Breaking new grounds for coffee

George May and Jessica Folkerts of bio-bean explain how spent coffee grounds have moved from a food waste problem to become a valuable resource and raw material.

It should come as no surprise that food waste is a big, global problem and it is passed time to do something about it. The world’s food waste accounts for 8% of our total global greenhouse gas emissions (GHG) if food waste were a country, it would be the third highest emitter of GHG. According to Project Drawdown, reducing food waste is the single most effective solution to climate change.

Thankfully, there are several innovative movements to address the staggering 30% of all food produced globally going to waste. From creative distribution and sharing, to upcycling and circular models, there are many opportunities to make a positive choice quickly and simply for sustainable, scaled impact. From peels and past-its-prime fruit, more manufacturers are getting creative, and more upcycled food start-ups are beginning to appear on the scene.

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Underpinning this upcycling trend in food and beverage ingredients is the demanding and discerning consumer. In fact, according to Mattson, a food innovation and development firm, 95% of consumers want to do their part to reduce food waste, and in 2019 more than half (57%) of consumers were aiming to buy more food and beverages made with upcycled ingredients in the next year.

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Spent coffee grounds as a food waste

The world’s population drinks over 2.25bn cups of coffee every day. With an estimated average of 11g of fresh ground coffee going into each cup, a staggering 9m tonnes of ground coffee are brewed every year, resulting in an estimated 18m tonnes of wet, spent coffee grounds as a by-product. Typically, this by-product is treated as a waste and sent to landfill or directed
other sub-optimal disposal methods for spent grounds. But what if instead we could reduce this coffee waste by harnessing its residual value and feeding it back into a circular economy? Bio-bean has established a way to collect spent coffee grounds and upcycle them into a valuable raw material, which can then be used to manufacture a range of sustainable bio-products. By diverting spent grounds away from conventional disposal methods, waste and subsequent greenhouse gas emissions are reduced. Upcycling the grounds into bio-based products for both industrial use and for consumers means that every ounce of useful resource is being recovered from this material that was once considered waste.

If sent to landfill, spent coffee grounds – like every other organic waste material – emit methane (a greenhouse gas 25 times more potent than carbon dioxide over a 100-year period) and other harmful greenhouse gases, contributing to the congestion in our atmosphere and the warming of the planet. If all the estimated 18m tonnes of wet, spent grounds were left to decompose naturally, they would release over 2.3bn cubic metres of methane annually – a global warming impact equivalent to the entire annual CO₂ output of France.

There are other disposal options, like anaerobic digestion (AD) and incineration. But coffee contains thousands of trace level volatile organic compounds, including pyridines, which have been shown to inhibit biomethane production in AD. As a result, and with greater awareness of organics recycling and available feedstocks, many AD plants prefer not to accept spent coffee grounds.

Many businesses choose incineration as a waste disposal method. But unrecycled spent coffee grounds are wet, and therefore an inefficient fuel. More importantly, incineration does not consider the residual value of the material and precludes any options for recycling or reuse.

Bio-bean recovers and recycles spent coffee grounds, processing and upcycling them into a range of sustainable bio-products for use across a variety of industries, both consumer and industrial. This enables greater resource extraction from a material previously considered to be waste. With the capacity to process around 16,000 tonnes of spent grounds annually, we are able to save approximately seven tonnes of CO₂ emissions every year compared to alternate disposal methods.

Spent coffee grounds lend themselves to being processed as a separate raw material feedstock into a range of value-adding bio-products. They are a naturally clean by-product of the
baking process, segregated at source by baristas and bean-to-cup machines, and are readily identifiable.

The spent grounds are collected from UK businesses of every scale: from coffee shops, office blocks and restaurants, to airports, universities, rail stations and instant coffee manufacturers. Working with the existing logistics and waste management infrastructure, spent grounds are collected through various models depending on the volumes produced and the business’s location and operational resources. These methods include backhauling or via daily collections along with, yet segregated from, general waste.

There are two streams of supply: one certified food-grade stream collected from a single source (a national coffee shop chain) via a backhaul model of collection and a second stream aggregated from all other recycling partners. The first stream makes sure the grounds remain within the food chain and certifies kosher and halal status. This enables bio-bean to extract the remaining volatile aroma compounds from these grounds to create a natural coffee flavour for use as an ingredient in food and beverage formulation.

**Residual value of spent coffee grounds**

The process of roasting green coffee beans generates hundreds of volatile chemical compounds responsible for the unmistakable flavour and aroma of one of the world’s favourite hot drinks. In fact, over 800 volatile compounds are responsible for coffee’s complex and instantly recognisable aroma (both flavour and fragrance). These flavour and fragrance compounds, combined with oils, caffeine, and a range of other beneficial compounds (such as antioxidants) naturally present within the beans, make coffee a rich source of functional components.

While brewing coffee grounds exhausts many of these functional compound groups, a significant percentage of a few key groups of residual volatile aroma and other compounds remain. In other words, there is still significant value in spent coffee grounds, which until recently had most often been wastefully and needlessly discarded.

By extracting coffee’s original, natural and non-depleted chemical compounds from spent grounds, the residual value within this by-product can be introduced back into the supply chain, contributing to the circular economy and sustainably reusing a valuable resource.

**Natural flavour ingredient**

The residual volatile aroma compounds found in fresh coffee are extracted to produce an ingredient with high concentrations of natural pyrazines, bringing roasted, nutty and smoked notes when utilised in flavour applications. The pyrazines provide a unique...
flavour profile and composition which widens the scope of potential product applications to a range of sweet and savoury, coffee- and non-coffee-related formulations, including alcoholic spirits, ready-to-drink beverages, dairy-based products and chocolates.

Raw material for plastics, packaging and more
Following the extraction of the residual valuable compounds to create a flavour ingredient, the solid grounds remain. These solids are added to a second feedstock supply stream (aggregated from all other recycling partners) to be processed and upcycled into a bulk, raw material for other product innovations to maximise the use of this significant resource.

When spent grounds arrive at bio-bean’s Cambridgeshire factory, they are put through a decontamination process before drying to pre-set moisture levels. With the ability to process to bespoke specifications, the product can be further refined to meet the specific demands of a particular customer. The technology guarantees a uniform product, meaning a consistent particle size and bulk density.

Rising consumer demand for sustainable products and packaging, accelerated by the climate emergency, is fuelling product innovation with an accompanying flow of new products using spent coffee grounds as a core ingredient coming to market. From bioplastics, packaging and automotive friction to cosmetics, textiles and printing inks, spent coffee grounds are a versatile raw material for a range of industries, and they allow the displacement of conventional virgin or synthetic carbon-heavy resources.

For example, spent coffee grounds have thus far been incorporated successfully into biobased, compostable as well as recycled polymers, including PE (polyethylene), PP (polypropylene), PETG (polyethylene terephthalate glycol), PS (polystyrene) and ABS (acrylonitrile butadiene styrene) and in an array of colours. In this application area, spent grounds can currently displace up to 30% of the original virgin or synthetic, and often petroleum-based, material.

The range of potential applications is vast and the technology is still breaking new ground in response to the push to build back greener in the wake of the pandemic.

Solid biomass heating fuel
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Food waste as a solution
Spent coffee grounds are anything but waste. Rather, their inherent breadth of potential serves as demonstrative proof that food ‘waste’ materials need not be wasted. There is nothing within nature that goes to waste - everything is recycled and reused. This is a circular model that has worked for centuries, so why reinvent the wheel?

Food waste need not be a problem - it can be the solution. We just need to look for the possibilities (often right under our noses), to be creative and inventive, and avoid jumping to past reliance on virgin and synthetic options that very often have a sizeable negative environmental footprint.

As Mahatma Gandhi so wisely declared, waste is merely a resource in the wrong place.

References and article available online at onlinelibrary.wiley.com/doi/10.1002/fsat.3502_8.x

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