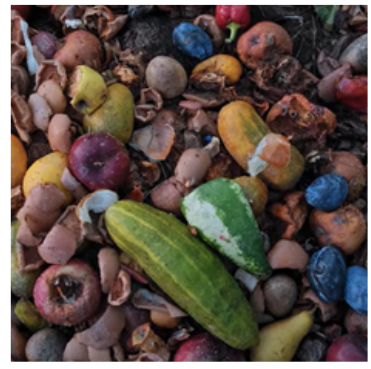
GROWING KENT & MEDWAY

Vegetable Crop Waste and Valorisation

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






March 2025

UK Research and Innovation

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 vegetable 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.

Vegetable waste valorisation

The region produces a variety of vegetables, and the residues from processing or harvesting operations can contribute to crop waste. During fruit and vegetable processing or preparation, peelings, trimmings, and other non-edible parts can be generated as by-products.

Fruit and vegetable waste is abundant in Kent, where its management includes composting, anaerobic digestion, and sometimes landfill. However, valuable compounds like polyphenols, pectin, and carotenoids in fruit waste, and proteins, polyphenols, and essential oils in vegetable waste can support the development of food additives, antioxidants, natural dyes, and biofuels.

Industrial applications and pre-treatment requirements

For effective valorisation, pre-treatment processes for all waste types include grinding, drying, acid or enzyme treatment, and innovative extraction methods like ultrasound and microwave-assisted extraction.

How much waste is produced in the region?

Exact figures for vegetable waste in South East England remain unavailable, but the region's prominence in horticulture suggests it contributes significantly to the millions of tonnes of agricultural waste generated nationally each year.

In South East England, horticulture accounts for 3.7% of farmed land, with a considerable portion dedicated to vegetables. These crops are particularly vulnerable to waste due to their perishability and the strict cosmetic and quality standards imposed by markets.

Initiatives such as "wonky veg" programs, which promote the sale of cosmetically imperfect produce, and improvements in supply chain management are among the measures being used to mitigate waste. However, the absence of systematic farm-level waste measurement makes it difficult to determine the exact scale of vegetable waste in the region, highlighting the need for better data collection and targeted interventions.

What is currently done with this waste?

The management of vegetable agricultural waste in Kent and South East England involves a variety of approaches, including:

On-farm management

- Composting
  - Vegetable waste can be composted on farms to create nutrient-rich soil amendments.
- Animal feed
  - Some vegetable waste, such as crop residues, can be used as animal feed.
- Direct application to fields
  - In some cases, vegetable waste can be directly applied to fields as a form of organic fertiliser.

Off-farm management

- Anaerobic digestion
  - Vegetable waste can be sent to anaerobic digestion plants, where it is broken down to produce biogas, which can be used to generate electricity or heat.
- Incineration
  - In some cases, vegetable waste may be incinerated to generate energy.
- Landfill
  - As a last resort, vegetable waste may be sent to landfill.

Specific initiatives and organisations in the region:

- WRAP (Waste & Resources Action Programme):
  - WRAP promotes sustainable resource use and has initiatives to reduce food waste, including agricultural waste.
- Local authorities:
  - Many local authorities in the region have programs to collect and compost food waste, which may include vegetable waste from households and businesses.
- Private companies
  - There are several private companies in the region that specialise in collecting and processing agricultural waste, including vegetable waste.

It's important to note that the specific methods used to manage vegetable agricultural waste can vary depending on the type of waste, the location, and the specific practices of individual farmers and businesses. However, there is a growing emphasis on sustainable waste management practices, and many efforts are being made to reduce the amount of vegetable waste that ends up in landfill.

How easily can this waste be sorted and/or treated for transportation?

The way agricultural vegetable waste is sorted and treated for transportation depends on its intended use. Waste is often sorted manually, separating organic material, plastics, and metals. Advanced technology like optical sorters can also automate this process by identifying and separating waste based on its physical and chemical properties.

Organic waste can be composted or undergo anaerobic digestion. Composting breaks down organic matter into nutrient-rich soil amendments, while anaerobic digestion produces biogas for energy generation. Wet waste may be dried to reduce weight and volume, and waste is often baled for easier transport and storage.

Transportation typically involves trucks, but rail or maritime transport can be used for larger quantities or longer distances. It's crucial to maintain strict hygiene practices to prevent disease and pest spread, minimise environmental impact through efficient and sustainable transportation methods, and adhere to local and national regulations for safe and legal waste transport.

By effectively sorting and treating agricultural vegetable waste, it can be transformed from a waste product into a valuable resource.

High-value compounds in vegetable waste

Agricultural vegetable waste is a surprisingly rich source of high-value compounds. These compounds have potential applications in various industries, from food and cosmetics to pharmaceuticals and biofuels.

Here are some of the most valuable compounds found in agricultural vegetable waste:

- **Polyphenols**
  - These powerful antioxidants have been linked to various health benefits, including reduced risk of heart disease and cancer. They are abundant in many fruits and vegetables, and their concentration is often higher in waste than in edible parts.
- **Carotenoids**
  - These pigments give fruits and vegetables their vibrant colours. They have antioxidant properties and are precursors to vitamin A.
- **Pectin**
  - This soluble fibre is commonly used as a thickening and gelling agent in food products. It can be extracted from various fruit and vegetable waste, such as apple pomace and citrus peel.
- **Proteins**
  - Vegetable waste can be a valuable source of protein, which can be used to produce animal feed, food supplements, or even plant-based meat alternatives.
- **Lipids**
  - Some vegetable waste, such as oilseeds and nutshells, contains valuable lipids that can be extracted and used for various purposes, including biodiesel production.
- **Vitamins and minerals**
  - Many vitamins and minerals, such as vitamin C, potassium, and magnesium, can be recovered from vegetable waste.

By extracting and utilising these high-value compounds, we can reduce waste, create sustainable products, and promote a circular economy.

What industrial applications might they be used for?

Agricultural vegetable waste, often overlooked, is a valuable resource containing a variety of high-value compounds. These compounds, including polyphenols, carotenoids, pectin, proteins, lipids, vitamins, and minerals, have potential applications in various industries.

The food industry can benefit from natural colourants, flavourings, functional food ingredients, and food additives. The cosmetics industry can utilise these compounds for antioxidants, natural colourants, and moisturisers. In the pharmaceutical industry, they can serve as antioxidants, antimicrobial agents, and anti-inflammatory agents. Additionally, the biofuel industry can leverage these compounds for bioethanol and biodiesel production.

The high-value compounds extracted from agricultural vegetable waste have a wide range of potential industrial applications:

Food industry

- Natural colourants and flavourings
  - Carotenoids, anthocyanins, and other pigments can be used to colour food products naturally.
- Functional foods
  - Polyphenols and other bioactive compounds can be added to foods to enhance their nutritional value and health benefits.
- Food additives
  - Pectin, for example, can be used as a thickener, gelling agent, or stabiliser in various food products.

Cosmetics industry

- Antioxidants
  - Polyphenols and other antioxidants can be used in skincare products to protect the skin from damage caused by free radicals.
- Natural colourants
  - Carotenoids and other pigments can be used to colour cosmetics naturally.
- Moisturisers
  - Pectin and other polysaccharides can be used as moisturising agents in skincare products.

Biofuel industry

- Bioethanol
  - Sugars extracted from vegetable waste can be fermented to produce bioethanol, a renewable fuel.
- Biodiesel
  - Lipids extracted from vegetable waste can be converted into biodiesel, another renewable fuel.

Pharmaceutical industry

- Antioxidants
  - Polyphenols and other antioxidants can be used to develop drugs to treat various diseases, such as cancer and heart disease.
- Antimicrobial agents
  - Some compounds extracted from vegetable waste have antimicrobial properties and can be used to develop new antibiotics.
- Anti-inflammatory agents
  - Certain compounds can be used to develop drugs to treat inflammatory diseases, such as arthritis.

By extracting and utilising these high-value compounds, we can reduce waste, promote sustainability, and create innovative products that benefit both human health and the environment.

What initial pre-treatment would be required?

The initial pre-treatment of agricultural vegetable waste will depend on its intended use. However, some common pre-treatment steps include:

- **Sorting and segregation**
  - Separating different types of waste (e.g., organic, plastic, metal) to ensure efficient processing. Removing contaminants like soil, stones, and foreign objects.
- **Size reduction**
  - Chopping or grinding the waste into smaller particles to increase surface area and facilitate subsequent processes like drying, extraction, or composting.
- **Washing**
  - Removing dirt, pesticides, and other contaminants from the waste, especially if it's intended for food or feed applications.
- **Drying**
  - Reducing moisture content to improve storage stability, reduce transportation costs, and enhance the efficiency of subsequent processes. This can be achieved through methods like air drying, solar drying, or mechanical drying.
- **Heat treatment**
  - Inactivating enzymes and microorganisms to prevent spoilage and improve the quality of the waste. This can involve processes like pasteurisation or sterilisation.

The specific pre-treatment steps will vary depending on the desired end product and the specific properties of the vegetable waste. For example, if the goal is to extract high-value compounds, more intensive pre-treatment may be required to break down cell walls and release the compounds.

A case study: Fermenti - Fermenting the future of food

Fermenti specialises in creating innovative fermented treats by combining traditional lacto-fermentation with freeze-drying technology, preserving live cultures and nutrients. Collaborating with nutritionists, microbiologists, and pastry chefs, they have developed products containing 3 billion CFU from 35 different live cultures.

The Challenge

Fermenti, a gut health start-up, recognised the pressing issue of food waste and the potential of fermentation to create nutritious and sustainable snacks. The company aimed to develop a new range of functional snacks using rescued fruits, vegetables, and food manufacturing by-products.

The Solution

Fermenti's innovative approach involved combining traditional fermentation techniques with modern food technology to produce a range of fermented snacks. By fermenting rescued food, the company not only reduces food waste but also enhances the nutritional value of the products.

The impact

Fermenti was awarded funding from the Growing Kent & Medway Business Sustainability Challenge to:

- Develop new products
  - Create a range of fermented snacks using rescued ingredients, expanding their product line and market reach.
- Collaborate with industry leaders
  - Partner with Nim's Crisps to leverage their expertise in food manufacturing and distribution, facilitating the scaling of Fermenti's operations.
- Conduct scientific research
  - ndertake laboratory testing to analyse the nutritional and health benefits of their fermented products, providing scientific evidence to support their claims.
- Educate the next generation
  - Organize fermentation workshops in schools to raise awareness about the gut microbiome, the benefits of fermented foods, and the importance of sustainable food practices.

fermenti

A case study: Fermenti - Fermenting the future of food (cont.)

The collaboration

Fermenti's partnership with Nim's Fruit Ltd strengthens their commitment to reducing food waste and promoting sustainable food systems. By collaborating with an established food manufacturer, Fermenti can access a wider market and benefit from their expertise in production and distribution.

Through this innovative project, Fermenti is not only addressing the issue of food waste but also promoting healthier eating habits and supporting local communities. By combining traditional fermentation techniques with modern technology, Fermenti is shaping the future of food, one fermented snack at a time.

Fermenti coco bites

This table shows each type of waste, allowing for specific industrial applications based on the unique properties and compounds present in vegetable waste. By maximising the use of these high-value compounds, industries can promote sustainability and reduce reliance on raw resources.

	Type of waste produced	**High-value compounds**	**Industrial applications**
Vegetable residues	Peelings and Trimmings	Polyphenols, carotenoids, vitamins (A, C, E), fibres	Natural food additives, antioxidants, moisturisers in cosmetics, functional food ingredients, biofuels
	Crop Residues (stalks, leaves)	Cellulose, fibres	Biofuel (biogas, bioethanol), compost, animal bedding
	Other Non-Edible Parts	Fibres, organic matter	Compost, soil amendments, animal feed

Valuable chemicals derived from vegetable waste

Agricultural waste, often considered a mere by-product, is emerging as a treasure trove of valuable compounds with immense potential for various industries. From pharmaceuticals to food and energy, these underutilised resources hold the key to a more sustainable and circular economy. By harnessing the power of these natural resources, we can reduce our reliance on non-renewable sources and create a greener future.

- **Vegetable residues**
  - Polyphenols, carotenoids, and vitamins
    - Found in vegetable trimmings, these compounds serve as natural food additives, antioxidants in cosmetics, and components in biofuels.
- **Fibres**
  - Residues like stalks and leaves contain cellulose, which can be transformed into bioplastics, bioethanol, and other biodegradable products.

High-value compounds sought by industry

In the push toward sustainable practices, high-value compounds derived from cereal waste are increasingly sought after by the chemical manufacturing sector and other industries.

- Bioethanol and biogas (from various agricultural residues)
  - Sectors
    - Energy, transportation, and manufacturing.
  - Uses
    - Produced from grape, fruit, and cereal wastes, bioethanol and biogas are alternative fuels that reduce dependency on fossil fuels.
  - Sustainable benefits
    - These renewable energy sources lower greenhouse gas emissions, particularly when used to offset traditional fossil fuel consumption in transport and manufacturing.

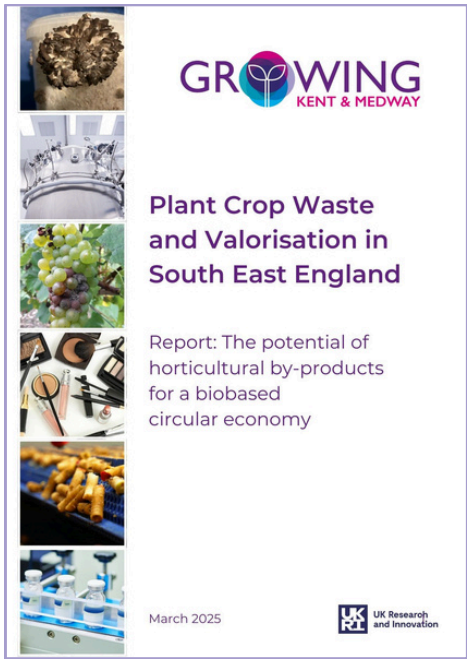
Conclusion

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

With thanks to the contributors from University of Kent, University of Greenwich, Niab and Canterbury Christ Church University