rural areas with few other economic possibilities.

CULTIVATION OF EDIBLE ECTOMYCORRHIZAL FUNGI: THE CASE OF *TUBER MELANOSPORUM*

Although there have been several attempts to cultivate edible ectomycorrhizal fungi in Spain such as *Lactarius deliciosus* Fr.³ or *Terfezia clavaryi* Chatin⁹, the most successful experiments have been done with *Tuber melanosporum* Vitt., the black truffle, an hypogeous ascomycete^{11,13}. It was not until the French came with their trained dogs in the mid 20th century that the Spanish were aware of their truffle bonanza. Therefore, there is no tradition of consumption of black truffle in Spain, and most of the produce collected is exported to France and Italy, but this trend is changing and now more and more people in Spain are interested in the



Fig. 1. Map of regions of Spain.

to 30 €/kg, but price does not seem to affect the demand for this product, which steadily increases year after year.

Although more research needs to be done

gastronomy of this fine fungus.

During the last decades, the production of wild black truffles has decreased markedly due to environmental problems such as deforestation, droughts or wildfires, a situation that has encouraged both scientists and farmers to find a successful way of cultivating the species and thus guarantee the future production.

The black truffle is a species with narrow ecological requirements¹³: It only grows in areas with calcareous soils (optimum pH = 8), an average annual temperature of 11-14 C and an average annual rainfall of 500-900 mm with at least 100 mm during July and August. Since it is an ectomycorrhizal species, it has to be associated symbiotically with the roots of certain tree species, being the most common hosts *Quercus ilex* L., *Q. faginea* Lam., *Q. humilis* Miller and *Corylus avellana* L.

The first step involved in the cultivation of the black truffle is the inoculation of seedlings of the host tree species chosen aiming at the formation of ectomycorrhizae. The most widely used host tree is *Quercus ilex*, considered to be the species that yields the best results. The inoculation is usually done by spreading the spores of the fungus over the naked roots of the 3-4 month old seedlings, although there are other inoculation techniques³. Six months later the seedlings are analysed to check if the inoculation was successful, *i.e.*, if there are ectomycorrhizae of black truffle in the roots. In order to do this, a few seedlings are chosen at random, their roots are cleaned of soil debris and observed under the stereomicroscope to record the presence of ectomycorrhizae. Single root tips are later excised and mounted to be observed with the microscope to make sure that the ectomycorrhizae formed belong to the inoculated fungus, since contaminations due



Fig. 3. Mycorrhizae of *Tuber melanosporum*. Note the epidermoid outer mantle and the cystidia ramified at a right angle. Bar = 100 µm.



Fig. 4. Black truffle plantation in Navarra. Note the "brûlées" around the trees.



Fig. 5. Plantation owner Javier Lander and his dog looking for black truffles in Navarra.

to other fungi present in the nursery (e.g., *Sphaerosporella brunnea*) are common. The ectomycorrhizae of *Tuber melanosporum* are typically brown, with a pseudoparenchymatous epidermoid outer mantle and cystidia which ramify at a right angle (**Fig. 3**), and are easily distinguishable from those belonging to other *Tuber* species, just in case there was any mistake in the inoculation and other not desired truffle species had colonised the roots of the seedlings¹³.

The inoculated seedlings are then taken to field conditions and planted in areas which fulfil the ecological requirements of the black truffle. In Spain, the oldest plantation dates from 1968, and was established using acorns, i.e., the trees were not previously inoculated. The first plantation with truly mycorrhized plants was established in 1979 (also the biggest in the world, with 600 ha), but most existing truffle plantations in Spain have been planted during the last 15 years¹².

The first truffles appear 5-6 years after the trees are planted, and it takes approximately 8-10 years until the plantation yields a profitable revenue. During the long spell of time between the establishment of the plantation and the harvest of the truffles, it is convenient to monitor the ectomycorrhizal state of the trees, checking if the ectomycorrhizae of *T. melanosporum* are still present or if they have been displaced by other competing fungi naturally occurring in the soil. Samples of roots are regularly taken to be analysed. There is also an external sign that shows that the plantation will probably be successful: the typical formation of “brûlées” or “quemados” about 5-6 years after the trees are planted. This is a circular area around the trunk of the tree (**Fig. 4**) in which the growth of vegetation is inhibited by the

presence of phytotoxic compounds produced by the black truffle^{11,13}. If a tree has a “brûlé”, then it is highly likely that its roots are colonized by *T. melanosporum*, and that the fungus will fructify in a short spell of time.

Since the black truffle is a hypogeous fungus, farmers need an efficient way of detecting the fruit bodies without destroying the soil surface and the ectomycorrhizae underneath. In the past, truffles were traced using pigs; animal not only difficult to handle, but also impossible to train not to eat the spotted truffle. Now, truffles are successfully harvested with trained dogs (**Fig. 5**), which are able to find the truffles due to the strong aroma.

The black truffles are sold in markets that are exclusively for the product. The most important black truffle markets in Spain are located in Vich (Cataluña), Morella (Comunidad Valenciana), Estación de Mora de Rubielos, Graus and Benabarre (Aragón). Depending on factors such as quality and, especially, availability, prices range from 100 €/kg to 360 €/kg paid to the collector¹¹. The average harvest in a truffle plantation after 8-10 years of its establishment is 20 kg/ha/year. Thus, benefits can range between 2,000-7,200 €/ha/year, which makes black truffles a good alternative to other traditional crops such as cereal, with which the benefits are limited to 300-500 €/ha/year depending on the type of cereal and whether the field is irrigated or not^{14,15}. Revenue makes up for the major initial investment required for the establishment of a truffle plantation, for which farmers rely on agricultural subsidies and bank loans. Farmers need ca. 280 inoculated seedlings/ha at 6 €/unit, and when truffles start to grow they need a trained dog, which costs 2,400-4,200 €. Other optional expenses are the fencing of the field (6 €/

meter) and the establishment of an irrigation system (ca. 5,000 €), which is highly recommended to obtain a higher production of truffles¹².

The average annual production of black truffle in Spain between 1990 and 2002 was 22,400 kg¹², including both the truffles collected in the wild and those harvested from plantations, but amounts varied widely depending on the year, with a minimum of 4,000 kg and a maximum of 80,000 kg. The harvest season usually lasts from December 15th to March 15th, but it is officially determined by each city council after considering the weather conditions of the year.

As for the consumption of this delicious fungus, in Spain it usually takes place in specialised restaurants. Restaurants charge between 25-50% extra for a truffle dish compared to a similar one without truffles, and their owners agree that truffle dishes have become more popular in the last 10 years^{14,15}. In spite of the lack of a tradition in cooking recipes based on truffles, canned and fresh truffles can be easily found in supermarkets or retailer stores due to the increasing demand for them. The buyer can pay as much as 3,000 €/Kg for a high quality product, at this last step in the market chain.

There are now 3,500 ha of truffle plantations in Spain, 80% of them in the provinces of Teruel (Aragón) and Castellón (Comunidad Valenciana), and 50,000 new seedlings are planted every year¹². The success in the cultivation of *T. melanosporum* encourages mycologists and farmers to try to grow other edible ectomycorrhizal fungi to guarantee a stable production able to meet the high demand for these products. On the other hand, trees mycorrhized with edible fungal species could also be used in afforestation programmes, yielding an extra revenue together with the main aim of recovering the forest.

FINAL REMARKS

The collection, marketing and cultivation of edible fungi have numerous possible applications, and more attention needs to be drawn on them for a better understanding and use of their economical potential. Spain has become a mycophilic country during the last decades of the 20th century, probably because people may learn about nature through the mass media, the mycological societies, and, of course, knowledge spread from those regions that are traditionally mycophilic. This interest on edible fungi has led to the necessity of cultivating not only easily growing saprobic species, but also cultivating the more difficult to grow ectomycorrhizal fungi in order to guarantee a supply meeting the ever increasing demand. Edible fungi will help farmers adjust to the new reality of farming in the 21st century, providing them with an alternative to traditional crops that are no longer profitable. Edible fungi are a highly valuable natural resource, and we should start to consider them as a key product in our economy, doing everything we have at hand to ensure the sustainable development of their collection, marketing and cultivation.

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