



# **International Mushroom Research & Development**

## **A Summary Report of Useful Information Gathered for UK Mushroom Growers from Two Conferences**

7<sup>th</sup> International Conference on Mushroom Biology & Mushroom Products Arcachon, France  
4<sup>th</sup> – 7<sup>th</sup> October, 2011

2011 All Ireland Mushroom Conference and Trade Show  
Maintaining the Momentum  
Monaghan, Ireland  
20<sup>th</sup> – 21<sup>st</sup> October, 2011

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## Contents

<b>Background and purpose of this summary report</b>	1
<b>Introduction</b>	1
<b>Agaricus genome project</b>	2
<b>New mushroom species</b>	2
<b>Pest and disease</b> <ul style="list-style-type: none"><li>- Dry bubble disease</li><li>- Mushroom virus</li><li>- Green mould (<i>Trichoderma</i>)</li><li>- Mush TV</li></ul>	2
<b>Peat substitution/alternatives and recycling</b>	4
<b>Spent mushroom substrate/compost</b>	5
<b>Heating and energy use</b>	5
<b>Health and safety</b>	5
<b>Mushroom nutrition and quality</b>	6
<b>Sales and marketing</b>	7
<b>More to mushroom promotion in the UK</b>	7

## Background and purpose of this summary report

As well as commissioning near market research and development projects, HDC aims to provide growers with information on best practice and new information emanating from sources outside of the HDC.

Two conferences of interest to the mushroom industry were held in the autumn of 2011 and HDC commissioned Kerry Burton from East Malling Research to provide this summary report on key information that could be useful to UK mushroom growers.

## Introduction

Both conferences reported on were international but had very different emphases; the first in France focussed on a wide range of mushroom species, cultivated on substrate/compost, on living trees or collected from the wild. Throughout the world, mushrooms are largely used for food but there is increasing research and industry interest in mushrooms as a source of medicinal and bioactive compounds. This contrasts with the second conference in Ireland which focussed solely on the white cultivated mushroom *Agaricus bisporus*, dealing with applied and practical information from cultivation to marketing. The new approaches, opportunities and problems presented at the two conferences demonstrate that the mushroom industry and research sectors remain dynamic.

The 7<sup>th</sup> International Conference on Mushroom Biology & Mushroom Products was held in Arcachon, France (4 - 7 October 2011). This conference drew delegates from 43 countries with only 3 from the UK and 2 from Ireland. It included sections on genomics, genetics and breeding, diversity and taxonomy, physiology and development, mycosourced molecules and nutritional quality, medicinal properties, waste conversion, substrates and casing, pests and diseases, mycorrhizal mushrooms and economical and societal features. The full proceedings from the conference can be downloaded from the following website:  
<https://colloque4.inra.fr/icmbmp7/Download-proceedings>

The 2011 All Ireland Mushroom Conference and Trade Show, 'Maintaining the Momentum', was held in Monaghan, Ireland (20 - 21 October 2011). This conference was organised by the industry, governments and researchers on both sides of the Irish border. The conference delegates were largely drawn from Ireland although a significant number of British growers and suppliers also attended. The three platform sessions and poster session were concerned with practical aspects of the cultivated white mushroom, *Agaricus bisporus*, including research up-dates, peat replacements, spent mushroom substrate (SMS), energy, cooling and quality, and sales and marketing. Proceedings and presentations from the conference can be downloaded from the following website:  
<http://www.teagasc.ie/publications/2011/1056/index.asp>

## Agaricus genome project

May 2010 saw the first public release of the genome sequence of the cultivated white mushroom, *Agaricus bisporus*. This project costing \$1million was paid for by the USA government under the auspices of the Joint Genome Initiative (JGI). The mission of the JGI is to 'advance genomics to support clean energy generation and environmental characterisation and clean-up'. Mike Challen submitted the successful proposal for genome sequencing concentrating less on the fungus as an agricultural crop and more on the ecological aspects of *Agaricus bisporus* as a model fungus engaged in leaf litter degradation involved in carbon cycling and carbon sequestration. Two haploid genomes were sequenced, H97 a parent of the modern cultivated hybrids and JB137-s8 belonging to the wild four-spore variety collected in the Sonoran desert in southern California. The genome consists of 10,438 genes. The initial analysis can be considered as an inventory or 'parts list' of genes that make up *Agaricus bisporus* and in particular how the fungus has adapted to grow and thrive on composted straw rather than raw straw (which is favoured by many other fungi). This work has now been written as a scientific paper (headed by Francis Martin of France) entitled 'The genome sequence of the Button Mushroom *Agaricus bisporus* reveals mechanisms governing adaptation to a humic-rich ecological niche'. This work is of immediate use to all mushroom scientists especially the breeders looking to improve substrate utilisation, pest and disease resistance, pinning and quality improvements.

## New mushroom species

There are research groups in China, Thailand, Turkey and Mexico looking to expand the number of mushroom species available for sale by collecting wild mushroom species and observing what is being sold at the local markets with a view to developing new mushroom products. Kevin Hyde of School of Science, Mae Fah Luang University, Thailand, reported finding 12 new *Agaricus* species in Thailand which are edible and have the potential for cultivation. We should expect some of these to make an entry into the world market in the future. There was also continued interest in the species *Agaricus braziliensis*, which has potential for cultivation and has considerable evidence supporting beneficial health effects. Further information on this can be found in a scientific paper on the subject at the following website: <https://colloque4.inra.fr/var/icmbmp7/storage/fckeditor/file/poster%20session/P5.pdf>

## Pest and disease

The main disease focus at both conferences was on green mould (*Trichoderma* spp.) and Mushroom Virus X, although there was news that Cobweb (*Dactylium*) is becoming a problem in Spain and Serbia and Wet Bubble (*Mycogone perniciososa*) is a current problem in India. Further information on this can be found in a scientific paper on the subject at the following website: <https://colloque4.inra.fr/var/icmbmp7/storage/fckeditor/file/individual%20oral%204/ICMBMP7-Oral-4-21-%20Potocnik.pdf>

Research into disease control using essential oils from aromatic plants or biological agents in laboratory tests has been done, but such techniques do not often translate into practical control in crops.

### ***Dry bubble disease (*Verticillium fungicola*)***

A new growing medium has been developed by Helen Grogan (Teagasc) with greater selectivity which has enabled the detection of reservoirs of *Verticillium* in most farms tested, even those where there are no disease symptoms. This demonstrates that most farms have the potential for dry bubble disease to occur. A presentation by Helen Grogan including this subject can be found at the following website: [http://www.teagasc.ie/publications/2011/1056/Helen\\_Grogan.pdf](http://www.teagasc.ie/publications/2011/1056/Helen_Grogan.pdf)

### ***Mushroom virus***

Kerry Burton (East Malling Research) reported that Mushroom Virus X disease is now considered to be caused by a number of separate viruses. Strong evidence was presented to suggest that the 'browning virus' is caused only by bands 18 and 19 and that the other small bands (20-23) are fragments of 18 and 19. A new highly sensitive PCR test has been devised which can quantify the amount of infection and it is sufficiently sensitive to detect early infection in compost. Using this test it has been shown that the severity of the browning symptom correlates with the amount of active virus, and that the small amount of infection in Phase 3 compost can increase 100-fold during cropping. Therefore low levels of infection have the power to become major problems. This work was originally funded by Teagasc (Ireland) and HDC (Project M 51) and is going to be continued as part of the 'MushTV' new European funded project (see below). The HDC report on Project M 51 can be found at: <http://www.hdc.org.uk/project/developing-accurate-quantitative-and-predictive-test-mushroom-virus-x>.

### ***Green mould (*Trichoderma*)***

*Trichoderma* has been found to sporulate less in the dark. Johan Baars from Plant Research International (PRI), Wageningen, Netherlands, reported on a new project to develop an early warning system to detect *Trichoderma* infection in compost bunkers by analysing the gases and odours produced with the aim of making this technology commercially available. Further information on the mushroom work being undertaken at PRI can be found at: <http://www.mushrooms.wur.nl/>. This work is being further developed as part of the 'Mush TV' new European funded project (see below).

### ***EU funded MushTV project on diseases***

A new international project funded by the EU and led by Helen Grogan of Teagasc has been set up to provide mushroom businesses with research-based solutions to deal with *Trichoderma* compost green mould, Mushroom Virus X and other common

mushroom diseases so that businesses can improve efficiency, through reduced losses due to disease. The results from the project will provide mushroom growers and composters with:

- A better understanding of how *Trichoderma aggressivum* and MVX infect mushroom compost, and how they are spread around the industry.
- Improved molecular diagnostics for MVX and *T. aggressivum* and a new volatile-based diagnostic test for the early detection of compost green mould in compost tunnels.
- Information on the best disinfectants to kill *T. aggressivum* and MVX.
- Efficacy data on a promising biopesticide, based on the bacterium *Bacillus subtilis*, for the control of dry bubble and other mushroom diseases including compost green mould.

This combination of knowledge of pathogen biology, good hygiene practices, use of diagnostic tests and the use of effective plant protection products, is the cornerstone of a good integrated pest management (IPM) system. The consortium consists of 5 research groups from Ireland (Teagasc), UK (East Malling Research and Agri-food and Biosciences), The Netherlands (Wageningen) and Belgium (POVLT). The project is funded by the EU and managed by SME associations in Ireland, UK, Netherlands, Poland and Belgium. Further information about the project can be found on the Mushroom page of the HDC website at <http://hdc2.be-different.co.uk/mush-tv-0>.

Helen Grogan is requesting UK mushroom grower participation, for surveying and sampling on mushroom farms to provide information on Trichoderma and Virus X.

### **Peat substitution/alternatives and recycling**

Only 5% of the peat used in Britain goes into mushroom casing; however there is environmental pressure to reduce this, which could potentially make UK mushrooms less competitive than imported peat-grown produce. Ralph Noble (East Malling Research) discussed materials that could act as alternatives or part-substitutes (part of the work funded by HDC Project M 55. The HDC report on this project can be found at <http://www.hdc.org.uk/project/mushrooms-desk-study/literature-review-potential-alternatives-peat-mushroom-casing> ). Several materials can be used but are not a viable replacement due to the low yields achieved, insufficient supply or high cost. A good casing material should have high water holding capacity, low salt and nutrient content, low cost, a large and local availability, a low load or potential to harbour pests and disease and its use should not need to overcome red tape.

This latter point refers to the slow reaction of the Environment Agency in approving some waste materials for re-use (e.g. clay from mining waste). It is important to examine just how much water a material can hold when saturated but also how much water is retained even after a desorption treatment. Some materials that show promise include clay, re-used rockwool, coir, spent casing and PAS100 standard

green compost. New machinery is now available which separates spent casing from spent compost. Mairead Kilpatrick's group at AGRIFOOD and Bioscience Institute (AFBI) in Belfast, is looking at methods to compare and analyse the peat for mushroom casing using thermogravimetric techniques. Further information on this work can be found at: <http://www.afbini.gov.uk/horticultural-analysis-and-diagnostics>.

### **Spent mushroom substrate/compost**

There is a considerable research effort for expanding the potential uses of Spent Mushroom Compost or Spent Mushroom Substrate (SMS) in particular by Dr. Siobhán Jordan (Organic Resources Research Group, Dundalk Institute of Technology, Ireland) and Gerry Walsh (Teagasc, Showgrounds, Gorey, Co Wexford, Ireland). SMS can be used as a fertiliser for winter wheat and spring barley. The application rates depend on regulations which can change due to new considerations such as nutrient availabilities. SMS has too high a salt content for use as a casing material, however it can be used as a mulch or potting substrate for certain ornamental shrubs and as a soil conditioner for vegetable cultivation, due to its ability to increase water holding capacity and to act as a slow release fertiliser. SMS is not a good alternative fuel source as it has low calorific value and produces large quantities of ash. More information on this subject can be found in presentations by Siobhan Jordan and Gerry Walsh at:

[http://www.teagasc.ie/publications/2011/1056/Siobhan\\_Jordan.pdf](http://www.teagasc.ie/publications/2011/1056/Siobhan_Jordan.pdf)

[http://www.teagasc.ie/publications/2011/1056/Gerry\\_Walsh.pdf](http://www.teagasc.ie/publications/2011/1056/Gerry_Walsh.pdf).

### **Heating and energy usage**

Comparisons between mushroom farms have demonstrated that energy savings can be made by the choice of fuel, use of air heat recovery systems and condensing boilers vs. conventional boilers and pipe insulation. Biomass as a fuel is viewed as a successful and attractive option for mushroom growers, aided by the Renewable Heat incentive scheme which provides a rebate (available for 20 years) to cover the cost of the biomass at current prices. Further information on biomass use in mushroom production is included in a presentation produced by Brendan Burns of Sylvan in Ireland at

[http://www.teagasc.ie/publications/2011/1056/Brendan\\_Burns.pdf](http://www.teagasc.ie/publications/2011/1056/Brendan_Burns.pdf).

### **Health and safety**

Hydrogen sulphide (H<sub>2</sub>S) gas can be emitted from anaerobic Spent Mushroom Substrate (SMS). It is potentially toxic and therefore a safety concern. The storage conditions of SMS affect the amount of H<sub>2</sub>S release. Adequate measures should be taken to allow any H<sub>2</sub>S release from SMS to be dissipated. Some further information about research into this work at Teagasc is included in a presentation prepared by Helen Grogan of Teagasc, Kinsealy Research Centre at

[http://www.teagasc.ie/publications/2011/1056/Helen\\_Grogan.pdf](http://www.teagasc.ie/publications/2011/1056/Helen_Grogan.pdf).



## Mushroom nutrition and quality

Hanne Kristensen from Aarhus University in Denmark, reported that 40% of Danes have a low vitamin D status. This has prompted a study to examine the conversion of ergosterol to vitamin D by treatment of the mushrooms by ultra-violet light. Vitamin D content correlates with the dose of UV applied and there was no effect on mushroom yields. More information and a report on this study can be found at <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3321259/>.

Brian McGuinness of Teagasc, Kinsealy Research Centre emphasised that mushrooms are an excellent source of minerals and vitamins containing high levels of phosphorus, selenium and vitamins B2 (riboflavin), B3 (niacin) and B5 (pantothenic acid). The benefits of eating mushrooms should be conveyed to the health conscious consumer.

Cold chain is an important method to maximise quality at the point of retail sale. John Collier of Monaghan Mushrooms described three methods to rapidly cool mushrooms: forced air cooling and vacuum cooling (both of which are currently in use on commercial mushroom farms), and a new technology called cryogenic cooling, which is currently being evaluated. Further information on the effect of cool chain on mushroom quality is included in a presentation produced by John Collier at [http://www.teagasc.ie/publications/2011/1056/John\\_Collier.pdf](http://www.teagasc.ie/publications/2011/1056/John_Collier.pdf).

The most noticeable form of quality-loss for mushrooms is browning and Kerry Burton of East Malling Research described the factors which cause this problem which had been studied in HDC projects (M 8, M 19, M 19a, M 37, M 40, M 40a) and outlined in HDC Factsheet 15/04 – Optimising mushroom quality. Some of these HDC reports can be found at: <http://www.hdc.org.uk/research-projects/mushrooms?page=1>. He made the comparison of the structure of a mushroom with a lattice of cells supporting the skin to that of the Aviva Stadium with a lattice of girders holding up the structure. Bruising is caused when a mushroom is damaged during picking or transport when these supporting cells rupture. However the amount of bruising damage depends on how it is grown, and ranges from severely bruised to hardly noticeable. A bruisometer machine was designed and developed in the HDC projects which can deliver a simulated 'slip-shear' bruising damage. Use of the bruisometer has revealed that water during the growing process is the key factor influencing mushroom 'bruisability', which is influenced by casing wetness, humidity and calcium chloride irrigation. Two Dutch groups have developed a similar bruisometer based on the Burton bruisometer design and are examining bruising from a genetic point of view, trying to identify the genes that determine bruising sensitivity with a view to breed new strains with improved quality characteristics, perhaps with the capacity for mechanical harvesting for the fresh market. Further information on improving mushroom quality by reducing bruising damage is included in a presentation produced by Kerry Burton at [http://www.teagasc.ie/publications/2011/1056/Kerry\\_Burton.pdf](http://www.teagasc.ie/publications/2011/1056/Kerry_Burton.pdf).

## Sales and marketing

Michal Slawski from Bord Bia presented an overview of mushroom production and the retail markets in Ireland and the UK. Recent years have seen an expansion of Irish mushroom production and a decrease in UK production. However the low exchange rate of sterling to euros has affected Irish profitability and stability. Both Irish and British retail markets have been affected by the recession but mushroom sales are holding up. The strongest growth is for the browns/chestnut type mushrooms. Two of the trade stands at the All Ireland Mushroom Conference promoted brown varieties: Triple X and Forestière.

Michal Slawski also presented a poster outlining the advantages and disadvantages of 'Branding in Mushrooms' such as the fruit brands found on the supermarket shelves. There are opportunities for branding as consumers are interested in *who* grew the product (taking in heritage and trustworthiness of producer), and environmental and ethical issues.

## More to mushrooms promotion in the UK

Mushrooms are being promoted in the UK in a new campaign targeted at women aged 25-45 which emphasises health benefits. The campaign includes advertising in women's magazines, health leaflets (distributed to doctor's surgeries and nutritionists), digital adverts and a web-site [www.moretomushrooms.com](http://www.moretomushrooms.com). The adverts promote the high B vitamin and antioxidant content of mushrooms, and show an apple and tomato shaped as a mushroom (see below). The more to mushrooms advertising campaign is financed by the European Union, Irish and British producers as well as traders. Further information on mushroom retailing in the UK and Ireland can be found in a presentation by Michal Slawski at: [http://www.teagasc.ie/publications/2011/1056/Michael\\_Slawski.pdf](http://www.teagasc.ie/publications/2011/1056/Michael_Slawski.pdf)

