

Controlling exposure to dust and bioaerosols on farms growing common commercial mushrooms (*Agaricus bisporus*)

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Commercial mushroom farms generate quantities of dust and bioaerosols which can be exposed to staff during their work. This factsheet which has been produced jointly by the HSE and HDC for mushroom growers, briefs production managers on the respiratory risks involved and how to limit and control such exposure.

Introduction

The guidance provided in this factsheet focuses on the risks of respiratory disease associated with the growing and harvesting of

common white/chestnut mushrooms (*Agaricus bisporus*) and provides advice on controlling the exposure of workers to dust and bioaerosols during typical work activities on commercial farms (Figure 1).

It does not include the production of mushroom compost, the spawning

of compost or the growing and harvesting of exotic species which may spore heavily prior to and during harvesting. Exotic species include varieties such as Oyster (*Pleurotus ostreatus*), Shiitake (*Lenitinus edodes*), Bunashimeji (*Hypsizigus marmoreus*) and Shimeji (*Lyophyllum aggregatum*).



1 Commercial mushroom farms generate quantities of dust and bioaerosol which can be exposed to staff

Typical growing cycle and working practices

The commercial mushroom growing industry in the UK has changed dramatically over recent years, with over 70% of the crop now being produced by a small number of growers who have invested heavily in new growing sheds, equipment and control technology. These growers no longer produce their own compost but purchase supplies from dedicated producers based in either the UK

or mainland Europe. Pasteurised and inoculated compost (Phase II or Phase III) is delivered in bulk or in the form of growing blocks.

Commercial growers use three grades of compost:

Phase I compost is a basic growing medium made from a composted mixture of straw, chicken or horse

manure, lime and water. The composting process generates temperatures in excess of 70°C and pasteurises the medium which helps to prevent the growth of competing or pathogenic micro-organisms. However some thermophilic bacteria, particularly actinomycete species, and fungi which are essential for crop nutrition, will survive the process.

Phase II compost is Phase I compost which has been inoculated with mushroom spores, usually coated on rye grains and mixed into the medium.

Phase III compost is Phase II compost in which the mushroom spawn has been allowed to develop for 14-21 days.

Most commercial growers use Phase III compost bought in from specialist producers.

Common mushrooms are typically grown in sheds which resemble opaque rigid polytunnels (Figure 2) that each contain two parallel aluminium racks running the length of the building. Each rack supports up to four open-mesh flat growing frames or shelves (Figure 3). The exact arrangements and layout may vary from producer to producer. The environmental conditions (humidity, temperature and ventilation) inside the sheds can be altered to promote the different phases of the growing cycle.

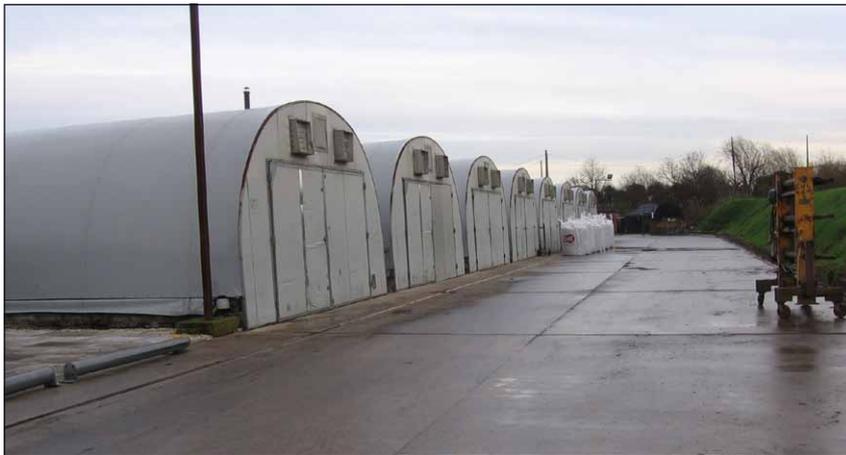
There are 5 processes within the typical cropping cycle of a modern commercial mushroom farm.

1. Shed preparation

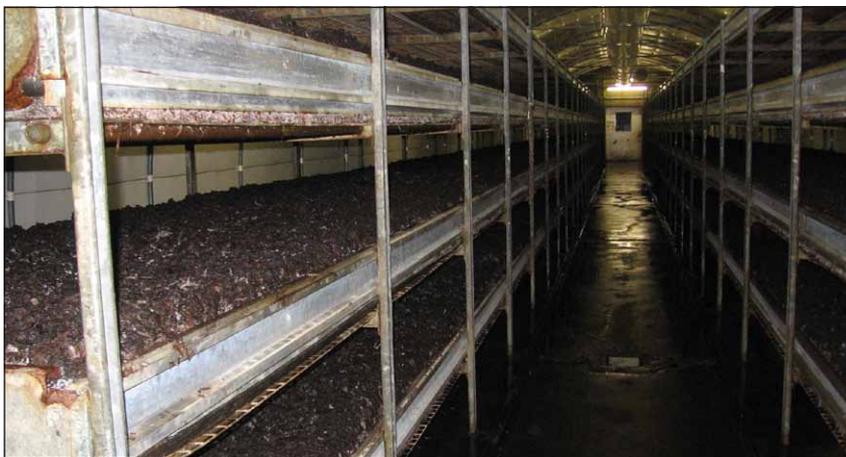
The start of the cycle involves filling the sheds with inoculated compost.

Bulk compost is transferred by a system of mobile hoppers (Figure 4) and conveyors from the delivery lorry to a purpose designed and built filling machine (Figure 5) which produces a continuous, layer of compost covered with a thin covering of casing. The compost is also compressed and watered on passage through the machine.

The layer of compost is discharged onto a strong nylon mat (similar to a length of conveyor belt) which is drawn by a remote winch through the racking (Figure 6)



2 Typical sheds used to house racks and shelves



3 Aluminium racks supporting shelves



4 Hopper transferring compost from lorry



5 Filling machine used to lay compost in shelves



6 Compost being drawn through the racking



7 15-20cm deep growing bed



8 Casing colonised by mycelium

to form a growing bed about 15-20 cm (6-8 ins) deep along the shelf (Figure 7). The process is repeated for each shelf in turn.

The casing which is an inert mixture of peat, sugar-beet lime and water helps to promote the production of fruiting bodies (i.e. mushrooms).

It normally takes two operatives between two and a half and three hours to fill each shed, but times will vary depending on the tonnage. Filling may not take place every day.

More manual handling is involved in forming the growing beds when the compost is delivered as growing blocks, but the end result is very similar.

2. Growing

The compost is watered with a hose pipe at the start of the growing period to raise the moisture level inside the shed. The temperature is raised and the ventilation rate reduced to encourage the mushroom spores to develop hyphae which permeate the compost to form the mycelium.

Once the mycelium has colonised the casing (Figure 8), the conditions are reversed and become more challenging for the fungi which respond by producing fruiting bodies which appear on the surface of the casing and are known as pins. The pins are left to grow to picking size.

The level of carbon dioxide, which is produced naturally by the bed, is critical to the development of the crop. Levels are regularly monitored by automatic sensors or hand-held meters and adjusted by altering the airflow through the shed. Typical carbon dioxide levels in growing sheds vary and can reach up to 5,000ppm.

Operatives enter the sheds intermittently to examine the crop.

3. Picking

All mushrooms are picked by hand (Figure 9 - overleaf) at various stages of development depending on the prevailing market demands. The first flush of mushrooms is usually picked about 16-17 days into the growing phase and over a period of 5-6 days. Second and third flushes of mushrooms will be picked from the same bed at later dates.

The first small mushrooms are



9 All mushrooms are picked by hand

immature and have closed cups. The upper white cap still completely covers the gills which themselves remain closed. These are often called button mushrooms and do not release spores.

Some mushrooms are allowed to grow older and to become much larger and flatter. They are known as 'flats' and their caps have opened to reveal the gill covers (open cup). Most 'flats' are picked before fully mature when the gills are still pink or light brown, are not open and are not releasing spores. However, it is difficult to be certain, just by looking, if the gills have started to open and release spores.

Waste mushrooms are taken off the bed in early flushes to allow space for the next crop to develop.

4. Packing

The punnets of mushrooms are check-weighed, sealed and labelled before distribution to customers. Packing takes place in a separate room.

The product may be refrigerated or hydro-cooled during packing which may inhibit spore release.

5. Shed clearance

After the final flush of mushrooms has been picked, the entire shed is filled with steam which is maintained for about 12 hours, usually overnight. This process is called 'cooking out'. During this period the temperature of the beds is raised to about 70°C which is sufficiently high to destroy the mushroom fungi and any mesophilic (growth at ambient temperature) bacteria in the compost (Figure 10).

The compost is removed by reversing the filling process and drawing the compost out of the shed by rewinding the nylon netting. The pasteurised compost, still warm and damp, falls in lumps onto the base of a mobile inclined conveyor (Figure 11) and is elevated into a parked trailer or skip (Figure 12). The spent compost is taken away by local farmers for use as a fertiliser and soil-conditioner.

It may take up to one and a half hours to remove the compost from each shed, again depending on tonnage.

The sheds are hosed down with clean water after the compost has been removed. Each shed takes a further hour to wash.



10 Cooking out destroys mushroom fungi and mesophilic bacteria in the compost



11 Spent mushroom compost is removed in lumps



12 Spent mushroom compost is loaded into trailers

Health hazards

Workers on commercial mushroom farms may be exposed to bioaerosols containing bacteria and fungi present as a result of the compost production, or that have later colonised the compost or casing, and possibly spores from the mushrooms themselves. All have the **potential** to cause respiratory ill health.

Thermophilic (heat-loving) bacteria such as species of thermophilic actinomycetes and some fungi such as species of *Aspergillus* are fundamental to the composting process and their spores may still be present in large numbers in the finished mushroom compost. Therefore they may be abundant



13 Exotic mushroom species (not covered in this factsheet) are more frequently documented as causing respiratory allergies

in the air whenever the compost is disturbed. Fungi such as *Aspergillus fumigatus* and *Trichoderma* species may colonise the surface of the casing in the growing sheds and their spores may become airborne during picking.

The pasteurisation of the compost after picking will reduce the number of viable micro-organisms in the compost at disposal. However, workers may still be exposed to large numbers of intact but non-viable spores which retain the potential to trigger allergic responses.

Respiratory disease in the mushroom industry can be separated into two distinct syndromes caused by exposure to different aetiological agents:

- Mushroom worker's lung, which is an extrinsic allergic alveolitis (also referred to as hypersensitivity pneumonitis) - similar to Farmer's Lung disease. This is associated with exposure mainly to actinomycete spores in the compost.
- Mushroom picker's lung or mushroom picker's asthma. This is caused by inhaling spores of the mushrooms themselves or of contaminating fungi such as *Aspergillus fumigatus* present as a coloniser of the compost in the growing sheds.

Although the spores of the **common mushroom** (*Agaricus bisporus*) are capable of causing allergic reactions there are few reported cases and they are unlikely to represent a significant respiratory hazard. However, exotic mushroom species (Figure 13 - not covered by this guidance) are more frequently documented as causing respiratory allergies and, if grown at the same premises as common mushrooms, should be the subject of a separate risk assessment.

Although bulk compost has a high-moisture content, some organic dust particles are released into the air when the material is transferred from the delivery lorry into the sheds. However, the levels are not sufficiently high for the dust to fall within the definition of a hazardous substance under the Control of Substances Hazardous to Health Regulations 2002 (as amended) (COSHH) on the basis of this qualification alone.

Very little dust appears to be released at other stages of the cycle, but it is worth bearing in mind that during shed clearance ('cookout') the raised temperature could cause drying out of the compost and create the potential for dust.

Carbon dioxide is not a toxic gas but in high concentrations acts as a simple asphyxiant.

Workplace exposure limit

It is not known what concentration of an allergen is required either to cause an initial sensitisation, or to cause reaction in those already sensitised or to cause other symptoms of ill health in the respiratory system.

Consequently, no workplace exposure limits have been set in the UK for bacteria, fungi or fungal (including mushroom) spores.

The long-term workplace exposure

limit (WEL) for carbon dioxide is 5,000 ppm (8-hour time weighted average). The corresponding short-term limit is 15,000 ppm (15-minute reference period).

Health risks

The consequences of exposure to bioaerosols may be very serious but the health risk to an individual worker will depend on his or her job which, in turn, will determine the

duration, frequency and levels of exposure to the harmful agents.

It is difficult to assess the health risks of exposure to bioaerosols in

the absence of defined workplace exposure limits but changes in growing practices coupled with the relatively small number of reported cases of ill health amongst mushroom



14 Spores are only released when caps and gills open

workers in this sector of the industry would suggest that, provided reasonable precautions are taken, the risks are low when undertaking tasks common to many commercial farms.

Nevertheless, growers still have a duty to assess the risks to their own workers which will be determined largely by the growing systems, working practices and routines. Particular attention should be paid to assessing the risks to workers potentially exposed to dust and bioaerosols from compost handling, or associated with specific tasks such as cleaning and maintaining machinery.

Spores from the common mushroom are only released when the fruiting bodies are allowed to mature when the caps and gills open (Figure 14). Common mushrooms are normally

picked before the caps open so will not release spores before or during picking. However, if left to mature, the gills may open and release spores on handling. Although there is little evidence of respiratory symptoms associated with the inhalation of spores released by common mushrooms themselves, the risk still needs to be considered.

The levels of inhalable dust in mushroom sheds have been measured and, generally, have been found to be very low (<1mg/m³).

In practice, accumulations of dangerous levels of carbon dioxide are prevented by monitoring and adjusting the shed climate, in particular by operation of the shed ventilation systems.

Legal requirements

Mushroom spores and other micro-organisms present in the growing compost are subject to the Control of Substances Hazardous to Health Regulations 2002 (as amended) (COSHH).

COSHH requires employers and self-employed people to:

- Assess the risks to health from

work activities which involve hazardous substances;

- Prevent or, where this is not reasonably practicable, adequately control exposure to the hazardous substances;
- Introduce and maintain control measures;

- Inform, instruct and train employees about the risks and the precautions to be taken;
- Provide health surveillance where appropriate.

It is important to consult workers or their representatives when assessing risk and making decisions about control measures.

Controls



15 Carbon dioxide levels should be monitored and sheds ventilated accordingly

growers to comply with their responsibilities under COSHH.

Some common control measures that apply to all activities include:

- Exclude all non-essential personnel including visitors from working areas including growing and packing sheds. This will also reduce the risk of contamination.
- Maintain ventilation levels in growing and packing sheds.
- Practise wet cleaning, such as low pressure washing, to minimise the creation of airborne dust and bioaerosols.
- Good husbandry and site management support high standards of health and safety.

Shed preparation

- When receiving deliveries of bulk compost, carefully position the delivery lorry, transfer conveyors and filling machine, especially in relation to the wind direction, to reduce exposures to airborne contaminants. Try to keep workers remote from and upwind of any releases of dust and bioaerosols.
- Minimise the free fall of compost during transfer operations.
- Use vehicles such as material handlers with enclosed, ventilated cabs with filtered air intakes. Keep windows closed during use. Maintain the ventilation system of each vehicle in accordance with the manufacturer's instructions.

This section describes reasonably practicable measures which should be taken to protect workers' health. These measures represent 'good working practice' for the industry sector and should help

Growing

- Control shed climate to reduce levels of carbon dioxide commensurate with the needs of the crop.
- Monitor carbon dioxide levels (Figure 15) in growing sheds and operate ventilation systems to prevent the accumulation of gas.

Picking

- Work carefully and avoid disturbance of the compost and casing as much as possible.
- Consider wearing filtering

respiratory protective equipment (RPE) with an APF of at least 10, e.g. FFP2, if there is evidence of fungal contamination on the surface of compost and casing, or when picking flat mushrooms that may be releasing spores.

Packing

- Consider the need for engineering controls such as local exhaust ventilation (LEV) on lines if they are used to pack mature flat mushrooms which may release spores.

Shed clearance

- Fit vehicles such as tractors used to tow trailers for transporting spent mushroom compost with enclosed, ventilated cabs with filtered air intakes. Keep windows closed during use. Maintain the ventilation system of each vehicle in accordance with the manufacturer's instructions. Alternatively drivers should vacate the cabs during trailer filling.
- Workers stand upwind or remote from the compost conveyor and trailer during loading.
- Depending on working practices, consider the need to wear RPE.

Respiratory protective equipment (RPE)

All RPE should be manufactured to a suitable standard and should be CE marked. Nuisance disposable dust masks do not provide protection against harmful dusts and bioaerosols and should never be used at work. They are not CE marked.

Selecting the right respirator for

each user is essential. It is unlikely that one particular type or size of respirator will fit everyone.

Face-fit testing (either qualitative or quantitative) must be carried out for all respirators that rely on a good face seal to be effective, i.e. disposable, half and full face masks.

Face-fit testing only ensures that the respirator is capable of fitting properly.

All users of RPE should be adequately instructed and trained in its correct use. The importance of checking the fit before each use should be stressed.

Health surveillance

Workers on mushroom farms may be exposed to micro-organisms that are respiratory sensitisers. It is therefore essential that health surveillance is undertaken to enquire positively about any early symptoms of ill health. Employers have a legal duty to carry out health surveillance under COSHH (regulation 11 and Appendix 3).

There is no means of identifying susceptible individuals prior to employment. People who are atopic are naturally predisposed to becoming sensitised to common allergens and are more at risk of reacting to exposure to compost or mushroom spores. Asthmatics and smokers are also at increased risk.

Objectives of health surveillance

The objectives of health surveillance are to:

- protect the health of individual workers by detecting, as early as possible, symptoms that may be caused by exposure to substances hazardous to health;
- help evaluate the effectiveness of measures taken to control exposure;
- collect information to update knowledge of health hazards in the workplace.

As a **minimum**, health surveillance should include:

- Pre-employment screening that includes a questionnaire about present or past asthma or chest illness.
- Informing new starters about what symptoms they should look out for and report.
- Completion of a questionnaire for all workers after employment

at 6 weeks, 12 weeks (or similar intervals) and at least annually thereafter to enquire about any developing symptoms. The questionnaire must be administered by a responsible trained person who understands the purpose of the questionnaire and knows how to interpret the answers and what action to take if any adverse effects are found.

- Keeping an individual health record for each worker. This should not include any personal clinical or medical data. Any such information should be treated in confidence and kept separately and securely.

Lung function testing may also help with assessing a worker's respiratory health.

Each employer must also identify a named occupational health professional (doctor or nurse) who can:

- help to develop the scheme;
 - train the responsible person;
 - advise on any adverse findings from the questionnaire and, in particular, fitness to continue in the work;
 - make arrangements for further investigations where necessary.
- Each employee should be given information about the health risks associated with exposure to mushroom spores and other micro-organisms present in mushroom compost, the relevant symptoms to look out for and the need to report any symptoms to the nominated responsible person.

Further information

Useful publications

- **Control of substances hazardous to health (Fifth edition). The Control of Substances Hazardous to Health Regulations 2002 (as amended). Approved Code of Practice and guidance**
L5 (Fifth edition)
HSE Books 2005
ISBN 978 0 7176 2981 7
- **A step by step guide to COSHH assessment**
HSG97 (Second edition)
HSE Books 2004
ISBN 978 0 7176 2785 1
- **Five steps to risk assessment**
Leaflet INDG163 (rev2)
HSE Books 2006 (single copy free or priced packs of 10
ISBN 978 0 7176 6189 3)
www.hse.gov.uk/pubns/indg163.pdf
- **Preventing asthma at work. How to control respiratory sensitisers**
L55 HSE Books 1994
ISBN 0 7176 0661 9

- **Respiratory sensitisers and COSHH: Breathe freely – An employers' leaflet on preventing occupational asthma**
Leaflet INDG 95(rev2)
HSE Books 1995 (single copy free or priced packs of 15 ISBN 0 7176 0914 6)
- **Farmer's lung – leaflet**
AS5 HSE Books 2006
- **Respiratory protective equipment at work: A practical guide**
HSG53 (Third edition)
HSE Books 2005
ISBN 978 0 7176 2904 6
- **Using filtering face pieces**
C100 02/09

Other sources of information

HSE priced and free publications are available by mail order from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA Tel: 01787 881165 Fax: 01787 313995

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British Standards are available from BSI Customer Services, 389 Chiswick High Road, London W4 4AL, Tel: 020 8996 9001, Fax: 020 8996 7001 e-mail: cserVICES@bsi-global.com, Website: www.bsi-global.com.
This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

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