

Hop Crop Waste and Valorisation

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



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 hop 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.

Hop waste utilisation

After the hops are harvested for the brewing industry, the remaining stems and cones can generate a substantial amount of waste. Kent is also home to several breweries and distilleries, which can produce by-products like spent grains after the brewing process.

Hop waste is notable but largely underutilised. Key by-products like spent hops can be repurposed in animal feed, fertilisers, and food products or transformed into biofuels. Extraction of xanthohumol and other compounds for pharmaceutical, cosmetic, and agricultural applications can bring added value to hop by-products.

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?

Hop waste production in South East England is notable but difficult to quantify precisely without more specific data on post-harvest losses and processing waste. The region, especially Kent, Sussex, and Surrey, accounts for nearly half of the UK's hop production, sharing this responsibility primarily with the West Midlands.

Traditionally, hops are harvested and dried in oast houses, which are common across Kent and surrounding counties. However, these drying processes, along with other post-harvest handling stages, generate organic waste in the form of discarded bines (stems), leaves, and any unsuitable cones.

Hop waste is often repurposed rather than disposed of. Some farmers use it as a soil conditioner due to its organic matter content, while others work with local breweries or composting facilities to convert it into usable agricultural inputs. Efforts in South East England also include projects to improve hop resilience, which may reduce waste by enhancing crop yields and quality through climate-adaptive varieties.

What is currently done with this waste?

Spent hops, the primary hop waste product, are often used in a variety of ways:

- **Compost**
 - Spent hops are rich in nutrients and can be composted to create a valuable fertiliser for gardens and farms.
- **Animal feed**
 - Some farmers use spent hops as a feed supplement for animals like cows and pigs.
- **Fertiliser**
 - The nutrient content of spent hops makes them suitable for direct application to fields as a fertiliser.
- **Food products**
 - In some cases, spent hops are used in food products like bread, granola, and even snacks.
- **Bioenergy**
 - Spent hops can be processed to produce biogas or bioethanol, contributing to renewable energy sources.

The specific disposal methods used by breweries and farmers can vary depending on local regulations and resources. However, there is a growing trend towards finding innovative and sustainable uses for hop waste, reducing its environmental impact.

Expanding on hop waste utilisation

Spent hops, a by-product of the brewing process, are increasingly recognised for their potential as a valuable resource. Here's a more detailed look at how this waste product is being repurposed:

Agricultural applications

- Animal feed
 - Spent hops can be incorporated into animal feed, particularly for livestock like cattle and pigs. They provide a source of fibre, protein, and antioxidants.
- Fertiliser
 - The nutrient-rich composition of spent hops makes them an excellent natural fertiliser for gardens, farms, and landscaping. They can be composted or applied directly to soil to improve its fertility.

Food and beverage

- Food products
 - Spent hops can be used as a flavouring agent in various food products, including bread, beer bread, and even ice cream. Their unique bitter and slightly floral taste can add a distinctive flavour profile to these items.
- Beverages
 - Beyond beer, spent hops can be used to create unique tea blends. They can also be infused into water or other beverages to impart a subtle hop flavour.

Other innovative uses

- Biofuels
 - Spent hops can be converted into biofuels, such as ethanol, through processes like anaerobic digestion. This helps reduce reliance on fossil fuels and promotes sustainable energy practices.
- Textiles
 - Research is ongoing to explore the potential of using hop fibres to create textiles. This innovative approach could lead to the development of eco-friendly and sustainable clothing and other textile products.
- Packaging materials
 - Some companies are investigating the use of hop fibres as a component in biodegradable packaging materials. This could help reduce plastic waste and promote sustainable packaging solutions.

By finding creative and sustainable ways to utilise spent hops, the brewing industry can minimise its environmental impact and contribute to a more circular economy.

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

Hop waste in the UK can be easily sorted and treated for transportation due to several factors:

Established recycling infrastructure

The UK has a well-developed network of waste management companies specialising in brewery by-products. These companies have the expertise and resources to efficiently collect, sort, and treat hop waste from breweries of all sizes

Diverse recycling options

Hop waste can be repurposed in various ways:

- Animal feed
 - High in protein and fibre, spent hops can be used as a valuable feed supplement for livestock.
- Composting
 - Hop waste can be composted to create nutrient-rich soil amendments for agriculture.
- Bioenergy production
 - Hop waste can be converted into biogas through anaerobic digestion, generating renewable energy.
- Innovative food products
 - Some breweries are exploring the use of spent hops in food products like bread, snacks, and even beer.

Government support

The UK government promotes sustainable waste management practices, including the recycling of brewery by-products. This support encourages breweries to adopt responsible waste disposal methods.

Overall, the ease of sorting and treating hop waste in the UK is facilitated by a combination of established infrastructure, diverse recycling options, and supportive government policies. This makes it a relatively straightforward process for breweries to dispose of their hop waste in an environmentally friendly manner.



Here are some additional details about the recycling of hop waste in the UK

- Collection
 - Hop waste is typically collected from breweries by waste management companies. The waste is then transported to a recycling facility.
- Sorting
 - At the recycling facility, the hop waste is sorted to remove any contaminants, such as metal or plastic.
- Treatment
 - The hop waste is then treated according to its intended use. For example, hop waste that is going to be used for animal feed may be dried and pelletized. Hop waste that is going to be composted may be mixed with other organic materials.
- Transportation
 - Once the hop waste has been treated, it is transported to its final destination. This may be a farm, a composting facility, or a biogas plant.

The recycling of hop waste is an important part of the UK's efforts to reduce waste and promote sustainability. By recycling hop waste, breweries can help to reduce their environmental impact and conserve resources.

High-value compounds – Hop waste

Hop waste, particularly spent hops, contains several high-value compounds with potential applications in various industries. Some of the most notable compounds include:

- Xanthohumol
 - This prenylated flavonoid is known for its potent antioxidant, anti-inflammatory, and anticancer properties. It has attracted significant interest in the pharmaceutical and nutraceutical industries.
- Alpha and beta acids
 - These compounds contribute to the bitterness and aroma of beer. They also possess antimicrobial and antioxidant properties.
- Essential oils
 - Hop essential oils contain a complex mixture of terpenes, which contribute to the aroma and flavour of hops. These oils have potential applications in the fragrance and flavour industries.
- Polyphenols
 - Hops are rich in polyphenols, which are known for their antioxidant and anti-inflammatory properties. These compounds can be extracted from spent hops and used in various products, such as dietary supplements and skincare products.

By extracting and utilising these high-value compounds, the brewing industry can reduce waste and generate additional revenue streams.

High-value compounds in hop waste: A deeper dive

Xanthohumol

- Potent antioxidant
 - Xanthohumol has been shown to be a powerful antioxidant, capable of neutralising harmful free radicals.
- Anti-inflammatory properties
 - This compound exhibits anti-inflammatory effects, which may be beneficial in managing various inflammatory conditions.
- Cancer-fighting potential
 - Research suggests that xanthohumol may have anticancer properties, potentially inhibiting the growth of tumour cells.
- Neuroprotective effects
 - Studies have indicated that xanthohumol may protect brain cells from damage, making it a potential agent for preventing neurodegenerative diseases.

Alpha and beta acids

- Antimicrobial properties
 - These compounds possess antimicrobial activity, which can help inhibit the growth of harmful bacteria and fungi.
- Antioxidant effects
 - Alpha and beta acids contribute to the antioxidant properties of hops, helping to protect cells from oxidative damage.
- Sedative and anxiolytic effects
 - These compounds have been linked to sedative and anxiolytic effects, which may contribute to the calming and sleep-inducing properties of hops.

Essential oils

- Aromatic compounds
 - Hop essential oils contain a complex mixture of terpenes, which contribute to the distinctive aroma and flavour of hops.
- Antimicrobial activity
 - Some of these terpenes have antimicrobial properties, making them potential natural preservatives.
- Sedative and anxiolytic effects
 - Certain terpenes in hop essential oils, such as myrcene and humulene, have been associated with sedative and anxiolytic effects.

Polyphenols

- Antioxidant properties
 - Polyphenols are powerful antioxidants that can help protect cells from oxidative damage.
- Anti-inflammatory effects
 - These compounds have anti-inflammatory properties, which may be beneficial in managing various inflammatory conditions.
- Cardiovascular health
 - Polyphenols may help improve cardiovascular health by reducing cholesterol levels and blood pressure.

By extracting and utilising these high-value compounds, the brewing industry can not only reduce waste but also contribute to the development of new products with potential health benefits.

What industrial applications might they be used for?

The high-value compounds extracted from hop waste have a wide range of potential industrial applications. Here are some of the most promising areas:

Pharmaceutical industry

- Antioxidant supplements
 - The potent antioxidant properties of compounds like xanthohumol can be harnessed to develop dietary supplements.
- Anti-inflammatory drugs
 - The anti-inflammatory potential of hop compounds could lead to the development of new medications for various inflammatory diseases.
- Neuroprotective agents
 - Compounds with neuroprotective properties, such as xanthohumol, could be used to develop drugs for neurodegenerative diseases like Alzheimer's and Parkinson's.
- Anticancer drugs
 - The anticancer properties of certain hop compounds offer potential for developing novel cancer therapies.

Food and beverage industry

- Natural food additives
 - Hop-derived compounds can be used as natural preservatives, antioxidants, and flavouring agents in food products.
- Functional foods and beverages
 - These compounds can be incorporated into functional foods and beverages to provide health benefits, such as improved antioxidant status and reduced inflammation.

Cosmetics and personal care industry

- Skincare products
 - The antioxidant and anti-inflammatory properties of hop compounds make them ideal for use in skincare products like creams, lotions, and serums.
- Hair care products
 - Hop-derived compounds can be used to develop hair care products that promote hair growth, reduce hair loss, and improve hair health.

Agricultural industry

- Natural pesticides:
 - The antimicrobial properties of hop compounds can be utilised to develop natural pesticides for crop protection.
- Animal feed additives
 - Hop-derived compounds can be added to animal feed to improve animal health and productivity.

By exploring the diverse applications of hop waste-derived compounds, the brewing industry can contribute to a more sustainable and innovative future.



What initial pre-treatment would be required?

Initial pre-treatment of hop waste

The initial pre-treatment of hop waste will depend on the specific compounds of interest and the desired extraction method. However, some common pre-treatment steps include:

1. Drying

- Purpose: To reduce moisture content and improve handling and storage.
- Methods: Air drying, oven drying, or freeze-drying can be used, depending on the desired quality and efficiency.

2. Grinding or milling

- Purpose: To increase the surface area of the hop waste, facilitating efficient extraction.
- Methods: Hammer mills, ball mills, or other grinding equipment can be used to reduce the particle size.

3. Cleaning

- Purpose: To remove impurities, such as dirt, debris, and microbial contaminants.
- Methods: Sifting, washing, or other cleaning techniques can be employed.

4. Size separation

- Purpose: To separate different particle sizes, which can influence extraction efficiency and product quality.
- Methods: Sieving or other separation techniques can be used to obtain specific particle size fractions.

Specific pre-treatments based on extraction method:

- **Solvent extraction**
 - Drying: Essential for efficient solvent extraction.
 - Grinding: Increases the surface area, improving solvent penetration.
- **Supercritical Fluid Extraction (SFE)**
 - Drying: Necessary to avoid interference from water vapour.
 - Grinding: Can enhance extraction efficiency, but may not be essential.
- **Microwave-Assisted Extraction (MAE)**
 - Drying: Can improve extraction efficiency by reducing moisture content.
 - Grinding: Can increase the surface area, facilitating microwave penetration.

The specific pre-treatment steps will be optimised based on factors such as the target compounds, desired extraction yield, and the overall cost-effectiveness of the process.

A case study: Essel Innovation & Development Services and Goacher's Brewery Ltd

Essel Innovation & Development Services Ltd specialises in offering distinctive and healthy South Indian cuisine in the Maidstone area. They are developing sustainable packaging solutions from brewers' spent grain, aiming to create environmentally friendly products that contribute to the circular economy.

The challenge

Essel Innovation & Development Services, a purveyor of healthy South Indian cuisine in Maidstone, faced a significant challenge in aligning its commitment to sustainability with its packaging practices. Traditional packaging materials often contribute to environmental pollution and waste, hindering the company's goal of creating a truly eco-friendly dining experience.

The solution

To address this challenge, Essel embarked on an innovative project to develop bespoke packaging solutions derived from brewers' spent grain. By repurposing this brewing by-product, Essel aimed to reduce waste and emissions generated by both the brewing and food industries.

The impact

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

- Source raw materials
 - Purchase the necessary ingredients to produce sustainable packaging from brewers' spent grain.
- Optimize packaging design
 - Tailor the packaging to suit the specific needs of takeaway South Indian cuisine, ensuring optimal functionality and aesthetics.
- Conduct rigorous safety testing
 - Validate the safety and quality of the new packaging materials through comprehensive testing procedures.
- Establish a manufacturing process
 - Develop efficient manufacturing processes to produce the sustainable packaging on a larger scale.

The collaboration

Essel's partnership with Goacher's Brewery Ltd further strengthens the project's impact. By collaborating with a local brewery, Essel ensures a reliable supply of spent grain, reinforcing the circular economy approach.

Through this innovative project, Essel Innovation & Development Services is not only addressing a pressing environmental challenge but also inspiring positive change within the community. By embracing sustainable practices and fostering collaboration, Essel is setting a new standard for responsible business operations.

This table provides a summary of industrial application for hop waste:

Hops	Spent hops (after brewing)	Xanthohumol, polyphenols, alpha and beta acids, essential oils	Pharmaceuticals (antioxidants, anti-inflammatories), animal feed, fertilisers, functional foods, biofuels, natural pesticides
	Hop vines (stems)	Organic fibre	Compost, biodegradable packaging materials
	Leaves and unsuitable cones	Organic matter	Soil conditioners, compost

Valuable chemicals derived from agricultural 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.

Xanthohumol

- This potent antioxidant with anti-cancer properties holds promise for nutraceuticals, pharmaceuticals, and skincare. Its neuroprotective potential also makes it a candidate for Alzheimer's and Parkinson's therapies.

Alpha and beta acids

- Known for their antimicrobial properties, these acids are valued in pharmaceuticals and natural preservatives, and contribute to the aroma of beverages.

Essential oils and polyphenols

- Hop essential oils and polyphenols are applied in skincare, as antioxidants, and in the flavour and fragrance industries, providing natural preservatives and flavouring agents.

High-value compounds sought by industry

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

Polyphenols (from grape, hop, and fruit waste)

- Sectors
 - Cosmetics, pharmaceuticals, food, and nutraceuticals.
- Uses
 - Known for antioxidant and anti-inflammatory properties, polyphenols like resveratrol, anthocyanins, and other phenolic acids are in high demand for natural skincare products, dietary supplements, and as natural preservatives in food products.
- Sustainable benefits
 - Polyphenols offer greener, plant-based alternatives to synthetic antioxidants and preservatives.

Xanthohumol (from hop waste)

- Sectors
 - Pharmaceuticals and nutraceuticals.
- Uses
 - Sought after for its potential in anti-inflammatory, antioxidant, and anticancer applications, xanthohumol is increasingly explored for therapeutic drugs and dietary supplements.
- Sustainable benefits
 - This natural compound reduces the need for synthetic bioactives, aligning with the demand for plant-based, low-impact medical and wellness products.

Essential oils and terpenes (from hop waste)

- Sectors
 - Fragrance, cosmetics, food and beverage.
- Uses
 - Essential oils and terpenes extracted from hops are used for natural flavours, fragrances, and in aromatherapy. They are valuable as natural alternatives to synthetic flavouring and aromatic compounds.
- Sustainable benefits
 - Terpenes support the trend of moving away from petrochemical-derived fragrances and flavours.

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

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