GROWING KENT & MEDWAY

Mushroom Crop Waste and Valorisation

Report: The potential of mushrooms by-products for a biobased circular economy






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The Kent and Medway region generates substantial crop waste from various sectors, including wine, hops, fruit, cereals, and vegetables. Each type contributes specific by-products such as grape pomace, hop stems, apple pomace, and cereal straw. This report examines the potential of mushroom crop waste and by-products to contribute to a biobased circular economy.

This report is an extract from a wider publication looking at the potential for agricultural and horticultural waste and crop by-products to contribute to a biobased circular economy across South East England. The full Growing Kent & Medway report explores the opportunities for fruit, vegetable, hop, cereal and mushroom waste valorisation.

How much waste is produced?

The UK's mushroom production is forecast to grow steadily over the next few years. By 2026, it's expected to reach 109,020 metric tons - up from 103,200 metric tons in 2021 (Reportlinker.com). Commercially, mushrooms are grown on lignocellulosic biomass substrates such as wood chips, straw, sawdust, and agricultural residues. Whilst mushroom farming converts these low-value biomass residues and waste streams into higher-value food, it generates its own waste stream in the form of spent substrate. Spent mushroom substrate (SMS) is the substrate remaining after the mushroom growth cycle and is considered a waste as it cannot be used for further cycles.

SMS is produced in large quantities with most mushroom farms producing about 3-5 kg of SMS per kg of fresh mushrooms. There are about 13-14 mushroom farms in South East England. Most farms in the UK are small or medium farms with very few large farms. Although the productivity can vary widely, on average, small farms produce about 300 kg of fresh mushrooms per month. This amounts to about 900 to 1500 kg per month of spent substrate being generated per farm.

Mushrooms growing in spent grain from whiskey distillation at Canterbury Brewers and Distillers, following Growing Kent & Medway funding

Current practice in waste management and ease of handling

SMS is light, free of weeds and disease, rich in organic matter, and easy to sort and transport. Traditionally, SMS has been disposed of either by incineration, spreading on land, landfilling, or composting. Mushroom farmers are increasingly moving away from incineration towards the utilisation of SMS for agricultural and other applications. For example:

- **Composting**

This is currently the most common application of SMS. The high organic content of SMS makes it a useful component in the composting process, contributing to the overall nutrient content of the compost. It is often mixed with rotted horse and chicken manure. Some farms compost the substrate themselves, use part of it for their fields (if available) and sell the excess. Others sell the SMS to companies for further processing. One tonne of bulk mushroom compost costs around £75-100 making it an inexpensive fertiliser. However, SMS often contains chalk and peat (https://www.rhs.org.uk/soil-composts-mulches/compost) and therefore is no longer recommended for horticultural use, due to damage to peatland ecosystems. SMS is also alkaline in nature and therefore not suitable for fruit crops or crops that require acidic conditions.

- **Soil amendment**

SMS is rich in organic matter and other nutrients and it can be used as a soil amendment to improve soil structure, fertility, and water retention.

- **Mulching**

Some gardeners use SMS as a mulch around plants. It helps retain soil moisture, suppresses weeds, and releases nutrients into the soil as it breaks down.

- **Land reclamation**

In some cases, SMS is used in land reclamation projects, where it can help restore soil quality in areas affected by erosion or other environmental disturbances.

- **Animal bedding and feed**

Depending on its composition, SMS can be used as bedding for livestock. SMS has also been tested as a component of animal feed.

- **Energy production**

In certain bioenergy systems, spent mushroom substrate can be used as a feedstock for biogas production through anaerobic digestion or as a source of biomass for bioenergy production.

- **Research**

Researchers may use spent mushroom substrate in studies related to soil ecology, microbiology, or sustainable agriculture practices.

High-value compounds in SMS

During their growth and metabolism, mushrooms secrete several types of metabolites and bioactive compounds including polysaccharides, polyphenols, polyaromatic compounds, pigments, and enzymes in the form of a liquid called mushroom exudate. The composition of the exudate depends on the species of mushrooms. The exudate remains in the spent substrate and the excess collects at the bottom of the mushroom growth bags or containers. The bioactive compounds in the exudate have been recently explored for their fungicidal, antibiotic, antioxidant, cytotoxic, and other useful properties.

Pre-treatment methods

The pre-treatment methods include solvent extraction to extract crude mixtures of bioactive compounds from the exudate. The type of solvent would depend on the type of bioactive compounds. For instance, polysaccharides and glycoproteins can be extracted using hot water extraction, acid or alkali extraction or ethanol precipitation. Polyphenols and polar compounds can be extracted using alcohols. Enzymes are extracted using water or buffers and non-polar compounds using solvents such as hexane. Crude mixtures extracted by solvent extraction can then be separated using chromatography techniques.

Industrial applications

Once purified, these compounds can be used in nutraceutical, cosmetic, and pharmaceutical applications. Crude extracts have been explored for their fungicidal and antibacterial properties for plant disease control. Some examples of bioactive compounds, their extraction methods, and applications are provided below:

Table: Bioactive compounds in Spent Mushroom Substrate

Bioactive compound	Extraction solvent	Properties
Polysaccharides	Hot water/ethanol	Antibacterial, antioxidant, anti-inflammatory activities
Crude polysaccharides	Water	Protection from plant disease
Polyphenols	Alcohol	Antioxidant activity
Enzymes	Water/buffer	Degradation of lignin and cellulose

The mushroom industry, though generating valuable food, also produces a significant amount of spent mushroom substrate (SMS). Traditionally viewed as waste, SMS is undergoing a transformation. Its rich organic content and ease of handling make it a versatile resource with a range of potential applications.

Beyond its current uses in composting, soil improvement, and mulching, SMS offers exciting possibilities. Research is exploring the extraction of valuable bioactive compounds from the mushroom exudate, potentially leading to applications in nutraceuticals, cosmetics, and pharmaceuticals. SMS could even play a role in sustainable agriculture through its use in plant disease control.

This shift in perspective on SMS highlights a move towards a more sustainable future for the mushroom industry. By maximising resource efficiency and exploring the full potential of this by-product, the industry can minimise waste and create valuable new products.

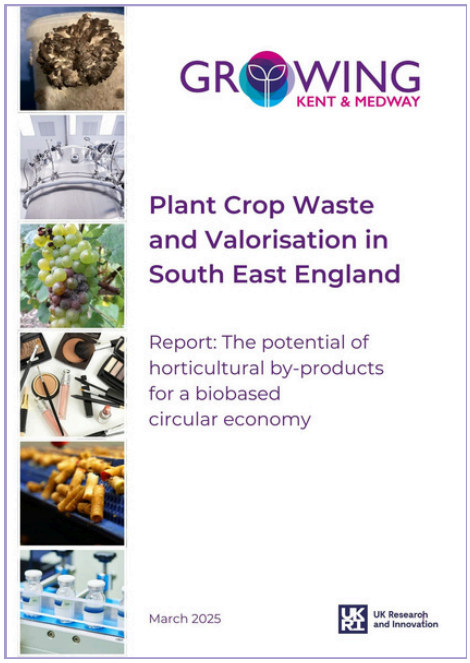
Conclusion

The agricultural waste in Kent and Medway holds immense potential for sustainable and profitable reuse. By focusing on high-value compounds and innovative industrial applications, these by-products could be transformed from environmental burdens into resources supporting diverse sectors, from pharmaceuticals to biofuels.

Sustainable practices like anaerobic digestion, composting, and nutrient recovery, coupled with advanced extraction techniques, are central to maximising the value of agricultural waste while minimising its environmental footprint. This approach aligns with a circular economy model, positioning the region as a leader in resource-efficient agricultural waste management.

The transformation of agricultural waste into high-value chemicals and materials marks a significant step towards a sustainable future. By leveraging the untapped potential of these resources, industries can reduce their environmental footprint, minimise waste, and create innovative products that benefit society.

From polyphenols with potent antioxidant properties to cellulose for biodegradable plastics, the possibilities are vast. As research and technology continue to advance, we can expect to see even more innovative applications for agricultural waste, driving a circular economy that prioritises resource efficiency and environmental responsibility.



This report is an extract from Growing Kent & Medway's report: Plant Crop Waste and Valorisation in South East England.

Read the full report at growingkentandmedway.com

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