GROWING & USING MUSHROOMS

WRITTEN BY JOHN MASON AND STAFF OF ACS DISTANCE EDUCATION

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The information in this book is derived from a broad cross section of resources (research, reference materials and personal experience) from the authors and editorial assistants in the academic department of ACS Distance Education. It is, to the best of our knowledge, composed as an accurate representation of what is accepted and appropriate information about the subject, at the time of publication.

The authors fully recognise that knowledge is continually changing, and awareness in all areas of study is constantly evolving. As such, we encourage the reader to recognise that nothing they read should ever be considered to be set in stone. They should always strive to broaden their perspective and deepen their understanding of a subject, and before acting upon any information or advice, should always seek to confirm the currency of that information, and the appropriateness to the situation in which they find themselves.

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FORWARD

Many different species of edible mushrooms are both harvested from the wild and cultivated by man. There is however one mushroom genus that dominates what we eat. This is the genus "*Agaricus".* There are a number of species within that genus that are eaten, but one species *(Agaricus bisporus)* dominates.

This book touches on other genera and species, but is mostly about "*Agaricus bisporus*". Despite this focus though, learning to grow and use one species of mushroom is an excellent foundation for growing and using other genera and species.

This book is a useful resource for amateurs and professionals alike, bringing together and presenting information about mushrooms collected by ACS over decades. This includes information from a range of texts listed in the bibliography; numerous brochures and articles, and experience gleaned by our expert tutors and students who have studied our mushroom course (originally developed in 1988; revised and updated many times since).

CHAPTER 1 NATURE & SCOPE OF MUSHROOM PRODUCTION

'Mushroom' is a name that is loosely given to edible fungi (i.e. the fleshy fruiting body). Although they resemble plants, mushrooms are not considered true plants because unlike plants they cannot synthesise their own food. Instead, they are classed in a kingdom of their own.

NATURE OF MUSHROOM GROWING

Mushrooms are not plants and, unlike plants, do not use photosynthesis to produce food to satisfy their nutritional needs. They cannot photosynthesise because they have no chlorophyll containing tissue, which is why they have no green pigments like true plants. They therefore have to utilise the nutrition found in organic matter for growth instead.

There are many edible types of fungi, with only 10 or so being in commercial production. In general, we more specifically relate edible mushrooms to two different species from the genus *Agaricus*, namely:

1. *Agaricus bisporus* (the champignon or button mushroom)

2. *Agaricus campestris* (the field mushroom)

This book focuses on the cultivation and use of *Agaricus bisporus*, which accounts for around 36-40% of mushrooms produced and consumed worldwide. Other genera and types of mushrooms share similarities in both the way they grow and the way they are used. Some of these other types may be more popular in different countries or cultures. Nevertheless, understanding the production of *Agaricus* is an excellent foundation for developing an understanding of growing any other type of edible fungi.

Agaricus bisporus

Mushrooms need a dark controlled environment to grow well. Home gardeners can grow mushrooms on a small scale but the growing techniques used are not as sophisticated as commercial growers. Home gardeners (and occasionally those looking for a different taste) may also seek out and harvest wild mushrooms. However, harvesting wild mushrooms requires

expertise in identification because there are many forms of deadly (poisonous) mushrooms growing wild and their appearance can be very similar meaning that some poisonous varieties are very easily mistaken for edible mushrooms by novices.

A variety of edible mushrooms

SIGNIFICANCE OF MUSHROOM GROWING

Mushrooms are significant for several reasons. Firstly, they are a valuable crop that can be produced and harvested throughout the year; seasons do not influence growth. Secondly, they are highly nutritious. Mushrooms are an important part of the human diet perhaps more so for some people than others; vegetarians (for example) may eat mushrooms more than others as a meat substitute. Thirdly, they have cultural value, with the Chinese being by far the largest consumers and producers.

Commercial production has increased significantly over the past century and especially in the past 40 years.

Mushroom production expanded exponentially worldwide from 350,000 metric tons in 1965 to 10 million metric tons in 2013. Production has steadily increased since then.

Out of the 10 or so commercially produced species, button mushrooms (*Agaricus bisporus*) take the lead at 36-40% of global production. Along with oyster and shiitake mushrooms, button mushrooms constitute around 75% of the world's commercial mushroom production. Asian countries are still the largest mushroom producers (around 70% of the total world production) and also the largest consumers of button mushrooms, shiitake and other edible specialty mushrooms. The United States and Europe are also major producers, focussing mainly on white button mushrooms but also contributing to the production (although on a much smaller scale) of the shiitake mushroom (particularly Western Europe).

The major mushroom producing countries (in order of greatest production) are:

1. China
2. USA
3. Netherlands
4. Poland
5. Spain
6. France
7. Italy
8. Ireland
9. Canada

NUTRITIONAL VALUE OF MUSHROOMS

Protein and Amino Acids

With regards to their nutritional value, mushrooms have largely been of interest due to their protein content. On a fresh weight basis, the protein content of mushrooms varies between 1.8 and 5.9%. Fresh mushrooms contain about twice as much protein as many vegetables. However, some vegetables like green peas, Brussels sprouts and pulses (beans, dried peas and lentils) contain more protein than mushrooms. Other high protein sources such as meat, fish, egg and cheese are also superior in protein content.

Flammulina velutipes
Enoki Mushrooms

Studies have shown that humans are able to digest about 71 to 90% of mushroom protein. In comparison, approximately 99% of meat protein can be digested.

The quantities of the amino acids threonine, valine and phenylalanine in mushroom protein are comparable to the quantities found in meat protein. However, mushroom protein is slightly inferior in isoleucine, leucine, lysine and histidine. Methionine and cysteine amounts in mushroom protein are significantly lower than in meat protein, but similar to the amounts found in vegetable protein. Mushroom protein contains more lysine and tryptophan than vegetable protein typically does. It can therefore be said that the nutritional quality of mushroom protein lies between that of meat and vegetable protein.

Pleurotus spp. Oyster Mushroom

Carbohydrates

Apart from water, carbohydrates are a main component of mushrooms, accounting for up to 4.2 % of the fresh weight.

Letinus edodes -Shitake

THE SCIENCE

Mushrooms are fungi. Traditionally, fungi have been included in the plant kingdom. However, now they are placed in a kingdom of their own. All fungi (apart from yeast) grow as hyphae. These are microscopic filaments which radiate from the spore and branch out to create a mycelium. The hyphae of *Agaricus bisporus* are approximately 0.005 mm wide.

The mycelium is septate (divided into cells). Each of the individual cells holds all of the necessary organelles for independent growth. Therefore, if a mycelium is fragmented, each fragment is capable of regenerating and forming a new colony. The nucleus is the most important organelle, as it contains the genetic information and controls the cell functions. Cells without a nucleus are not viable. In the typical mushroom or toadstool, mycelial cells are uninucleate or binucleate i.e. they contain one nucleus or two nuclei.

The mycelium represents the vegetative phase of fungal growth. Spore bearing structures, called fruiting bodies, represent the sexual phase. The fruiting body (also known as the sporocarp) is the part we eat, commonly referred to as the mushroom. It is made up of hyphae which are differentiated into tissues.

Fungi are divided into four classes:

- Chytridiomycota
- Zygomycota
- Ascomycota
- Basidiomycota

Mushrooms and toadstools belong to the Basidiomycota class. Members of Basidiomycota have sexual spores which are carried on external structures called ‘basidia’. Each of these basidia typically carries four spores. Mycelia arising from the germinating spores are usually not fertile - they cannot produce fruiting bodies. Clamp-connections are another characteristic of the Basidiomycota. A clamp-connection is a structure which allows an interaction between two single spore mycelia, resulting in the growth of a fruiting mycelium. Not all members of the class Basidiomycota exhibit clamp-connections.

Mushrooms and toadstools produce umbrella-like fruiting bodies, and are together called the ‘gill fungi’. The fruiting part of the gill fungi is composed of the following:

- The cap (also called the pileus).
- The stalk which supports the cap (called the stipe).
- The gills on the under surface of the cap (called the lamellae).
- On some species; a ring on the stalk (called the annulus). The ring is the remains of a veil which covered the gills earlier. It is a thin flap of tissue encircling the stalk near the top of it.

The mature fruiting body of *Agaricus* species has chocolate brown gills which are not attached to the stipe. The spores are also chocolate brown. Another characteristic of *Agaricus* species is a distinct ring on the stipe.

The lifecycle of *Agaricus bisporus* has a couple of unusual features: the

mycelium lacks clamp-connections, and the basidia only carry two spores. The mycelium arising from a germinating spore of A. *bisporus* is fertile and therefore capable of producing fruiting bodies. Multinucleate mycelial cells are a further unusual feature of A. *bisporus*.

Vermiculite has been used successfully for casing mushrooms

Agaricus basketsmall

OTHER TYPES OF EDIBLE MUSHROOMS

While *Agaricus* is the most commonly cultivated mushroom type, the following are also increasingly grown:

Auricularia auricula: This is one of the 'jelly fungus' mushrooms and bears the common name 'Judas' Ear'. This is based on a myth that it grew, as a result of a curse, on the tree that Judas hanged himself on. It was eaten in ancient China, and cultivated on logs throughout Asia. Species of *Auricularia* mushroom can commonly be found dried in Asian stores.

***Coprinus fimetarius* (Grey Shag):** Suited to freezing, canning and drying. It has excellent flavour and potential as a novelty vegetable. Whilst many species of Coprinus are highly ephemeral (they have an extremely short shelf life), *C. fimentarius* has the potential as a cultivated mushroom. It is easy to grow and can quickly produce good commercial yields.

Flammulina velutipes: This fungus is commonly known by names such as 'Winter Mushroom', 'Velvet Stem' and 'Velvet Foot'. Cultivated Japanese varieties are known as Enoki and Enokitake, but bear little resemblance to wild populations. Whereas wild ones are dark in colour, the cultivated Japanese varieties are grown in low-light conditions and have pale flesh and skin. This mushroom fruits in cold conditions. Fruiting bodies are small, but delicious. This mushroom has been eaten for centuries in parts of Asia. It grows naturally on wood and can be cultivated on sawdust.