MushroomLink

SPRING 2022

ISSUE 2

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Communications Manager

Hort Innovation

Level 7, 141 Walker Street
North Sydney NSW 2060
Australia

Email: communications@horticulture.com.au

Phone: 02 8295 2300

TECHNICAL CONTENT

Dr Jenny Ekman
jenny.ekman@ahr.com.au

EDITOR

Paulette Baumgartl
paulette.baumgartl@ahr.com.au

PROJECT COORDINATOR

Ryan Hall
ryan.hall@ahr.com.au

DESIGN

Jihee Park

hello@jiheeparkcreative.com

PUBLISHER

Applied Horticultural Research Pty Ltd
www.ahr.com.au

Cover: Graham Price with University of Sydney technical officer Katarzyna Safianowicz at the Marsh Lawson Research Unit.

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CAN MUSHROOMS REALLY HELP LOWER **OUR CHOLESTEROL?**

By Paulette Baumgartl

For over 20 years, breakfasters around the world have enjoyed their daily oats, confident in the knowledge that their morning repast was doing them some good. But what about mushrooms?

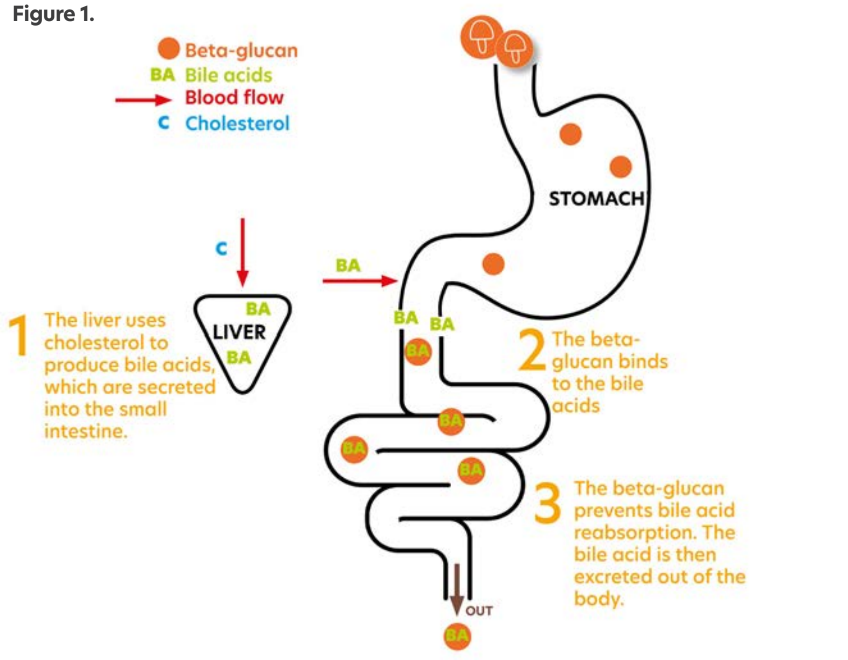
The well-documented cholesterol-lowering effect of oats has been certified by nutritional regulators globally since the late 1990s. Subsequent studies and clinical trials have shown consistent results that confirm, and even boost, the original claims. This high-level health claim has driven an increase in the consumption of oats globally[1].

Beta-glucan, the compound responsible for lowering cholesterol, is famously present in oat and barley grains. However, its presence in mushrooms is less well known.

The oats and barley health claim is currently authorised by Food Standards Australia New Zealand (FSANZ), the US Food and Drug Administration (FDA), and the European Food Safety Authority. To be eligible for the claim, FSANZ specifies that the food must contain at least 1 g of beta-glucan per serving and be consumed in the context of a diet containing 3 g of beta-glucan/day.

A key goal of the mushroom Strategic Investment Plan (SIP) is to support research that increases domestic consumption of mushrooms. Achieving a cholesterol-lowering high-level health claim would help achieve this aim. A levy-funded CSIRO project, *Mushrooms and their potential health benefits of lowering blood cholesterol (MU20001)* is now generating the evidence needed to pursue this claim.

Figure 1.



What is beta-glucan and how does it work?

Beta-glucan is a type of soluble dietary fibre that is present in the cell walls of some grains, yeasts, bacteria, fungi, and algae.

As illustrated in Figure 1, when beta-glucan enters the small intestine it can bind cholesterol-containing bile acids, preventing bile-acid reabsorption in the small intestine. It then passes into the large intestine where it is excreted from the body. Bile acids are important in aiding absorption of nutrients in the small intestine. As the body must then produce new bile acids in the liver using cholesterol, this results in reduced levels of cholesterol in the blood.

Beta-glucan and mushrooms

A small number of clinical trials have indicated that mushrooms could have cholesterol-lowering properties, but current evidence lacks the scientific rigor to support a health claim. While previous studies have established that mushrooms contain beta-glucan, the path to approval of a high-level health claim by FSANZ is long. It requires deeper knowledge of the type of beta-glucan, its functionality in the human intestinal tract, the likelihood of consumers achieving the serving size required to lower cholesterol levels, and evidence from human clinical trials.

Prior to undertaking a clinical trial, it was first necessary to establish the beta-glucan levels in a variety of mushrooms consumed in Australia, understand how these beta-glucan levels were affected by cooking and compare their bile acid binding capacity with oats.

For this project, beta-glucan content was determined for raw and cooked (boiled or fried) Australian *Agaricus bisporus* (button, cup, flat and brown mushroom) and *Pleurotus spp* (shimeji and oyster) mushrooms. This could then be compared to oats. A digestion simulation test was also used to evaluate the bile acid binding potential of different mushroom varieties.

	Preparation method	Serving (g) providing 1 g beta-glucan	Freeze dried powder (g) providing 1 g beta-glucan	Approx. number of mushrooms for 1 g beta-glucan[2]
Button (average weight 24 g)	Raw	150	12.4	7
	Boiling	100	7.5	
	Frying	80	13.0	
Brown (average weight 22 g)	Raw	150	13.2	7
	Boiling	90	8.8	
	Frying	90	13.8	
Cup (average weight 38 g)	Raw	200	15.7	6
	Boiling	150	12.4	
	Frying	120	14.4	
Flat (average weight 70 g)	Raw	300	22.1	5
	Boiling	200	13.9	
	Frying	170	21.9	
Oats	Raw	14	13.2	
	Cooked	100	20.4	

Table 1: Average serving sizes required to provide 1 g beta-glucan

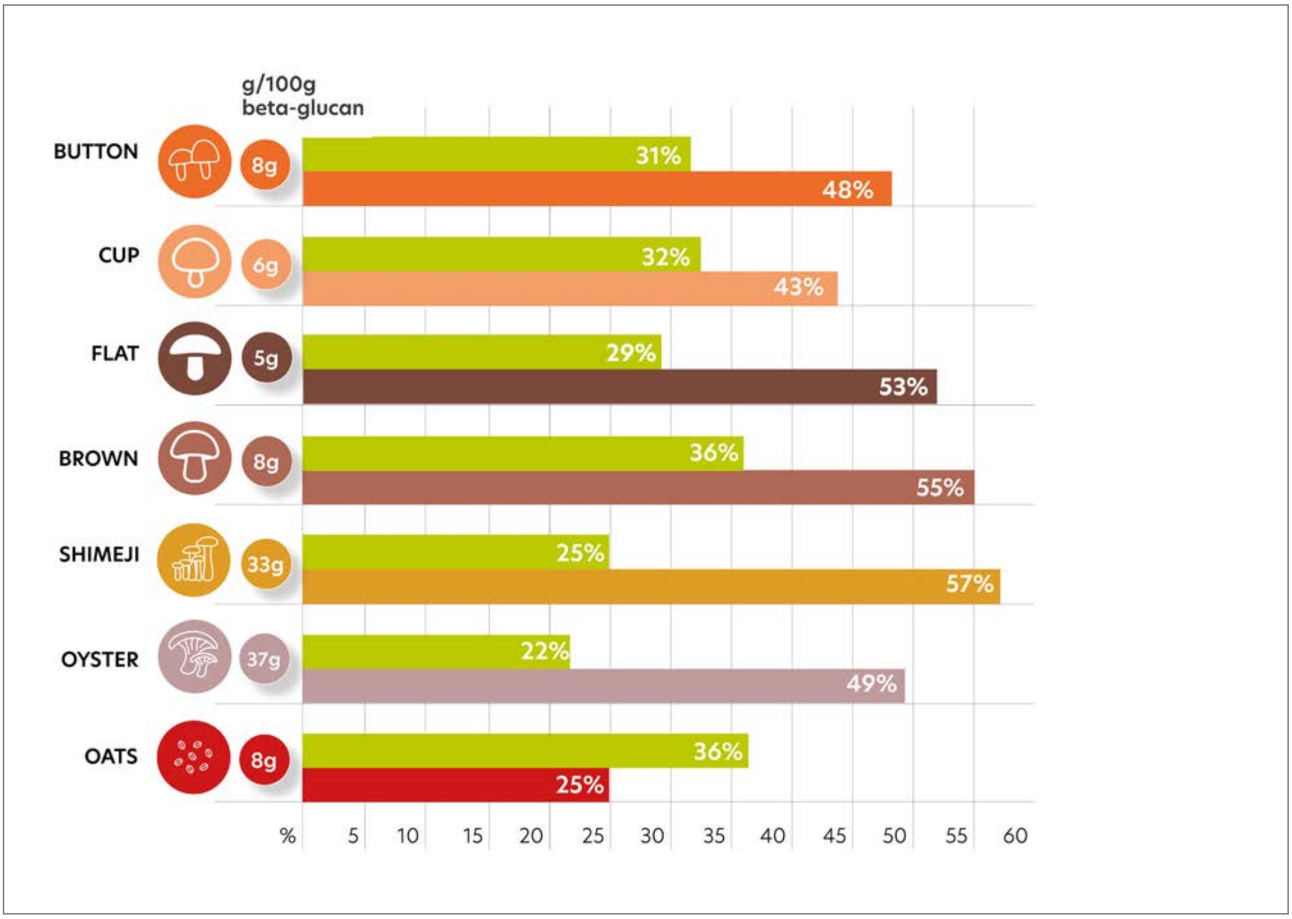


Figure 2. Total beta-glucan/100 g dried weight and percent bile acid binding capacity/500 mg of freeze dried boiled (coloured bars) and raw (green bars)

Beta-glucan content of raw and cooked mushrooms
Beta-glucan was a significant component in mushroom dry-matter. It was highest in oyster (37 g/100 g) and shimeji mushrooms (32.5 g/100 g), followed by button (8.1 g/100 g), brown (7.6 g/100 g), and cup (6.4 g/100 g), with flat mushrooms containing the lowest amounts (4.5 g/100 g). Freeze dried raw oats contained 7.6 g/100 g.

Although *Agaricus bisporus* contain similar levels of beta-glucan to oats, the high moisture content of mushrooms means the serving size needed to provide 1 g of beta-glucan is considerably higher (Table 1). Nevertheless, for most of the popular varieties, a handful of mushrooms is all it takes to provide the 1 g of beta-glucan.

Mushroom beta-glucan bile acid binding capacity compared to oats
To help determine the capacity of mushroom beta-glucan to bind bile acid, the CSIRO team compared *in vitro* binding of bile acids by mushrooms and oats using a simulated human digestive system. Data was reported as a percentage of bile acids bound per 500 mg of food (freeze dried weight).

The bile acid binding capacity of dried raw *Agaricus bisporus* mushroom varieties ranged from 29% to 36% which is comparable to raw oats (36%). Figure 2 illustrates the total acid-binding capacity for both raw and cooked versions of several varieties of mushrooms.

For all *Agaricus bisporus* varieties, cooking (boiling and frying) increased the bile acid binding capacity:

- Boiling increased capacity by 23% for flat, 19% for brown, 17% for button and 11% for cup.
- Frying increased capacity by 16% for flat, 9% for brown, 11% for button and 8% for cup.

Feasibility of lowering cholesterol by consuming mushrooms

This study showed that conventional *Agaricus bisporus* (button, cup, flat, brown) mushroom β-glucan had similar bile acid binding properties to oat β-glucan. However, as mushrooms are approximately 90% moisture, larger volumes of fresh *Agaricus* (150 g or more per day) are needed to achieve an intake of 1 g β-glucan per day.

However, this study also suggests that a lower level of daily mushroom intake could still be effective in lowering blood cholesterol levels if the mushrooms are cooked, as frying or boiling markedly increased bile acid binding. A follow up investigation is needed to confirm these findings.

Australian mushroom consumers currently eat an average of around 60 g mushrooms/day, equivalent to two large buttons or one small flat mushroom. They need to double this daily serve of fresh or cooked *Agaricus* – which is still only a handful of mushrooms each day – to consume 1 g of β-glucan. They could also increase β-glucan intake by eating mushrooms in a combination of different forms, including raw, cooked, and freeze-dried.

Based on these findings, the potential of lodging a health claim is currently being explored. This includes determining what further scientific evidence is required to support a high-level health claim.

Just **seven button mushrooms** contain **1 g of beta-glucan**

KEY POINTS

- In a freeze-dried sample, common mushroom varieties contain a similar amount of beta-glucan to oats.
- Beta-glucan in button, cup, flat, and brown mushrooms have a similar bile acid binding capability (the primary cholesterol lowering mechanisms of beta-glucan) to oats.
- Cooking both concentrated the beta-glucan in mushrooms and improved its bile acid binding capacity.
- Consuming 1 g of beta-glucan may help to lower cholesterol within a diet containing 3 g of beta-glucan per day.
- Just seven button or five cup mushrooms daily can provide 1 g of beta-glucan.
- As mushrooms have high moisture content, the serving size needed to provide 1 g of beta-glucan is higher than average Australian consumption; *Australians with high blood cholesterol should eat more mushrooms! – Ed.*
- A clinical trial is needed to support these preliminary fundings and strengthen the case for a cholesterol lowering effect of beta-glucan from mushrooms.

This article has been based on:

Damien P Belobrajdic, Henri Brook, Paul Orchard, Genevieve James-Martin, Welma Stonehouse - Mushrooms and their potential health benefits of lowering blood cholesterol: Phase 1 beta-glucan content and activity of Australian mushrooms. Draft Report Version 1. Project code: MU20001, June 2022

References

1. The global oats market size stood at USD 5.18 billion in 2019 and is projected to reach USD 6.90 billion by 2027, exhibiting a CAGR of 3.8% during the forecast period (2020-2027). https://www.fortunebusinessinsights.com/industry-reports/oats-market-100199
2. https://www.foodstandards.gov.au/science/monitoringnutrients/ausnut/foodmeasures/Pages/fruits-and-vegetable-measures-program.aspx

Hort Innovation | MUSHROOM FUND

This project has been funded by Hort Innovation using the mushroom research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

ADDING MUSHROOMS TO THE MENU

Where are the **opportunities?**

By Paulette Baumgartl

The Australian food industry loves mushrooms. With their characteristic umami and meaty taste profile, mushrooms are a unique nutrient rich plant-based food, and while common on menus, they are rarely the main act, seldom featured nor celebrated.

To elevate mushrooms in the minds of food professionals, highlighting their benefits through impactful education and engagement could bring them out of the shadows and into the limelight.

The levy-funded research project MU20003: *Educating the food industry about Australian mushrooms* sought to identify and understand the existing barriers to featuring more mushrooms on Australian menus. Probing industry insiders through a series of one-on-one interviews, combined with quantitative data collected from more than 600 surveys, the objectives were to:

- **Understand existing knowledge** on mushroom nutrition within the Australian food industry
- **Identify pathways and opportunities** to increase this knowledge
- **Gather evidence on the level of impact** that increased knowledge may have on the inclusion of more mushroom-forward meals on menus
- **Identify which of the food industries** would provide the best opportunity to boost mushroom consumption and show benefit to that industry

- **Produce a 'road map' and resources** for mushroom growers to create their own successful business model with the food sector.

The success of this project in achieving these objectives has been greatly enhanced by a unique and fruitful collaboration of industry insiders. Leah Bramich, who leads the projects, has first-hand knowledge of the challenges and opportunities that exist in the industry through her role as General Manager of the Australian Mushroom Growers' Association. Leah has collaborated with two food industry leaders at each end of the hospitality equation, namely the Chief Executive Officer of Nutrition Research Australia Dr Flávia Fayet-Moore and chef Adam Moore.

"Working with Flávia and Adam, both of whom 'speak the language' of their respective industries and have shared expertise with the interviewees, has meant greater access, more openness and deeper and honest insights into the barriers that exist in regard to using mushrooms," Leah said.

"We can be confident that the data we have collected is a true reflection of the situation within the commercial and institutional sector."

Despite 'COVID chaos', twelve in depth interviews with key industry leaders were completed with food service managers, chefs and educators from across the commercial and institutional (health-care) sectors.

Interview questions explored opportunities to expand/ feature mushrooms in catering and to include mushrooms in hospitality training curricula. The project team also inquired as to which health and nutrition messages would resonate with food service professionals, and what were the most effective and efficient ways to disseminate and distribute the educational materials.

Adam Moore

Dr Flávia Fayet-Moore

Divided into two sectors, institutional and commercial, it was clear that the largest potential lay within the institutional sector, including hospitals, aged-care and other facilities.

Although chefs and others within the commercial sector find the nutritional benefits of mushrooms fascinating, menus are nevertheless designed with flavour and texture as a priority. However, catering to dietary requirements does provide an avenue to incorporate more mushroom-forward dishes.

In contrast, nutrition is a key factor in menu creation for the institutional sector, especially in health-care catering. It is in this sector that further systematic studies are planned to provide evidence of tangible health outcomes resulting from 'eating more mushrooms'. An example could be addressing vitamin D deficiency in aged care residents.

Overall, the findings emphasised that while mushrooms were a much-loved ingredient, there was little knowledge among industry practitioners as to their nutritional, culinary, and health benefits. However, when properly informed of these benefits, interest increased dramatically. The insights are summarised on page 12.

Putting these results to work

Using these insights, the project will produce a series of resources confident that they are targeting the best people with right messages and in a useful format.

“We have put a lot of our efforts into sectors and leaders with a high quantum of influence,” Leah said.

“This means that achieving cut-through with one person can have a huge trickle-down impact, whether that be through the supply chain or via organisational change.”

As well as materials for industry, the team are creating a pack of materials to ensure growers are well equipped with resources and knowledge to run farm tours for nutrition education independently.

Future work on this project will include the development of two case studies: *Improving Vitamin D in an aged care facility through mushrooms* and *Improving health outcomes with mushrooms in ‘made to order in room dining’ of a private hospital.*

Leah says, “We wanted to achieve some very specific outcomes from the project. Specifically, that food industry professionals will have increased knowledge of the nutrition and health benefits of mushrooms and therefore use them more often, and that the mushrooms industry gains insights into the food industry landscape and the opportunities that exist within.”

This research project has provided a unique opportunity to mutually benefit growers, the food industry, and their shared stakeholders, bringing together resources that will have a legacy and help growers work with the food industry.

MU20003 Educating the Food Industry is led by the Australian Mushroom Growers' Association together with Nutrition Research Australia and chef Adam Moore. The project aims to develop ways to educate food industry professionals, uncovering ways that the mighty mushroom can solve some of the nation’s biggest nutrition problems.

NUTRITION

Nutrition is not a focus in the National Commercial Cookery Curriculum, with taste being the top priority across the industry.

COMMERCIAL SECTOR

- Nutrition and health are rarely considered
- Nutrition focus limited to catering for dietary intolerances and trends, for which they seek/are open to inspiration

INSTITUTIONAL SECTOR

- Nutrition and health are central to the sector
- Current existing national nutrition standards are sub-standard in the sector

KNOWLEDGE

Mushrooms are best known for their culinary benefits, with most cooking professionals also surprised and delighted that mushrooms were a good source Vitamin D. Education around nutrition and health benefits sparks motivation and interest.

COMMERCIAL SECTOR

- Nutrition and health knowledge are lacking
- Common misconception that mushrooms are a 'meat protein equivalent'

INSTITUTIONAL SECTOR

- Dietitians are the professional group most confident in their ability to talk about nutrition, health and culinary benefits of mushrooms, with management the least confident

USAGE

Mushrooms are considered a highly versatile ingredient and used right across the menu to add flavour and are leveraged in plant based menu items. Barriers to usage were shelf life, lack of top-of-mind awareness and inspiration. Cost can be a barrier but also seen positively when are used as a substitute for meat. For specific sub-sectors, food safety constraints and poor performance when thawed from frozen were identified.

COMMERCIAL SECTOR

- Favoured for texture and flavour, not nutrition
- Viewed as a meat replacement

INSTITUTIONAL SECTOR

- Valued for nutritional benefits, including ability to reduce sodium & fat when using mushrooms
- Usage needs to incorporate a cost benefit story for cut through, particularly in institutional sector

COMMUNICATION

HOW

- Materials that are practical, visual, tactile and easy to understand
- Tangible materials that can be used in the kitchen, e.g. posters in the kitchen with QR code
- A digital go-to hub for information and resources
- 'Train the trainer' has potential as high quantum of influence strategy, e.g., master-classes, supply chain educators, executive chef events

WHAT

- Messaging should be targeted
- Irrespective of sector, leading with culinary benefits is key
- Taste, flavour, texture = greater food intake/less waste - common to both sectors
- 'Exploit' plant-based food trends.

OPPORTUNITIES

CATERING ORGANISATIONS

- Plant-based, vegetarian and flexitarian diets are a key opportunity, as well as 'the blend', which offers nutrition & cost saving benefits
- Tapping into 'Food as Medicine' and the provenance story could foster greater uptake
- Inspiring chefs to use mushrooms more, while supporting with fun nutrition and health facts

CULINARY EDUCATION

- Develop proposal to update national curriculum to have mushrooms acknowledged as a separate food group to vegetables
- Individual TAFE or RTO can develop materials that can be used to support the new unit SITHCCC031 - Prepare vegetarian & vegan dishes
- The Learning Vault is currently developing materials to support SITHCCC031

EDUCATION

- Mushrooms are not part of the national culinary education curriculum
- While registered training organisations (RTOs) for commercial cookery need to show evidence of achieving performance criteria and assessment guidelines, they are free to teach the curriculum how they wish
- RTOs often develop their own education materials and many value and utilise the materials produced by leading digital education training company, *The Learning Vault*.
- In practice, while not formally specified in curriculum, mushrooms are an ingredient often chosen to teach various units and different preparation styles due to its versatility.

Information for this article was sourced from Food Industry Insights Final Report
Prepared for: Australian Mushroom Grower's Association July 2022
Prepared by: Nutrition Research Australia Pty Ltd.

Hort Innovation Strategic levy investment | MUSHROOM FUND

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GROWING THE FUTURE TOGETHER

The 2022 AMGA conference

By Dr Jenny Ekman

At the end of October, the mushroom industry will meet in Adelaide for the first industry conference in several years. With a diverse speaker program, the conference provides a unique opportunity to learn about new advances in research, farm practice and marketing initiatives, as well as offering great networking opportunities.

This year, the AMGA conference will host suppliers, growers, farm owners and well-respected national and international speakers.

Following farm tours on day one, day two of the conference (Thursday 27 October) is dedicated to international speakers. A wide range of presentations will focus on topics critical to the ongoing sustainability of the industry, including harvest mechanisation, new variety development and alternative casing materials.

Three of the great range of international guests are profiled below.

- Jack Lemmen from GTL will outline the development of more efficient harvesting systems, including advances in robotic picking.
- Reflecting the changes in consumer attitudes to exotic mushrooms, Jorge Calvo from Sylvan will present an overview on the market for exotic mushrooms in Europe, with a focus on oyster, shiitake, and king oyster.
- Dr Ralph Noble from the UK and Folkert Moll from Kekkilä-BVB will discuss issues surrounding the sustainability of peat as casing and possible alternatives to this vital commodity.

Picking the best from harvest practices

Mushrooms are already a technology-intense crop. More than any other, they rely on precise control of substrate, climate, nutrition, and irrigation. Many aspects have been mechanised, with computer-controlled compost production, bulk phase 3 compost, automatic casers and fillers and many other technological aids.

However, the most important part of cropping – harvest – is still entirely done by hand. Many growers were already struggling with rising labour costs before COVID-19.

In recent months, the difficult situation resulting from numerous unfilled positions has been exasperated by illness-derived labour shortages. Added to the major cost of labour to growers is now the almost daily worry of worker availability.

For more than 30 years engineers have been trying to develop a robotic mushroom harvester. This is no easy task. Mushrooms need to be picked gently, trimmed appropriately, and placed into grades according to size and shape. A firm touch or sharp edge can easily disfigure or bruise mushrooms. Furthermore, as mushrooms are not regularly spaced on the beds, picking single mushrooms from clustered groups poses another special challenge.

Initial robotic harvester designs had limited success. Silsoe Research Institute developed an early robotic harvester in 1993[1]. A suction cap attached to each mushroom, which then twisted and lifted the mushroom. While it could locate 84% of mushroom targets, only 57% were picked successfully. Overlapped or closely packed mushrooms were the most difficult to pick.

Technology has come a long way since the 1990s, and so has the search for robotic mushroom harvesting. A quick Google search reveals at least 10 companies (and universities) involved in developing commercial harvest technology for mushroom farms.

Any such technology is inevitably going to be capital-intensive. A potentially less expensive approach is to develop ways to increase efficiency of human pickers. This may mean using single layer beds, or moveable and/or tilting trays.

One company working on both options is GTL Europe. The company was initially formed in 1994 by Jack Lemmen as a tiny start-up in a shed beside his parents' house. In 2013 he merged with three companies: Geraedts, Thilot and Lemmen. This has given the larger group expertise in air handling and control, composting and growing equipment, and waste management.

GTL Europe is now a globally recognised company involved in all levels of mushroom cultivation. It offers solutions to compost producers and farms including construction design, climate control systems, machinery, and automation solutions.

Jack Lemmen will be presenting at the 2022 AMGA conference on some of the latest developments in automation on mushroom farms. According to Jack, "The tilting shelves system was just the beginning. It is really the starting point towards a fully integrated harvesting system. Technological developments such as robotics and artificial intelligence are creating an array of opportunities to further optimise the harvesting process."

Huge improvements have been made in scanning, grading, and packing equipment for many fresh horticultural industries. Perhaps it is time for a great leap forward for mushrooms. Jack is certainly well qualified to give insight into what new technologies are becoming available, and potential benefits for the mushroom industry. It is certain to be a fascinating subject.

1 Reed JN and Tillett RD. 1993. Initial experiments in robotic mushroom harvesting. Mechatronics 4:265-279.

Pleurotus and Shiitake growing methods

It's not often we mention the "E" word – exotics – in Australian mushroom communications. With an industry (and levy) very firmly based on *Agaricus*, production of exotic mushrooms such as shiitake, oyster, king oyster, and lion's mane has been outside industry concerns.

However, a number of things have changed in the last few years.

The first is an increasingly adventurous, Masterchef-inspired consumer, interested in trying new tastes and flavours. However, our favoured Asian cuisines are definitely not *Agaricus*-centric. As noted in the previous MushroomLink journal, *Agaricus* production in China ranks a distant fourth behind shiitake, oyster, and black wood ear, and is closely followed by enoki and king oyster. At least 60 mushroom species are cultivated commercially, with many others collected for sale.

The second factor is the increasing availability of imported spawn and substrate for exotic mushroom production.

People who found themselves out of work due to COVID-19 restrictions discovered that they could set up a small mushroom farm in their backyard, with nothing more than a few plastic tubs, some racking, and a second-hand refrigerated shipping container. There are even kits for growing exotic mushrooms at home (along with other COVID-19-distractions such as sourdough starter and espresso machines…).

Such start-ups make for great visual appeal. Articles about ex-baristas discovering the joy of growing fungi at their "city farm" have found their way onto Landline, ABC Rural and many local newspapers.

While such small operations remain at the fringe, more commercial operations are also starting to experiment with some of these new species. Such trends are likely not unique to Australia, but also occurring in other countries.

While this innovation may grow the mushroom category as a whole, it also presents a potential reputational risk to the mushroom industry, as new growers of exotic mushrooms are likely to lack knowledge of postharvest handling and good food safety practices.

Sylvan is the world's largest producer and distributor of mushroom spawn, with facilities in 16 locations serving 65 countries. They carry a wide range of white, off-white and brown *Agaricus* strains, which can be combined with a variety of different carriers and various growth supplements. However, they also produce a vibrant array of oyster mushrooms, coming in colours ranging from dark chestnut brown to ivory white and brilliant yellow. There are also shiitake, king oysters and wood blewits within their catalogue.

Sylvan have long participated in Chinese mushroom days and have been a major sponsor for this event for at least six years. Sylvan's European commercial manager for exotic and territory sales in Spain, Jorge Calvo has participated in many of these events.

Jorge will provide an overview of the market for exotic mushrooms in Europe, with a focus on oyster, shiitake and king oyster, at the 2022 AMGA conference. He will also discuss optimal methods of production for these mushrooms, including substrate production, incubation, and growing techniques.

As production of exotic mushrooms increases, the industry has a choice to either compete for market share or expand the category as a whole. *Perhaps it is time to consider the latter*.

Oyster mushrooms

Future materials for mushroom casing

Dr Ralph Noble is one of the key international speakers at the upcoming AMGA conference (26-28 October 2022).

Ralph is an applied microbiologist who has had a special interest in mushrooms since 1984. After a distinguished government and university research career spanning 34 years, he more recently moved into private enterprise, co-founding Microbiotech in 2017. His interests with the company include the use of different raw materials for mushroom compost, non-chemical methods of pest and disease control, and substrate supplements and casing.

Ralph has previously published several papers on partial replacements for peat in casing. Due to environmental concerns, mushroom businesses have been searching for alternatives to peat since the 1970s. Increasing costs and disruption of global transport have added extra pressure to finding alternatives to peat for mushroom farms.

In Ireland and the UK, a radical phase out is underway, with a schedule to eliminate all horticultural uses of peat by the early 2030s and possibly earlier.

However, finding alternatives is not easy. Peat has been the main component of mushroom casing since it replaced soil in the 1950s. While mixtures have changed over time, peat plus chalk or lime has proven ideal for mushroom casing. When combined with new mushroom spawn strains and composts, casing with peat has been one of the key factors improving yield and quality.

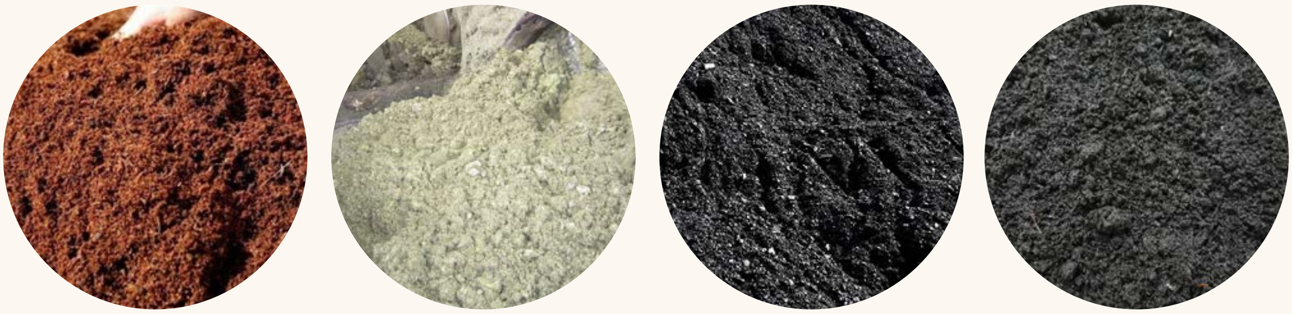
A good casing material needs to have a number of specific features including:

- High water holding capacity
- Low salt content
- Low cost
- Readily available
- Does not stick to mushrooms
- Does not contain pathogens or contaminants
- Does not encourage growth of moulds.

Ralph and his colleagues have trialled a number of alternatives to peat over the years, generally as partial substitution rather than complete replacement. These include:

- Composted bark fines
- Mature compost from green waste
- Recycled cooked-out casing
- Recycled spent mushroom substrate
- Coconut coir
- Recycled granulated waste rockwool slabs
- Filter cake clays
- Paper waste
- Fine particle coal tailings.

According to Ralph, one of the biggest issues with products such as pinebark fines, coir and other organic materials is that they are easily infected with mould, especially green mould (*Trichoderma* spp.).



Coconut coir, granulated rockwool, coal tailings and composted green waste; just a few of the materials proposed as partial replacements for peat

"While good results can be obtained using spent mushroom substrate, the issue is concentration of salts," says Ralph. "Not only is a lot of water required to leach salts from the material, there must also be a disposal method for the contaminated leachate."

Recycling the casing material itself may be a better solution. The MushComb casing separator provides a way to collect the casing, which can then be re-wetted. According to Ralph "we've found you can use about a third recycled casing without affecting yield or quality. Once you go above this the salt content starts to cause problems, and yield will go down."

"The other problem is that with this system we're still using peat. It's not clear whether you could recycle a non-peat based casing material. And of course this relies on good pasteurisation to prevent carryover of pests and diseases."

Green waste compost is also a possibility. Trials at the Marsh Lawson Mushroom Research Unit (MLMRU) by Adam Goldwater (AHR) have shown that adding up to 50% well composted green waste to peat as casing still provided good yields (see figure below). While this material is cheap and abundant, quality is highly variable. The three batches of material used in the MLMRU trials were all clearly different. This is a common issue, as is the potential presence of unacceptable contaminants.

There are also a range of other bi-products from other industries which may be used as part of a casing mix, such as sugar beet lime, de-watered clays and recycled rockwool. As these have different water-holding qualities, the best material could be a blend, combining strong water holding properties with the mushroom cleanliness and casing structure provided by peat.

"For example, we have found that a 70% bark; 30% filter-cake clay blend can make a suitable casing material for mushrooms," explains Ralph.

Coal tailings can also make a suitable additive. Research published by Dr Noble back in 2004* demonstrated that addition of 25% coal tailings (CT) to various different types of peat did not affect yield. Moreover, there was some benefit, as dry matter was significantly higher in the mushrooms grown with CT amended casing.

However, peat qualities are hard to match when it comes to choosing a casing material.

As well as showcasing some of his work on alternative casing materials, Ralph's presentation at the 2022 AMGA Conference will discuss:

- The properties of peat that make it suitable for mushroom casing
- Effects of casing material on mushroom quality
- Future availability of peat in different countries
- New research and commercial developments on alternative casing materials, and which materials may be suitable for Australian growers
- How irrigation, management of pests and diseases, and other aspects of mushroom culture need to change in a peat-free world.

It should be a fascinating discussion.

Mushrooms at the MLMRU cased with peat only (left) 25% recycled organics plus peat (centre) and a 50:50 recycled organic:peat mixture (right)

* Noble R and Dobrovin-Pennington A. 2004. Use of fine particle tailings in mushroom casing. Mushroom Science 16: 335-341.

FULL INTERNATIONAL GUEST SPEAKER PROGRAM

Speaker	Presentation	Country
Roland van Doremaele - Christiaens	Robotics	Netherlands
Ger Hendriks	Compost	Netherlands
Dr Ralph Noble - Microbiotech	Casing Alternatives	United Kingdom
Folkert Moll - BVB	Casing Sustainability	Netherlands
Jorge Calvo - Sylvan	Exotic Mushrooms	Spain
Brigette Hendrix – Mushroom Harvesting Consultancy	Harvesting	Netherlands
Anne-Marie Arts – The AgriChain Centre	Climate Change, Pathogens and Food Safety	New Zealand
Maksym Yenchenko	The Ukraine Mushroom Industry	Ukraine
Jack Lemmon - GTL	Robotics	Netherlands

DAY THREE

The final day of the conference is dedicated to Levy Investment updates, with topics ranging from economics, the nutritional value mushrooms (see pages 35 and 5 for more detail on these projects), food safety and risk management, managing nitrogen supply in mushrooms (see page 24 for our feature on nitrogen and compost), pests and disease updates, and the latest from the Marsh Lawson Mushroom Research Centre.

A small sample of the highlights of day 3 are presented below:

Mushroom quality and safety, Dr Jenny Ekman

MushroomLinks's very own Dr Jenny Ekman is collaborating with the AMGA's Leah Bramich and industry expert Clare Hamilton-Bate on a levy project dedicated to delivering food safety services to growers.

In her presentation, Jenny will showcase the resources that are available to growers through the MU20000 project, and how they can use these to reduce risk.

The Australian mushroom industry has long been at the forefront of assuring food safety. It was one of the first industries to develop a HACCP plan, and has always been committed to ensuring mushrooms are safe to eat.

As well as grower resources, the Mushroom Food Safety Extension and Adoption (MU20000) project is developing an information library, offers food safety training, and provides 'Act and React' industry support.

Through the project, industry members are also eligible for a **FREE** annual test of mushrooms and water for microbial, chemical, and heavy metal contamination, meeting the requirements of certification bodies such as Freshcare.

However, not all growers have customers that require them to have a third party audited food safety program in place. The project team have therefore developed a simplified food safety standard specific to mushrooms. 'Safe mushrooms' can be used by growers to demonstrate due diligence without the cost and complexity of other programs.

With Jenny's 20 years plus experience in horticultural research and her highly regarded skills as a science communicator, her presentation is not to be missed.

Marsh Lawson Mushroom Research Centre Update, Dr Gordon Rogers

Managing Director of Applied Horticultural Research and Adjunct Professor of Horticulture at the University of Sydney Dr Gordon Rogers is the joint leader of a new levy funded project that will help the mushroom industry identify key research directions and ensure the Mushroom Research Unit continues as a world class research facility.

The project will be delivered jointly by the University of Sydney and Applied Horticultural Research (AHR) and has the following key aims:

- Drive innovation in the mushroom industry with research-based solutions
- Direct activities of the Mushroom Research Unit at the University of Sydney
- Identify and test sustainable best practice
- Encourage new expertise in the industry through R&D.

A new diagnostic tool to help growers control disease

Dr Rogers will also update conference delegates on the levy-funded project (MU12007). The project has delivered a commercially available early disease detection service which has revolutionised the way growers manage disease. Growers can identify disease early, whether in compost, grow room, or the crop itself, facilitating timely action to manage diseases and minimise losses.

The PCR test used to detect diseases uses the same technology as the gold standard PCR test for detecting COVID-19. This method can reliably identify Trichoderma (*Trichoderma aggressivum*), Dry Bubble (*Lecanicillium fungicola*), Cobweb (*Cladobotryum* sp.) and Bacterial Blotch. All four diseases are included in the same testing 'panel' so only one sample is required.

Dr Rogers' focus is on extension and research, and his passion is for communicating the results of research to producers and end-users in a way that helps them implement research results profitably and sustainably.

FULL LIST OF LEVY INVESTMENT R&D UPDATES

Speaker	Presentation
Brett Fifield, CEO, Hort Innovation	Hort Innovation update
Mark Spees, Industry Strategic Partner	Hort Innovation investment update
Jane Smith & Kylie Hudson, General Managers of Marketing, Hort Innovation	Australian mushrooms marketing update
Leah Bramich, Relationship and General Manager, AMGA	AMGA update
Natasha Greenwood, General Manager WA/SA/NT, Regional and Agribusiness, Commonwealth Bank	Economic update
Dr Flávia Fayet-Moore, Nutrition Research Australia	Educating the food industry about the nutritional benefits of Australian mushrooms
Dr Damien Belobrajdic, CSIRO	Mushrooms and their potential health benefits in lowering blood cholesterol
Dr Jenny Ekman, Applied Horticultural Research	Food safety, quality, and risk management
Dr Michael Kertesz, The University of Sydney	Developing a database of bio-markers for compost quality control to maximise mushroom production yield and, Optimising nitrogen transformations in mushroom production
Dr Warwick Gill, University of Tasmania and Judy Allen	Pest and disease management approach for the Australian Mushroom Industry
Dr Gordon Rogers, Applied Horticultural Research	Marsh Lawson Mushroom Research Centre Update

The full conference program, including details on the social events and farm tours is available on the AMGA conference website: https://amgaconference.com.au

FEEDING MUSHROOMS

The 'ins' and 'outs' of nitrogen in mushroom compost

By Meghann Thai and Michael Kertesz

Remember the slogan "Meat for Vegetarians"? Button mushrooms contain around 3 g/100 g protein. This is similar to mung bean sprouts and slightly lower than chickpeas, but considerably higher than most vegetables.

While protein is a valuable portion of the dry matter (DM) in mushrooms, its content is quite variable, ranging from 14-30%. Dry matter itself ranges from a low as 7% up to 14%. High DM content and, therefore, high protein content, is associated with firmer mushrooms and improved shelf life.

Important amino acids, such as leucine, lysine, and tyrosine, are the building blocks of the majority of protein in mushrooms. Nitrogen is an essential component in all of these compounds. It is therefore unsurprising that the nutritional content of mushrooms is strongly correlated to the nutritional quality of the substrate on which they have been grown.

Nitrogen is one of the most important elements in mushroom composting and cropping. Button mushrooms are grown on a composted substrate made from wheat straw, poultry manure, and gypsum.
See p24 for more on nitrogen in poultry litter.

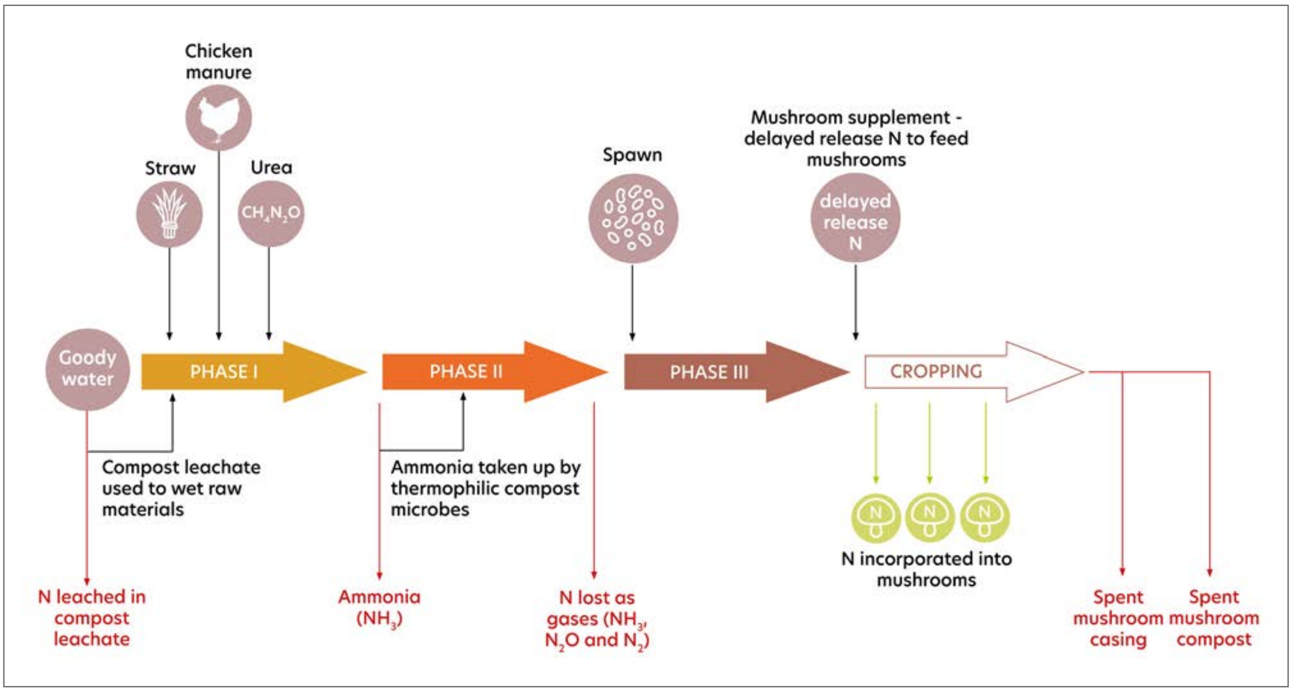


Figure 1. Nitrogen transformation throughout mushroom composting and cropping. Nitrogen inputs, losses and outputs are indicated by the black, red, and green arrows, respectively.

The inputs and outputs of nitrogen in mushroom composting are summarised in Figure 1.

At the start of composting, composters adjust the ratios of their raw mixtures to meet the desired C:N ratio of 35:1. Poultry manure is the primary source of nitrogen in mushroom compost, contributing approximately 40-50% of the total nitrogen in the initial feedstocks. Wheat straw adds another 20-25% of the total nitrogen, and additional nitrogen can be provided using organic sources such as cottonseed meal or soybean meal.

Inorganic nitrogen sources such as ammonium nitrate, ammonium sulphate or urea can also be used. These additional nitrogen feedstocks usually contribute approximately 3-5% of the total nitrogen at the start of composting.

Compost leachate ('goody water'), which is recycled from the previous compost crop, is used to wet the raw materials and makes up the remainder of the nitrogen balance. Although some nitrogen is potentially lost during prewetting as goody water runoff, adding this to the next compost batch means the net loss of nitrogen is likely minimal.

There are several ways in which nitrogen is lost during the composting process. During Phase I, the microbially intense process of composting is typically characterised by a strong ammonia (NH_3) odour. The NH_3 is released due to proteolysis (enzymic breakdown of proteins into amino acids) and heat generated by the microbes in the feedstocks.

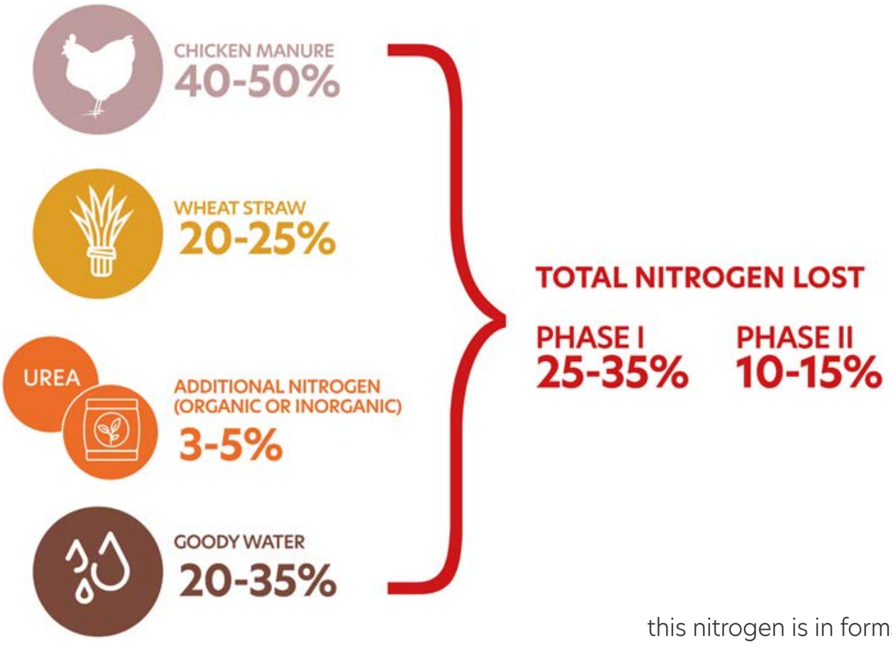
By the end of Phase I, approximately 25-35% of the nitrogen inputs from the start of composting have been lost. However, it is difficult to fully quantify how much of the nitrogen loss during Phase I is from ammonia volatilisation or due to goody water runoff.

During Phase II, the free ammonia from Phase I is used to aid in pasteurisation. It is then re-assimilated back into the compost by thermophilic microbes during conditioning, producing biomass. Although this stage of composting is conducted inside an enclosed tunnel, a further 10-15% of nitrogen is lost during Phase II, most likely in the form of nitrogenous gases.

By the end of Phase II, only 40-50% of the total nitrogen from the initial feedstocks remains. During Phase III, protein from the grain in mushroom spawn offers a small amount of nitrogen. However, the mushrooms gain most of their nitrogen from the microbial biomass in the compost.

After Phase III, commercial supplements contribute approximately 10-15% of nitrogen used during cropping. Commercial supplements are designed to release

NITROGEN INPUTS AT THE START OF COMPOSTING



nitrogen slowly over time. This maximises nitrogen availability for the mushrooms during consecutive flushes.

Nitrogen becomes an output when mushrooms are harvested. Total nitrogen in button mushrooms increases over consecutive flushes; total nitrogen content of first flush and third flush mushrooms is approximately 5% and 7% of dry weight respectively.

When total nitrogen is converted to approximate protein content, 5-7% total nitrogen corresponds to approximately 30-33% protein in the mushrooms. By the end of cropping, approximately 50% of the nitrogen inputs from composting and cropping are left over in the spent mushroom casing and compost. However, most of this nitrogen is in forms that cannot be accessed by the mushroom mycelium.

Improving nitrogen management throughout composting could provide a major financial benefit for the mushroom industry, improving efficiency of nitrogen uptake and accumulation of dry matter. Unfortunately, not enough is known about where and how nitrogen is lost during composting.

Research on developing a mass balance model on nitrogen inputs and losses during composting is currently underway. This includes measuring nitrogenous gases during Phase II and maximising nitrogen output in mushrooms.

This project was funded through Hort Innovation project MU17004 *Optimize nitrogen transformations in Mushroom production*.

Further reading

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Noble R, Hobbs PJ, Mead A & Dobrovin-Pennington A (2002) Influence of straw types and nitrogen sources on mushroom composting emissions and compost productivity. Journal of Industrial Microbiology and Biotechnology 29: 99-110.

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Hort Innovation Strategic levy investment | MUSHROOM FUND

This project has been funded by Hort Innovation using the mushroom research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

POULTRY LITTER – MORE THAN JUST A NITROGEN SOURCE

By Jenny Ekman and Geoff Martin

Poultry litter is surely proof that one person's waste is another's windfall. Poultry litter is a highly cost-effective source of nitrogen. It is also a great source of the microbes essential for good compost production.

Poultry litter suitable for compost production is entirely sourced from broiler sheds. Litter is not just manure, but contains bedding material, feathers, blood, and potentially dirt or other materials. Manure from caged birds is less suitable, tending to be wet, sloppy, and low in carbohydrate. Litter from barn-based egg production and turkey manure are not suitable for making compost as they are relatively low in nitrogen.

What goes in affects what comes out

Modern broiler chickens are incredibly efficient converters of feed to body mass – approximately 1.5kg of chicken food produces 1kg of chicken. High feed use efficiency equals less waste, especially of the carbohydrates which nourish microbes during composting.

Despite this efficiency, feed still accounts for up to 70% of the cost of raising chickens. What goes in affects what comes out, so the type of feed used is clearly going to affect the attributes of the manure.

For example, broiler chickens were once fed mixtures of maize and soya, meat meals, offal, feather meal and tallow. However, the outbreak of mad cow disease in the UK focussed consumer concern about feeding meat meal (offal and poultry waste) products to chickens. Modern mixes are predominantly grains (wheat, barley, and sorghum) plus vegetable proteins and oils, vitamins, calcium carbonate, and other minor ingredients. These include enzymes to help the birds break down non-starch polysaccharides in grain.

Moreover, the life of a broiler chicken may be as little as six weeks, compared to 10 weeks a few decades ago. This factor, combined with dietary changes, has reduced nitrogen levels in manure from approximately 5.7% to 3.5%. Modern litter has 30% less phosphorus, as well as lower levels of fats, carbohydrates, uric acid, and enzymes than it once did. In particular, the decline in the enzymes uricase and urease, which break down uric acid, has reduced ammonia levels during Phase I – vital to kick start the breakdown of straw in the first 48 hours of composting[1].

While the use of antibiotics in chicken feed as growth promoters and therapeutic agents has been declining, they may still be used by some producers. Such products are not fully metabolised within the bird. They may even be designed to be excreted to avoid contaminating the flesh. Presence of such products in manure could also potentially affect microbial activity during composting.

Bedding materials matter

The type of bedding material used will depend on what is cheap and locally available. For example, rice hulls make an effective bedding material, but availability depends on how much rice is grown, which is largely

Once the chickens have been removed, the litter is swept into piles before being removed by front end loader (Photo: Australian Chicken Meat Federation)

determined by the cost of water. During the drought rice production fell close to zero, so there were no rice hulls to be had. Sawdust and wood shavings are also used as bedding, however the prices of these materials have increased. The last two years of good rainfall have seen many chicken producers change to wheat straw, which is now readily available.

A 2019 study by AgriFutures Australia[2] found that more than 65% of chicken meat producers were looking for alternative sources of bedding materials due to cost and supply issues. For example, wood shavings can cost \$22-\$40/m^3 compared to \$10-\$15/m^3 for straw. The study identified several other alternative litter materials including nut husks, oat hulls, stubble pellets, miscanthus grass, and tree-litter.

The type of bedding material used is likely to significantly alter the C:N balance in the waste product. For example, litter from wood shavings has much lower nitrogen content than that from rice hulls, with clear implications for composting.

Another change due to increased cost/reduced availability of bedding materials is the more frequent recycling of the litter by re-use, layering or mixing. In the past, about 70% of Australian broiler chickens were grown on new bedding, with the remaining farms practicing partial re-use[3].

In the US, litter may be re-used for up to 2 years before the sheds are fully cleared out. The bedding is windrowed inside the shed, allowing it to partially compost, before re-spreading for the next batch of birds[4].

Australian growers appear to be also recycling litter, altering both the volume and composition of material available for compost production. This material may have higher nitrogen than single use litter, but also lacks bulk. The result is an increased requirement for straw, which is more expensive than poultry manure.

In conclusion, compost producers need to maintain good communication with their poultry manure suppliers. They need to know if production methods change. The way the chickens are grown will affect not just nitrogen in the litter, but also moisture levels, density, and a multitude of other factors. And that in turn affects the quality of compost produced.

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GRAHAM PRICE AND THE HISTORY OF THE HAWKESBURY MUSHROOM INDUSTRY

By Dr Jenny Ekman

There wouldn't be many who have been in the Australian mushroom industry more than a few years who haven't come across Graham Price. Along with Rob Tolson, and other early trailblazers such as Roy Sanders, Raymon Mas and John Miller, Graham was one of those who helped take the Australian industry from its rudimentary beginnings to the mechanised, highly technical business that it is today.

Graham recently retired from his position at the Marsh Lawson Mushroom Research Unit, so I took the opportunity to talk to him about his amazing life with mushrooms, spanning more than half a century.

JE: So how did you get started in the mushroom industry Graham?

GP: I first got interested as a 14 year old kid helping to turn compost over the weekend. It was hard work I can tell you. Even after I joined the army at 18, I still used to come home at weekends to grow mushrooms. At that time mushrooms were still growing on ridge beds, but the business was profitable, and it was a great way to help the family income.

JE: But clearly being just a weekend mushroom farmer wasn't enough.

GP: No, so when I left the army at 21 I grew mushrooms from March to October, then did seasonal labouring jobs until the next season. I was still doing that when

Graham Price hand turning compost for his mushroom farm

I married my first wife Carol. However, in 1964 I was approached by Mal Manning to take over his farm at McGraths Hill. We doubled production almost straight away – Mal had been putting the Phase II compost in concrete troughs on the floor, when we changed to a rack system, it worked much better.

Mal had a small spawn laboratory at the farm, and that was where I learned how to produce spawn.

JE: That must have been relatively advanced technology at the time – who taught you the techniques?

GP: Well, in 1968 Carol and I really hit the jackpot. We were invited over to the US for a short course at Penn State University by Professor Kneebone. Dr Kneebone and his wife could not have been more hospitable; Carol and I stayed at his house, and nothing was too much trouble. We learned so much, it was a great experience.

JE: Understanding such new methods must have given you an edge when you came back to Australia.

GP: That's right. We became major suppliers of spawn around Australia. The AMGA had formed in 1961. They started conducting some marketing and promotion of mushrooms based on donations from growers. Having joined myself in 1964, I thought we should implement a spawn fund levy of 5c per quart (litre) to be used for research as well as promotion. This would include every grower, as everyone used spawn. It was met with some hesitation, but in the end it became a reality and continues to this day.

JE: Indeed – that spawn levy is the reason I can sit and talk to you now through project MU21003 – thanks Graham!

GP: The timing of the levy was very fortunate. By the late 60s canned mushroom sales were falling rapidly. In 1967 we used the new levy funds for a very successful campaign promoting fresh mushrooms direct to consumers. Promotion included a "Mushroom Week" with recipes in the Australian Women's Weekly, media appearances and the fabulous "Mushroom Girls". Whereas before only 25% of the crop at most would go to the fresh market, now we could easily sell 75%.

JE: It sounds like the industry was rapidly expanding into a whole new marketplace.

GP: It was, so we continued to develop the farm at McGraths Hill. In 1970 we put in a custom-made compost facility, using the first continuous 'Cook' compost turner, imported from England. This meant we could sell ready mixed compost to other growers. People

Mushrooms growing outdoors on ridge beds in the Hawkesbury

Graham operating the continuous 'Cook' compost turner with his son Stephen

Site inspection at McGraths Hill, c. 1992. Left to right Graham Price, Marsh Lawson, John Rodwell (UK/US), Dr Tan Nair and Rob Tolson.

started to realise that you could grow really good mushroom crops using properly made compost. We kept improving the mix, adding cottonseed hulls and meal, as well as adjusting the mix of poultry litter, straw and gypsum.

JE: Were these changes based on your own research, or were you getting advice from elsewhere?

GP: A bit of both. We had great help from NSW Agriculture, especially Dr Tan Nair. In 1977 Dr Jim Sinden visited Australia from Switzerland and provided an excellent short course. Every grower attended, and we all learned the latest technologies for making compost and growing mushrooms.

The kids – Geoff, Stephen and Alison – helped out too. Geoff of course has since gone onto great things, initially becoming the local mushroom industry advisory officer. He is now technical director at Giorgi Mushroom Co. in Pennsylvania, and head of the American Mushroom Institute.

JE: Clearly mycelia run in the Price blood. What next for the expanding empire?

GP: I purchased the railway tunnel at Bowral. I was splitting my time between the farm at McGraths Hill and Bowral, which meant I was working away a lot. In the end Carol and I separated, which meant I became a single parent to the two boys, then aged 9 and 12. I sold Bowral to Noel Arrold so that I could manage the McGraths Hill operation and care for the boys. I would get up at 5:30, do the daily rounds, then be back by 7am to give them their breakfast and get them to school.

JE: McGraths Hill mostly grows houses now!

GP: It does. Urban sprawl caught up and the complaints started. In 2000 I sold the land and retired – for the first time.

JE: You retired – but surely there was still mushroom growing in you?

GP: There was, and in 2002 I started managing Mike

Graham in the MLMRU growing room (left) and with Prof Michael Kertesz and students (right)

Hills' farm at Maraylya. My new wife Janet and I did that for four years. I'd go down to check everything was OK at 7:30 each night, and I remember Janet's granddaughter asking where I was going. She told her I was going to kiss the mushrooms goodnight – that really stuck, in the end we both had to go down and kiss the mushrooms goodnight.

In 2006 we again purchased our own place – a small farm out at Dubbo. However, once we reached our 70s we decided it was time to hang up our aprons and picking knives and come back to the Hawkesbury, where we could spend more time with friends and family.

JE: So that was a second retirement – but it didn't last either did it?

GP: No, it didn't, as in 2011 Greg Seymour asked if I could grow mushrooms at the MLMRU at Sydney University. I enjoyed my time at the unit, having great success with various trials examining casing, nutritional additives, irrigation, all sorts of things.

JE: So now finally the third retirement – third time lucky?

GP: Yes, now I plan to just watch on as others do the hard yakka*.

Once upon a time, all you needed to grow mushrooms was a supply of stable straw, a fork to turn the mix, a watering can, a shovel for adding casing, a picking knife and a very strong back indeed. Mushrooms were initially grown in the open on raised ridge beds made from straw mixed with manure. The spawn was inserted using a 'dibble stick' at 6" intervals then covered with hessian sacks.

Once the mycelium grew through the compost, it was cased using farm soil. Sometimes this was soaked in formaldehyde to make sure it was disease-free.

Pickers had to dodge snakes and mice, which sheltered in the straw and under the hessian. Even after the ridge beds were moved inside old poultry or packing sheds, a good mouser was an essential member of the farm team.

In his book "Reminiscences of a Fun'gi", John Miller talks about growing mushrooms as a safer crop than citrus, stonefruit and vegetables. A key turning point was the floods in 1956. That year the Hawkesbury flooded seven times. He and wife Beryl turned to mushrooms, as did Bert and Beryl Tolson, who were then vegetable growers near Cattai.

However, it was hard work. As John recollects, "I remember how refreshing it was to dive into the then clear water of the Hawkesbury at the end of a day spent hand turning compost!"

At that time mushrooms were already being grown in the disused railway tunnels at Circular Quay (Raymon Mas) and Lilyvale (Anne and Martial (Marsh) Lawson). By the mid 1950s there were close to 200 small mushroom farms operating up and down the Hawkesbury, mainly supplying the Edgells cannery at Bathurst.

The industry was thriving, creating employment and income in areas where fruit and vegetable production were often uneconomic. The 1960s saw development of mechanical turners used for Phase I and Phase II composting. New sheds were insulated, even air-conditioned. John Miller's farm built in 1966 used a tray system, which combined peak heat, spawn running and cropping all in situ; very new technology for the time.

It was in 1970 that this farm became Graham Price's first customer, buying in the compost made with his new automatic continuous compost turner. This was based on the "Tasma Turner" design invented by Tasmanian Gordon Griffen. As John says "this took the backaches and sweat out of compost making and improved the quality of the finished phase I compost… (it also meant) we could concentrate on just growing mushrooms, to compete against the cheap imports from Asia taking over the cannery market".

We may no longer be sending most mushrooms to canning, or sterilising casing by soaking it in formaldehyde, but I'm sure most growers today can identify with the need to improve efficiency for price competitiveness, already faced back in the 1960s.

***POSTSCRIPT:** Graham is now volunteering with the Secret Garden and Nursery in Richmond, a not for profit 'Community Hub' managed by the North West Disability Services, where he is once again setting up a small mushroom growing facility….

THE POWER OF MUSHROOM WASTE

By Dr Jenny Ekman

Growing mushrooms inevitably generates waste. There is spent compost, cut stems, unsaleable mushrooms and drain water all to dispose of. Finding ways to turn so-called waste into an income generating resource has been a puzzle, but one where there may now be solutions.

What is biogas?

Biogas is produced by the anaerobic digestion of organic matter. It is typically 50-70% methane and 25-45% CO_2, with small volumes of other gases.

Biomethane is identical to natural gas, both being created by degradation of organic materials under anaerobic conditions. Compressed natural gas can readily be used to power vehicles. In the UK, some trucks are now running on compressed natural gas, with five refuelling stations already open and plans for another 14 at least in the next two years.

Simpler systems can use the methane component of biogas directly. However, if hydrogen can be added, then CO_2 within the mixture can also be converted to biomethane, greatly increasing the amount of gas produced.

Anaerobic digestion also produces nutrient rich digestate. This is a mixture of dead bacteria, minerals, and incompletely degraded plant matter (mainly lignin and cellulose). The anaerobic digestion process has been shown to achieve a one-log reduction in any human pathogens present within 2.5 days at 35°C, and

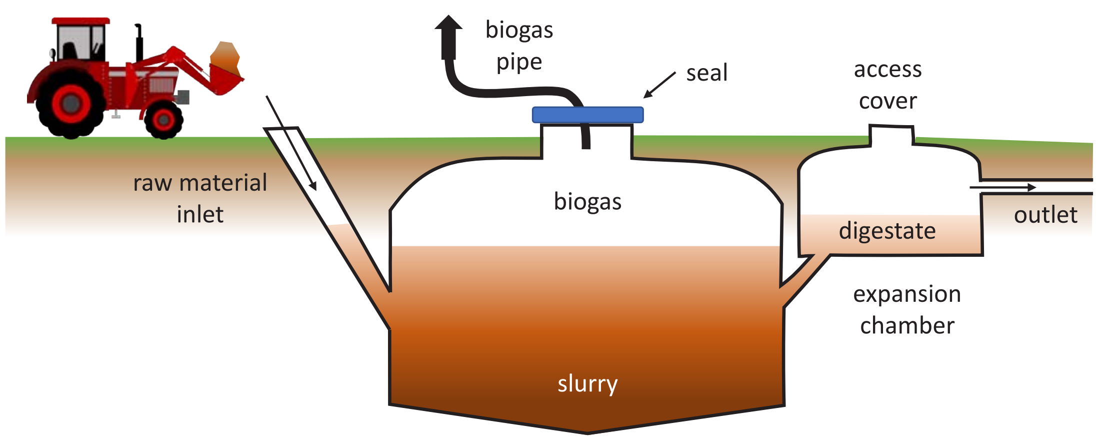

Figure 1. Biogas plant

less than one day at 53°C. Both plant pathogens and weed seeds are also destroyed during the digestion process[1]. As a result, the digestate can safely be used as a fertiliser[2], especially if it is dried and pelletised.

There are already at least 132,000 small, medium, and large digesters around the world. However, there is huge capacity to expand this technology; it is estimated that only 2% of organic wastes (e.g. food wastes, sewage, manure) that could be used to generate biogas are currently used for this purpose. According to the World Biogas Association, this technology could cut global emissions by up to 4 billion tonnes of CO_2 equivalent annually (CO_2e), reducing global emissions by up to 12% by 2030[3].

In 2019 the Australian Renewable Energy Agency[4] (ARENA) commissioned an extensive review of biogas opportunities for Australia[5]. They estimated that biogas could provide almost 9% of Australia's total energy costs as well as preventing up to 9 million tonnes of CO_2e emissions.

According to the report, key advantages of biogas are:

- Energy can readily be stored for later use
- Biogas can be transported through existing gas pipeline infrastructure
- Biogas production diverts waste from landfill
- Potentially a local industry supporting regional economies and communities and offering additional income for farmers

However, there are also barriers, including:

- High level of investment required
- Accessing funding may be problematic
- Government and local policies can create obstacles to development
- Plant operation is complex, and there is little local experience

Can mushroom wastes be used to generate biogas?

There are a number of key factors affecting the feasibility of biogas for mushroom farms:

1. The suitability of spent mushroom compost and mushroom waste as a substrate
2. The quantity of spent mushroom compost and mushroom waste available

Figure 2. Waitrose truck powered by biomethane. Photo by Scania Waitrose.

3. Availability of high calorie amendments (such as glycerin) to help break down the compost
4. The cost of natural gas and electricity
5. Capital investment required and the payback period

There has been considerable work on generating biogas from mushroom farm wastes, particularly trimmed stalks and spent mushroom substrate (SMS). The process may be even more attractive as biogas digestors produce CO_2, which can be used in mushroom growing rooms to manage pinning.

A recent review of biogas production notes that fungi are effective at breaking down lignocelluloses in different types of organic wastes. This reduces the need for pre-treatment with physical or chemical processes[9]. The authors suggest that waste products from mushroom production are therefore very suitable for biogas production.

However, according to Feng et al[6], the production of methane from SMS used to grow *Agaricus bisporus* is generally lower than other substrates. A mixture of SMS and casing material produced only 67m^3 methane/tonne solids. This compares to 155m^3 methane/tonne sewage sludge and 531m^3 methane/tonne food waste[7].

Unfortunately, it is not clear from this work whether the casing layer was removed before digestion; it seems likely that peat is not very suitable for biogas production due to its low nutrient content. This suggests that separating compost from the casing layer is likely to make biogas production from SMS more efficient.

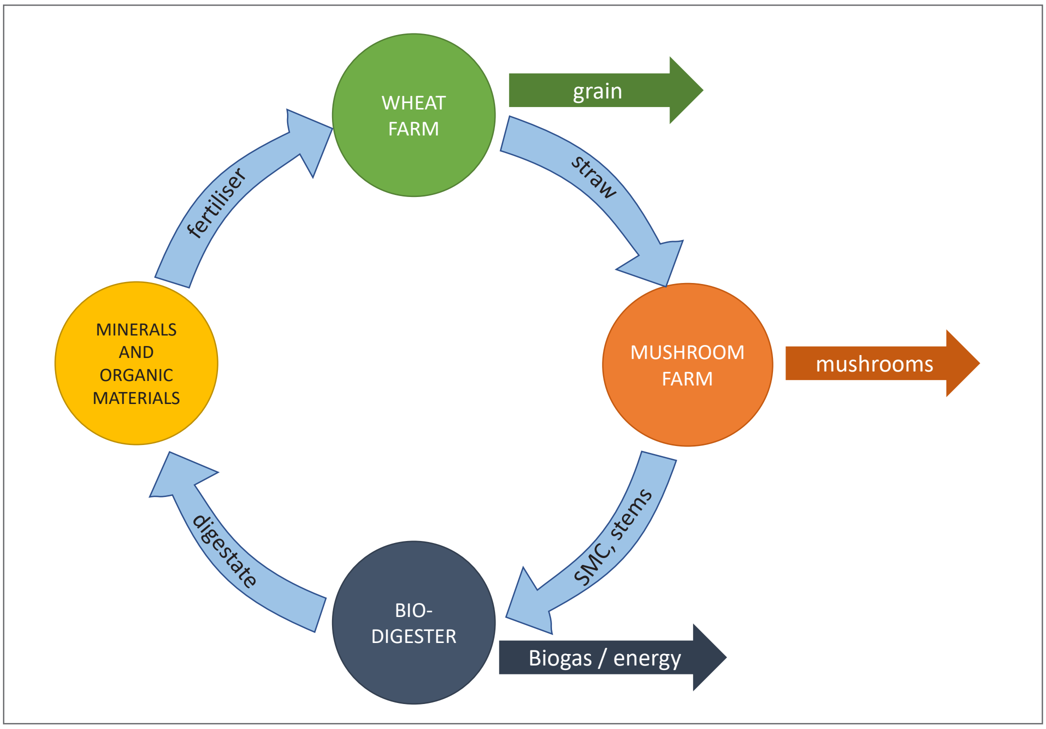

Figure 3. The "virtuous circle": sustainable production of biogas from mushroom wastes. From Perez-Chavez et al. 2019.

The "SmartMushroom" project

A recently completed project funded through the European Commission under GA 820352 and coordinated by the Mushroom Research Centre of La Rioja (CTICH; ctich.com) has developed a method to add value to SMS, using it to produce both biogas and pelletised fertiliser. The key aim was to develop a "virtuous circle" of production, as well as reduce disposal costs for the 3.65 MTonnes of SMS produced annually. This is a particular issue for farms in the Netherlands, as SMS cannot be used locally, but must be trucked to Germany for disposal.

Dr Thomas Helle, Managing Director of Novis GmbH in Tübingen, Germany, has suggested that SMS is difficult to ferment, being low in nutrients and high in insoluble fibre. However, adding certain fungal additives and enzymes can increase biogas production by 200-300%[8]. It is also possible to reduce salts in the digestate by increasing the digester temperature.

The project team has developed a pilot plant in La Rioja, Spain. According to project leader Pablo Martinez Martinez, "For our pilot plant we used glycerine and wastewater from a nearby jam factory as co-substrates. The jam water was very useful as it replaced half of the water needed for digestion and increases biogas yield. As a waste product, the only cost is for supply. Glycerin has very good properties for biogas production as it is 100% organic dry matter."

"We used a mix of 7 parts SMS to 2 parts jam water and 1 part glycerin. This achieved a yield of 120 m^3 biogas/ tonne wet material."

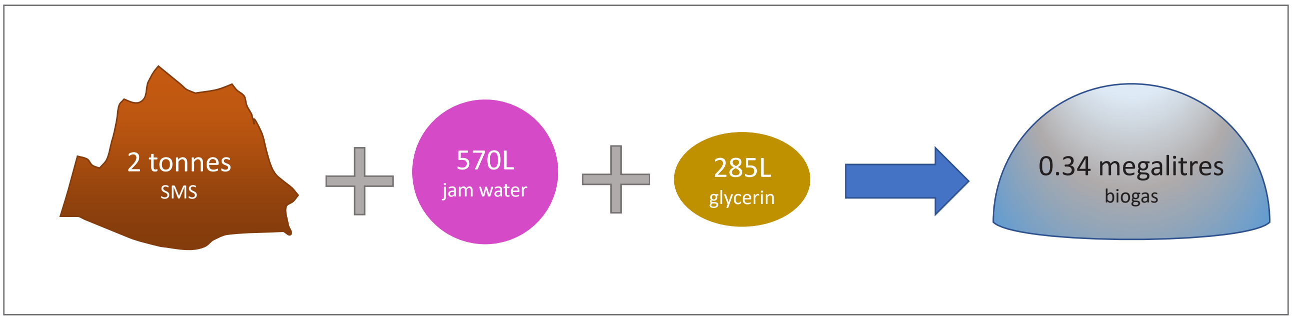

Figure 4. A 'recipe' for biogas from SMS

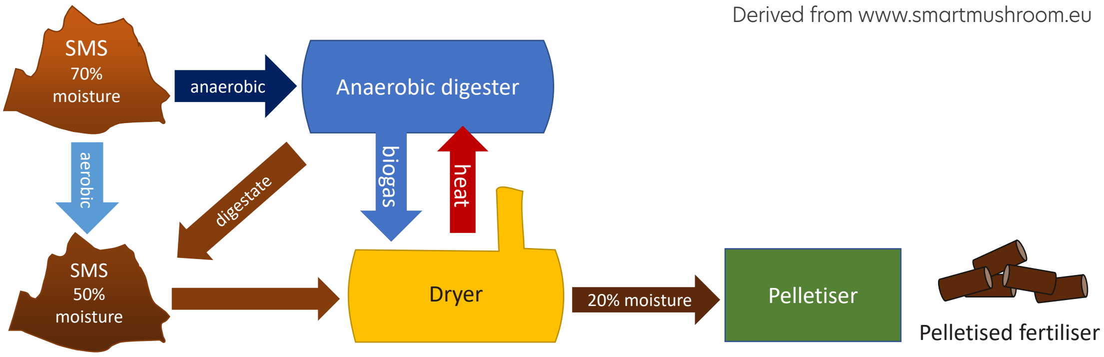

Figure 5. The SmartMushroom process. Derived from www.smartmushroom.eu

Only some of the SMS was used for anaerobic digestion. The remainder was combined with digestate and processed using a dryer fuelled directly by the biogas produced. Energy efficiency was further increased by extracting water from the saturated air with a condensation and absorption system, then reintroducing the hot air to the dryer. Drying at 65-80°C was most efficient and avoided loss of nutrients from the SMS.

The resulting fertiliser pellets are an excellent source of phosphorus, potassium, and nitrogen as well as trace elements. According to Pablo the material is readily transportable, adds organic matter to soil and is cheaper and more effective than conventional fertilisers. “We developed specific formulations for a range of vegetable crops. The preliminary results show that the fertiliser pellets improve rooting and vegetative growth as well as resulting in earlier flowering and fruiting compared to the controls”.

The team also conducted an economic feasibility study for an industrial sized SmartMushroom plant. While this includes SMS disposal savings of €6/t, the results suggest a high rate of return, with the plant paying for itself in less than 4.5 years.

If excess biogas is produced, this could potentially be used to generate electricity and fed into the grid or used for other purposes on-site.

Summary of economic assessment:

Throughput/year	10,000 tonnes
Size	1.25 kWh
Plant cost	€2.2 million
Operating cost/year	€307,000
SMS disposal savings	€6/tonne
Pellet sales	€90/tonne
Payback time	4.4 years
Project IRR	21%

Figure 6. The SmartMushroom pilot plant

Other benefits of biogas

The digestate has other uses apart from fertiliser. The early stages of anaerobic digestion produce a digestate with a fine structure and high moisture retention properties. There is some interest in testing this material as a partial replacement for peat, although salt content may prove limiting.

The digestate also contains readily extractable fibres. German researchers are developing natural fibre-boards based on combining these fibres with bio-based resins. The boards have properties that may make them superior to wood-based boards and are readily composted at the end of their life cycle.

Even without these processes, biogas offers an opportunity for the sustainable use of resources[9]. With 350,000 tonnes of spent mushroom compost SMS produced each year in Australia this technology could provide an alternative source of clean energy, whether used alone or as a co-substrate in anaerobic digestion.

A new Australian project on recycling SMS into fertiliser

The recent outcomes from the SmartMushroom project are particularly interesting given the recent contracting of new project MU21006 *Recycling SMS for fertiliser in a circular economy*.

Led by Dr Kevin Wilkinson from Frontier Ag & Environment, the project will focus on developing a circular economy for SMS. There is no doubt that SMS is an undervalued resource with many useful properties. The aim is therefore to improve the value proposition of SMS for potential end-users, including grain growers.

With few practical alternatives, the industry is heavily reliant on wheat straw as a compost input. However, drought, floods, climate change, changed farming practices and increased competition from the feedstock industry all affect the cost of wheaten straw, potentially reducing availability to compost producers.

Developing a circular economy between mushroom and grains production can strengthen linkages between these industries. It could also provide a revenue raising value-add proposition for mushroom farms and improve the sustainability of grain production.

The project will examine the options available for turning SMS into fertiliser by:

1. Reviewing past research on value adding to SMS
2. Mapping supplies of SMS with potential end-users
3. Conducting intensive consultation and demonstration trials with mushroom growers and agricultural producers

The circular economy models for recycling SMS will be presented as practical case studies.

For more information, please contact Dr Kevin Wilkinson, Director Frontier Ag and Environment, kevin@frontieragenvironment.com.au

Hort Innovation Strategic levy investment | MUSHROOM FUND

This project has been funded by Hort Innovation using the mushroom research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

References

1 Al Seadi T, Lukehurst C. 2012. Quality management of digestate from biogas plants used as fertiliser. Report by IEA Bioenergy.

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3 Anon. 2020. Putting biogas at the heart of the economy. Energy World, February 2020. p22-24.

4 ARENA https://arena.gov.au

5 Biogas opportunities for Australia (March 2019) https://arena.gov.au/assets/2019/06/biogas-opportunities-for-australia.pdf accessed 14/2/2020

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UNDERSTANDING PRICE ELASTICITY

in the Australian mushroom industry

By Jim Binney and Boris Lam, Natural Capital Economics

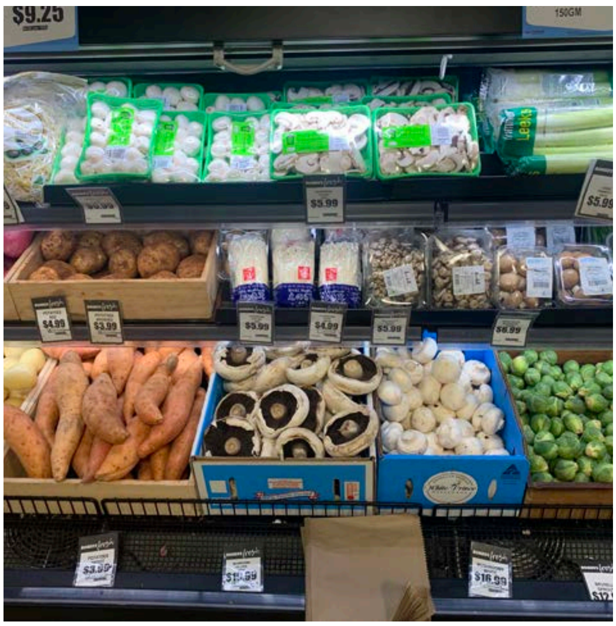
The Australian mushroom industry is a significant horticultural sector, with potential to expand in the future. Recent data from NielsenIQ, in partnership with Hort Innovation, reveals that almost 80% of households now purchase mushrooms. However, the role of price in changing demand, as well as potentially reaching new consumers, is not well understood.

Despite a decline in the production volume and value of mushrooms in 2020 and 2021 – possibly driven by the pandemic - mushroom consumption has remained fairly constant. This suggests that price increases over this period had little effect on consumer demand.

Understanding how changing prices impact consumer purchases can therefore benefit the industry as a whole as it will inform crop establishment and investment decisions.

Hort Innovation have engaged Natural Capital Economics to analyse the price elasticity of demand for mushrooms. Price elasticity is the effect of changing prices on the purchase quantity. While it is expected that people will purchase less when prices go up, this work examines exactly how sensitive mushroom customers are to changes in price.

An example of the effects of price on demand is shown in the table on page 36. To keep things simple, we



KEY POINTS

- Price elasticity is the effect changes in product prices have on total demand for that product
- As price is a key driver of demand, it is important to understand how changes in price affect consumer demand
- The project will also investigate how elasticities of demand might differ between mushroom varieties

	Price increase of 10%	Demand change (volume, %)	Revenue ($, %)
Unitary	$1.10 (↑10%)	90kg (↓10%)	$990 (↓1%)
Elastic	$1.10 (↑10%)	85kg (↓15%)	$935 (↓6.5%)
Inelastic	$1.10 (↑10%)	95kg (↓5%)	$1045 (↑4.5%)

assume a market quantity of 100kg mushrooms at a price of $10.00 per kg for a total revenue of $1,000[1]. There are three elasticity concepts to introduce:

- Unitary elasticity – a percentage change in price leads to an **equal percentage** change in sales volume
- Elastic elasticity – a percentage change in price leads to a **greater than proportionate** change in sales volume
- Inelastic elasticity – a percentage change in price leads to a **less than proportionate** change in sales volume

The table demonstrates that the effect of a change in prices on revenue depends on the elasticity of demand. Total revenue is only increased by increasing prices if demand is relatively inelastic.

To investigate this, NCEconomics will work together with a major data provider, quantitatively estimating the elasticity of demand for mushrooms using an economic model[2] . The project will also investigate how elasticities of demand differ between mushroom varieties (e.g., button, portobello, shiitake, oyster, and many more) that are sold as fresh supply in major supermarkets. This will allow estimation of the optimal price-volume mix to maximise industry revenues.

Mushroom producers and industry stakeholders will be engaged during the project to get feedback on research findings.

Understanding price elasticity can support well informed industry strategies for supply and demand. For example, understanding the optimal price-volume mix for mushrooms can better inform industry as a whole on the revenue impacts of increasing (or decreasing) production.

This project has recently started and will be completed around the end of November this year. Project findings will be reported in MushroomLink, as well as through the Hort Innovation website.

Hort Innovation
Strategic levy investment
MUSHROOM FUND

This project has been funded by Hort Innovation using the mushroom research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

NCEconomics

This project is being led by Jim Binney, an economist of 25 years' experience across a broad range of resource and environmental management issues including sustainable agriculture, climate change, and water use efficiency.

Working alongside Jim is Boris Lam, an economist with experience applying statistical analysis to water resource and agricultural issues. NCE has also worked on a similar project investigating the price elasticity of demand for sweet potatoes.

For more information contact: Sarah Cumpston, Horticulture Innovation, _ sarah.cumpston@horticulture.com.au or; Boris Lam, NCEconomics, boris.lam@nceconomics.com

References

1. Price x Quantity - Total Revenue
2. The model that NCEconomics will use is a version of the Almost Ideal Demand System (AIDS) model. It is commonly used to estimate the elasticity of demand for other commodities, not just mushrooms.

NATIONAL MUSHROOM VIRUS SURVEY

By Warwick Gill, Tasmanian Institute of Agriculture, University of Tasmania, Hobart

Judy Allan, Pest and Disease Service

The vast majority of mycoviruses - the viruses which are naturally widespread throughout both cultivated and wild fungi - cause no problems to their host. But occasionally, combinations of virus particles interact, causing quality and yield issues.

Pathogenic viruses can be hard to detect in mushroom crops. They can replicate unseen and undetected, establishing large disease reservoirs on-farm. Early symptoms can go unnoticed or be ignored. For example, sporadic brown mushrooms appearing in white button crops being dismissed as just 'one of those things'.

The delay in identifying the causal 'organisms' was one of the key factors leading to the devastating impacts of Mushroom Virus X (MVX) Syndrome in Europe. Early detection and appropriate intervention is key to successfully mitigating the effects of these serious pathogens.

Australia has a long history of virus disease. La France was first recorded in this country in 1969 and there have been sporadic but damaging outbreaks recorded over the years.

In 2021 a farm reported a disorder expressing La France-like symptomology. However, samples sent to an external diagnostic laboratory did not detect the La France virus. A second sample was tested for MVX Syndrome viruses. This test detected the AbV6 virus particle, which is associated with MVX Syndrome.

A preliminary survey of mushrooms from supermarkets, together with selected farm samples, provided results consistent with the findings from the farm outbreak samples. After consultation with Dr Helen Grogan (Teagasc in Ireland, the leading authority on MVX Syndrome), and discussions with the MU16003 project reference group, it was decided to offer a nation-wide survey to the industry to determine the extent of virus contamination in Australian button mushroom crops.

MUSHROOM VIRUS DISEASES

There are three recognised virus diseases of cultivated button mushrooms (summarised in Fig. 1) which result in yield and/or quality loss:

1. La France disease

- Symptoms include slow mycelial growth and distorted mushrooms as well as delayed, or reduced fruitbody emergence
- Caused by virus AbV1

2. Patch disease

- Resembles La France disease
- Results in major yield loss due to non-productive areas on the bed and misshapen mushrooms

- Virus AbV1 is absent
- Likely to be caused by virus AbVE1

3. Brown Cap Mushroom disease (BCMD)

- Expresses as fruitbody cap browning, causing significant reduction in quality
- Caused by virus AbV16

Viral mushroom diseases are not caused by one single virus in isolation. Both the pathogenic virus particle, and an auxiliary virus particle, need to be present to cause symptom expression. For La France, AbV1 interacts with mushroom bacilliform virus (MBV), while BCMD requires both AbV16 and AbV6 to be present to be pathogenic.

The situation is less clear for Patch disease, as only AbV6 has been identified. It is thought the second virus may be an endornavirus (type of virus that lacks a coat protein), AbVE1.

For all three viral mushroom diseases, both virus particles must be present before symptoms are expressed. The relative ratio of each virus type determines the severity of symptom expression in a synergistic interaction.

Until very recently, Patch disease and BCMD were thought to be one single disease – MVX. However, they are now considered to be distinct pathologies which have virus particle AbV6 in common.

MVX is sometimes referred to as 'MVX Complex' or 'MVX Syndrome' in recognition of this disease duality, but – confusingly – the label MVX has recently been applied to describe Patch disease only. To avoid misunderstanding, we will continue to refer to BCMD and Patch disease as separate and distinct diseases.

THE SURVEY

The nation-wide industry virus survey was launched in December 2021. Farms were invited to participate through the Australian Mushrooms Journal. The testing was managed by the **MU16003** project team with the assistance of Crop Health Services Victoria (CHS), who offered discount diagnostic services to industry. As costs were met through the project, farms had the opportunity to have their crops virus-tested for free.

Participating farms were sent a unique and confidential farm code, a link to a virus symptom recognition video, a set of sampling and dispatch instructions and a sample submission form. Results were communicated back to the farms via Judy Allan (the survey coordinator), who also helped farms with a positive result to develop an action plan.

THE SURVEY RESULTS

Virus survey results from the six participating farms (Table 1) were consistent with previously reported survey data from farm and supermarket samples (Allan 2021).

LA FRANCE DISEASE

Characteristic symptoms

- misshapen caps
- elongated stems
- premature opening
- patchy fruiting

Associated viruses

- AbV1
- MBV

PATCH DISEASE

Characteristic symptoms

- bare, non-productive patches
- distorted mushrooms

Associated viruses

- AbV6
- AbVE1 (to be confirmed)

BCMD

Characteristic symptoms

- mushrooms become brown
- poor overall quality
- reduced shelf-life

Associated viruses

- AbV6
- AbV16

Figure 1 Comparative features of the three known mushroom virus diseases a) La France Disease b) Patch Disease c) Brown Cap Mushroom Disease. Images: *a) John Fletcher personal collection; b & c) farm-supplied*

Table 1. Industry virus survey results

FARM	SAMPLE	VIRUS DETECTED AbV16	AbV6	MBV	AbV1
A	1	–	+	–	–
	2	–	+	+	–
	3	–	+	+	–
B	1	–	–	+	–
	2	–	–	+	–
	3	–	–	+	–
	4	–	–	+	–
C	1	–	–	–	–
D	1	–	–	–	–
	2	–	–	–	–
	3	–	–	–	–
	4	–	–	–	–
E	1	–	–	–	–
	2	–	–	–	–
	3	–	–	–	–
	4	–	–	–	–
F	1	–	–	+	–
	2	–	–	+	–
	3	–	–	+	–

Legend: + virus detected; — virus not detected

Neither the AbV1 nor Abv16 (La France and BCMD respectively) viruses were detected in the crops sampled. However, both of the ancillary viruses MBV (La France) and AbV6 (Patch and BCMD) were present in Australian mushroom crops. The good news was that because these viruses were present in isolation, they were not causing disease symptoms in mushrooms.

Although the number of farms participating was small and the sample size therefore limited, it is interesting to note that:

- The six farms that participated in the virus survey represent the four eastern states
- The three farms that tested positive for virus were from three different states
- For both states represented by two farms, one farm had virus detected while the other did not
- Of the three farms that tested positive, all had MBV
- Of the three farms that tested positive, only one detected both AbV6 and MBV

INTERPRETATION

The small sample size means it is not possible to draw any definite conclusions about prevalence of virus on Australian farms. However, the distribution of the detected viruses over four states indicates a viral problem could be developing in the Australian mushroom industry.

The BCMD virus AbV16 has not been detected so far in Australia. Despite this, BCMD-like symptoms identical to those described in the UK have recently expressed in Australian crops. According to Dr Helen Grogan from Tegasc, this suggests that there could be an unidentified virus particle, unique to Australian mushroom crops, which is mimicking the role of AbV16 in BCMD.

The situation with Patch disease remains unclear. The absence of La France virus AbV1 in survey samples, as well as samples from a farm experiencing a virus outbreak, indicates that Patch disease is responsible for the symptoms expressed. Standard virus testing by CHS did not include the suspected AbVE1 virus, so the status of this particle is unknown. AbVE1 will be included in future screens by CHS.

Interestingly, there was a similar case in the US during the project. One of our colleagues from Pennsylvania contacted the project team asking if we had any experience of mushroom crops expressing BCMD-like symptoms where the AbV16 virus particle was not detected. Whether the unidentified virus particle responsible for BCMD-like symptomology is unique to Australia, or the same as that occurring in the US, is at this stage unknown.

THE WAY FORWARD...

To determine the virus status of the Australian mushroom industry, AMGA and Hort Innovation have developed a new investment opportunity for a PhD student to study and characterise the entire viral genome found in Australian *Agaricus* crops. This study has the potential to identify the viruses responsible for both the patch disease-like and BCMD-like symptoms expressed in Australian crops. At the time of writing, the RFP for this investment has been issued and the procurement process to identify a suitable delivery partner is underway.

RECOMMENDED READING

Allan J (2020) Mushroom virus – frustrating and costly. *Australian Mushrooms Journal* 4:22-25 [available on AGORA]

Allan J (2021) Australian mushroom industry virus survey to commence in December 2021. *Australian Mushrooms Journal* 4:28-29 [accessible on AGORA]

Dobbs E, Deakin G, Bennett J, Fleming-Archibald C, Jones I, Grogan H, Burton K (2021) Viral interactions and pathogenesis during multiple viral infections in *Agaricus bisporus*. *mBio* 12:e03470-20 [accessible from Google Scholar]

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FOR FURTHER INFORMATION CONTACT THE PROJECT TEAM

Judy Allan | judyallan@bigpond.com | (02) 6767 1057

Warwick Gill | warwick.gill@utas.edu.au | 0417 766 588

UNIVERSITY of TASMANIA
TIA
Tasmanian Institute of Agriculture

Figure 2 Virus expressing in a mushroom bed. Image: Farm supplied.

MARKETING NEWS

My Mushroom Toast

The #MyMushroomToast campaign is up and running! And to celebrate the launch, media and foodie influencers were invited to a #MyMushroomToast cooking masterclass hosted by internationally known chef Jason Roberts.

Early in September, foodie social media influencers - with a combined following of over 255K - and reps from top-tier media outlets including *Delicious*, *Taste* and *Eativity* met in Sydney's Fish Markets Cooking School to learn how to cook, prep and experiment with the Mighty Mushie.

Attendees cooked two delicious #MyMushroomToast dishes - Miso Butter Mushrooms and Cavolo Nero on Toasted Ciabatta and Balsamic Mushrooms on Sourdough Toast with Blistered Cherry Tomatoes, Feta and Basil Oil. By working through the recipes together, the budding mushroom advocates learnt how quick and easy it is to prep and cook with mushrooms.

To ensure maximum amplification of the event, the Hort Innovation marketing team worked with their production crew to capture extra imagery and video footage. These resources will be used throughout Australian Mushrooms' social channels and other PR Initiatives.

Following the mushroom cooking class, Jason Roberts and Leah Bramich ran a Q&A with attendees. They answered questions and gave insight around the numerous nutritional benefits of mushrooms, the distinct umami flavour profile, and interesting facts around how mushrooms grow in a sustainable way.

The event was a great success with attendees really engaging with this most versatile of ingredients.

We are looking forward to following the #MyMushrroomToast hashtag over the next couple of months to see everyone's culinary creations.

To encourage Aussie cafés to hero mushrooms in more dishes, Australian Mushrooms is running a competition from September to October to determine the best #MyMushroomToast, with a major prize incentive to the café that produces Australia's Best Mushrooms on Toast dish. To read more about this initiative, see page 25 of the winter edition of MushroomLink, *Mushrooms on Toast Set to Infiltrate Café Culture*.

The video footage of the event can be viewed at australianmushrooms.com.au/foodservice or scan the QR code below.

Hort Innovation
Strategic levy investment
MUSHROOM FUND
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Collaborative Marketing Workshop with the Mushroom Industry

By Emma Day, Marketing Manager HIA

HORT INNOVATION'S COMMITMENT TO WORKING MORE CLOSELY WITH THE MUSHROOM INDUSTRY IN MATTERS RELATING TO MARKETING CAME TO REALISATION IN EARLY SEPTEMBER, WITH THE FIRST CO-DESIGN WORKSHOP. EARLIER IN THE YEAR THE AMGA WERE INVITED TO IDENTIFY THREE TO FOUR INDUSTRY REPRESENTATIVES TO BE A PART OF THE CO-DESIGN PANEL.

The outcomes of the workshop will inform the development of evidence-based marketing strategies for 2023-2026, and an annual marketing investment plan for FY23, ensuring that these plans are built on robust analysis, contain actions that clearly link to demand creation and facilitate transparent measurement and evaluation of actions and impact.

The workshops took place in Sydney, with representatives from the Mushroom Industry joining HIA Marketing, Data and Insights, and Industry Strategic Partnership personnel for two busy and productive days to jointly develop the marketing plans. The workshops were run by Jane Smith and Kylie Hudson, General Managers Marketing, with presentations from many of the HIA Mushroom team.

The Mushroom Industry was represented by Leah Bramich, GM AMGA, Kyle Davies, Marland Mushrooms, Georgia Beattie, Bulla Park, Tim Archibald, White Prince, with apologies from Elisa Siliato from Costa.

Day One focused on a big data download and share. Presentations were given on the broader market context of consumers' lives, industry feedback on important issues, the retail and trading environment in which we all operate, the consumer and shopper, needs and occasions, and a FY22 activity evaluation. As a group we then prioritised our learnings and implications and agreed on the focus for our plan and who we should target.

Day Two we regrouped and then defined the big shifts required from consumers to grow the Mushroom category and set our vision and goals according to what our category would stand for in the minds of consumers. With clear objectives, we could define the key strategic pillars which will underpin the activities arising from this marketing plan.

A brainstorming session resulted in a detailed one-year plan, as well as a more future-looking horizon plan. This was followed by the business of budgeting and how we might allocate the marketing funds for year one.

With all this valuable input, the HIA marketing team will now create the detail of the plan around our agreed vision, goals, and strategic pillars. The plan will be presented to the SIAP on 20 September for approval.

The outcome of the presentation and final details of the annual plan will be featured in future editions of Mushroom Link, so watch this space.

In the meantime, the first part of the plan details the 12 key facts gained from the data download on day one. These insights are the key pieces of data that drove our decision making as a team, and we thought worth sharing with the industry.

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Strategic levy investment
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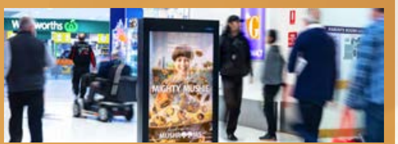
1	**Plant based diets, red meat reduction trends are mainstream**	» Red meat consumption is at its lowest point in 25 years. » 2.5 million Australians are eating all or almost all vegetarian.
2	**Food service channel is significant**	» 26% of fresh supply to food service vs 19% for all veg. » Projected 5 yr CAGR is 5.1%. 'Mushrooms are a heavily favoured ingredient in winter'.
3	**Penetration is lower than the competitive set**	» 88% of households have trialled mushrooms, behind onion and carrot trial rates. » Penetration in the most recent 4 weeks is 43%.
4	**Salience is low but improves with prompting**	» Salience is 7% vs onion 12% and potatoes 32%. » Prompted 43% vs onion 49% and potatoes 60%.
5	**Consideration to purchase conversion is exceptionally high**	Consideration to purchase conversion is 99%, stronger than either onions or potatoes.
6	**Light buyers are only eating 5x a year**	» Light buyers are consuming mushrooms x5 per year vs. x32 for heavy buyers » Mushrooms are only 1% of light buyers veg repertoire (7% of heavy buyers).
7	**Mushrooms play a key role as a flavour enhancer**	Key functional needs for mushrooms: » enhances flavour 40% vs 26% » adds to texture 33% vs 22% » takes on other flavours well, 20% vs 12% » strong intense flavour 12% vs 8%
8	**Key needs are taste, quick & easy and healthy and nutritious**	Key needs : » Taste, 68% vs 63%, » Quick & Easy 59% vs 61%, » Healthy and Nutritious 41% vs 40%. » 74% consumed at Dinner occasion.
9	**The top barriers are Price, shelf life and lack of confidence**	Top barriers to purchase » too expensive 33% vs 28% » goes off too quickly, 19% vs 15%. » Infrequent users lack confidence in how to cook. » capsicum & onion are strong substitutes for mushrooms.
10	**While considered expensive, mushrooms are worth paying for**	» 82% worth what you pay » 57% satisfaction (highest) among competitive set.
11	**Cubery research shows 'Add the Mighty Mushie' works**	A composite metric which equally rates creative against Captivate, Connect, and Compel measures: » Video 80, +21 norm » OOH 65, +9 norm » Radio 69, +21 norm
12	**Recall overall is low versus norms, yet conversion is strong**	» 14% recalled seeing the campaign (prompted de-branded stills). » Good conversion to comprehension, 79% and to feel better about mushrooms 56%.

Australian Mushrooms Marketing Update

16 September Update (3 July - 11 September)

$ Negotiated bonus activity achieved **160%** more media value vs the initial spend

OUT OF HOME

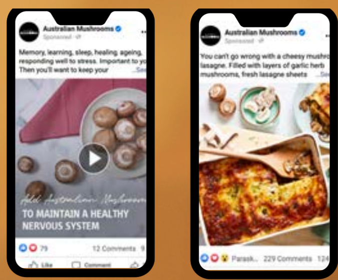


Delivered **423** panels. Including **174** bonus panels through Australian Mushrooms media negotiations.

RADIO

The mushroom radio advertisement has been heard on average 2 times per person by the main grocery buyer audience.

SOCIAL



Top performing content

Reach: 503,040

Top performing content

Link clicks: 4,619

Activity reach versus main grocery buyer audience

OUT OF HOME

This campaign has reached **2,388,494** people in Metropolitan Australia.

VMO Regional have reached **1,006,320** people. Shopper Media Regional have reached **485,544** people.

RADIO

This channel has reached **1.3M** people

SOCIAL

Meta (Facebook and Instagram) has reached **2,760,689** people

Australian Mushrooms Channel Spotlight

15 September Update

Channel Spotlight: Outdoor

Australian Mushrooms outdoor activity commenced on the 21st of August featuring the 'Add The Mighty Mushie' tagline. The outdoor activity is running nationally via 'out of home' panels that are in close proximity to grocery stores. This is to keep Australian Mushrooms top of mind during the customers final path to purchase.

To date, we have delivered **609** panels. Of this, **177** panels were bonus panels that were negotiated by Australian Mushrooms. We have reached **34% (1.3M)** of grocery buyers that live in Metropolitan Australia. This audience has seen the ad an average of **5** times.

In Regional Australia, Shopper Media (Outdoor Owner) has reached **485,544** people and VMO (Outdoor Owner) has reached **1,006,320** people.

If you have any questions, please reach out to Emma Day, Marketing Manager Hort Innovation.

Visit our website: https://www.australianmushrooms.com.au/

#AustralianMushrooms

FAR FLUNG *Fungi*

Mushroom research from around the world

FUNGUSCHAIN EU PROJECT : extracting value from the agricultural offcut of commercial mushroom farming

Rusu, A., Schwarze, A., and Penedo, B. (2020). Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj- Napoca. Bulletin UASVM Food Science and Technology 77 (1) / 2020

Each week more than 60,000 tonnes of mushroom by-products are generated in Europe.

This edition of MushroomLink has already outlined the outcomes of the SmartMushroom project, which produced biogas and fertiliser pellets from spent compost.

Another European Union project – FUNGUSCHAIN – brought together a consortium of 16 companies and research organisations from ten countries to explore methods to put mushroom production waste to good use.

The overall objective of the project was to develop suitable, scalable, cost-effective methods to extract high value chemicals from a large volume of waste material.

The approach uses cascading – an engineering approach that consists of subsequent steps, whereby each step processes output from the previous stage – to obtain valuable chemicals. The project involved the following steps:

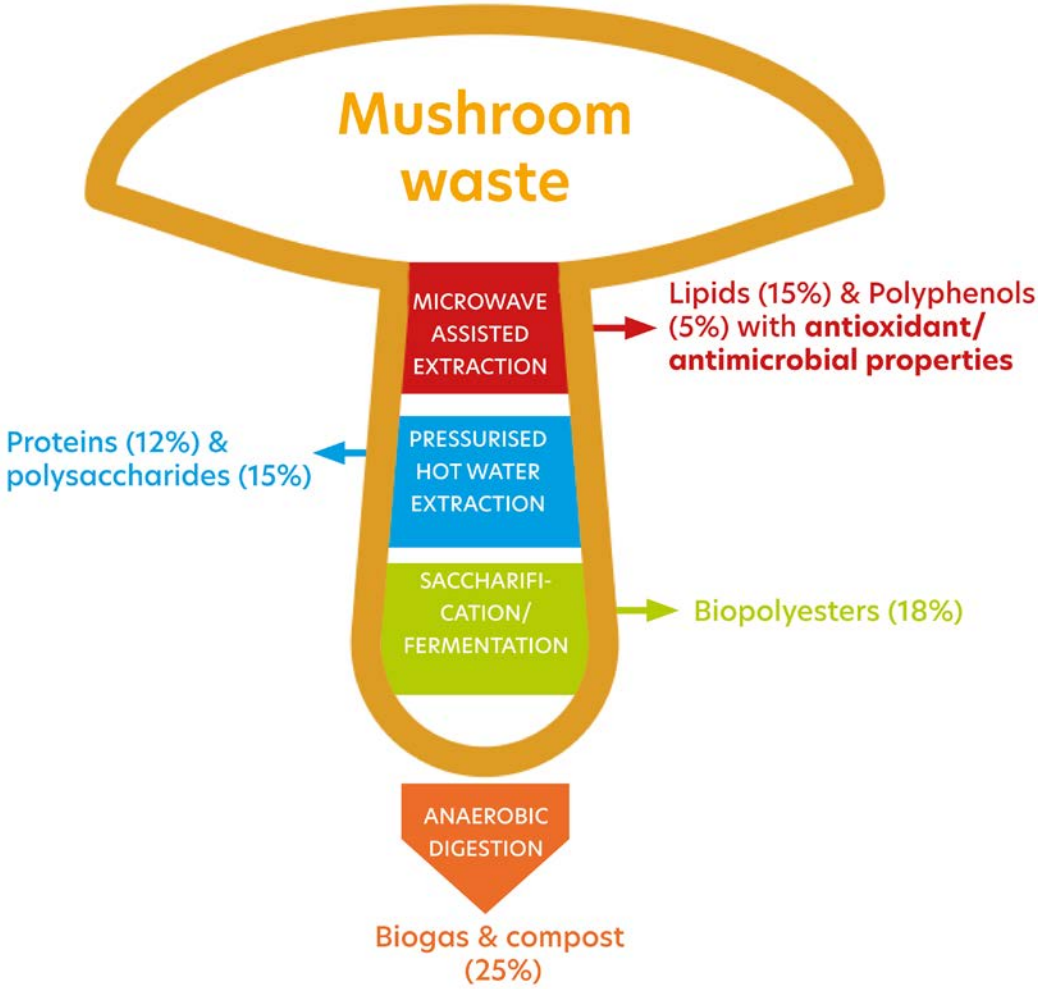
1. Characterise the potential of converting mushroom waste into high value chemicals.

2. Separate the biomass using different treatment and intensification techniques.

3. Propose a number of protocols for the appropriate treatment sequences (extraction, purification, and functionalisation).

For example, one FUNGUSCHAIN activity investigated pathways to convert waste mushroom product into building blocks for food, cosmetics, and plastic products.

Using the different extraction processes the team drew the following conclusions:



- **Antimicrobials** extracted in step one have potential applications in cleaning products and in the pharmaceutical field as a clinical antibiotic. Further physico-chemical tests would be required to ensure stability and other pre-requisites for drug development.
- Microwave assisted extraction (MAE) produced **polyphenols with the highest phenolic** content. Polyphenols are a category of compounds naturally found in plant foods. They can act as antioxidants, meaning they can neutralise harmful free radicals that would otherwise damage cells and increase the risk of conditions including cancer, diabetes, and heart disease.
- **Fatty acids** (linoleic acid, oleic acid and palmitoleic acid) were successfully identified and quantified in the lipid extracts obtained from the waste, with the highest concentration obtained after one step of MAE using a freeze-dried sample.
- **Polysaccharides** (starch, cellulose, etc) were successfully obtained from an optimised hot water extraction step.
- **Glucans** can be separated via selection and control of the extraction conditions.
- The saccharification (the process of breaking a complex carbohydrate into **simple sugars**) of the mushroom by-products was evaluated using a 1-step and a 2-step acid hydrolysis process. The fermentable sugars were successfully tested for microbial growth and the production of biopolyesters by FUNGUSCHAIN partner Biotrend.

The next phase of the project focussed on the technical and economic feasibility of the process when upscaled.

Other sources:

https://funguschain.eu/news/biorefining-and-cascading-approach-for-mushroom-residues-and-by-products/

NEWLY APPROVED HORT INNOVATION MUSHROOM FUND PROJECTS

PROJECT NAME	PROJECT CODE	ORGANISATION	PROJECT DESCRIPTION
Recycling spent mushroom substrate (SMS) for fertiliser in a circular economy	MU21006	Frontier Ag & Environment	This investment is developing models for a spent mushroom substrate (SMS) circular economy by improving the value-proposition of SMS for the end-user (primarily grain growers).
Marsh Lawson Mushroom Research Centre of Excellence	MU21004	The University of Sydney and Applied Horticultural Research	The Marsh Lawson Mushroom Research Centre (MLMRC) at the University of Sydney has received renewed funding through to 2025 to help drive mushroom innovation.
Mushroom industry conference	MU21008	AMGA	This investment delivers a national mushroom industry conference which will take place over three days from 26-28 October 2022.
Consumer usage and attitude tracking 2022/23	MT21202	Fifty-Five Five	This investment provides a category tracking service to allow various horticultural categories to better understand consumer usage and attitudes and the effectiveness of marketing campaigns.
Pest and disease management for the Australian mushroom industry	MU21007	University of Tasmania	This project is reducing the negative economic impacts experienced by the mushroom industry as a direct result of the influence of pests and diseases infiltrating mushrooms crops.
Non-synthetic alternatives to complement pest and disease management practices in mushrooms	MU22000	Victorian Department of Jobs, Precincts and Regions	This project is improving the Australian mushroom industry's knowledge of the potential of non-synthetic bioprotectants in an integrated pest and disease management (IPDM) approach.

Scan this QR code to read more about these projects on the Hort Innovation

Hort Innovation Strategic levy investment | MUSHROOM FUND

This project has been funded by Hort Innovation using the mushroom research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

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