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Technology Innovations and Business Models for Valorisation of Industrial Waste Biomass in Sparsely Located Enterprises



Circular economy cases and their business models in Irish brewing and distilling industry

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1 Breweries & distilleries in Ireland and their business models

There are currently 125 microbrewing companies operating in Ireland, of which 75 are independent production microbreweries. The majority are craft driven with an emphasis on taste, quality and balance compared to the large-scale brewery ethos which is more concerned with volume of brew output and the efficiency of the brewing process.

The total beer production in Ireland (2017) amounted to 8,019,000 hl of which the independent microbrewery production figures of 157,000 hl represented 1.9% of the production market. Total consumption of beer in Ireland (2017) was 4,479,000 hl. Of the figure produced by independent microbreweries some 126,500 hl were sold in the domestic Irish market, with 30,500 hl going for export (19.4% of total market) indicating an Irish independent microbrewery share of domestic beer consumption of 2.6%. More than one in six microbreweries had a turnover of less than €50,000 and more than one-third had less than €100,000. One in five microbreweries had a turnover in excess of €1m (ICBI, 2018).¹

Irish microbreweries consume twice as much energy per hectolitre of finished product compared to large breweries, as they do not benefit from the efficiencies of scale. New entrants to the industry in the past two years were partly offset by closures which reflect changed market circumstance, increased competitiveness and a need to adopt measures as an effective way to reduce overheads and stay in business (ICBI, 2018). In tandem with this change, waste policy in Ireland has been developing in line with the central elements of the Circular Economy resulting in an increased awareness within the Irish beverage industry that potentials exist to harness further growth and value addition from their waste streams. This has resulted in an increased uptake in the establishment of a circular economy ethos amongst micro-breweries in the Irish NPA regions.

Brewers spent grain (BSG) is the major by-product of the Irish brewing industry, representing around 85% of the total by-products generated.

1 Independent Craft Beer and Independent Micro-breweries in Ireland Oct 2018: A report for Board Bia and Independent Craft Brewers of Ireland. Link: <http://icbi.ie/economic-impact-reports/>

Within the sector primary opportunities involving spent grain being utilised as animal feed have highlighted its potential as a by-product rather than a waste while simultaneously reducing feed imports in the Irish agricultural sector.

The Department of Agriculture Food and the Marine (DAFM), as the competent authority for animal feed, is tasked with ensuring the control and safety of the feed. This department also oversees funding initiatives that will seek to underpin greater utilisation of natively produced grain as well as identifying higher value end uses for the waste streams generated from within the sector.

Breweries who are feed business operators (FBO's) are classified as "Suppliers of Feed Materials". DAFM requires that any operator producing or supplying feed materials from food or industrial processing must be registered and comply with their obligation as feed business operators (FBO's). To be compliant, breweries in the NPA region need to ensure that their (Hazard Analysis & Critical Control Point) HACCP is amended to indicate that their by-product is not a waste but a by-product under Article 27 of the Waste Management Acts and designated as animal feed-stuffs.

BSG as a potential functional ingredient capable of enhancing the nutritional value of cereal and bakery products due to its high content of protein and fibre (around 20 and 70% dry basis, respectively), continues to be investigated but developments in this respect have been speculative, slow to develop and niche. Noted challenges associated with using BSG as a bakery feedstock includes the existence of a complex outer layer, making it difficult to separate and convert, and a high moisture content (80% - 85%), making it susceptible to microbial growth and spoilage within a 7-10-day period. Research into bioprocessing techniques and enzymes to improve the quality of baked snacks with BSG are ongoing as are evaluation of the consumer acceptance of these products (Ktenioudaki et al., 2012)².

2 Ktenioudaki, A. et al (2012). Brewer's spent grain as a functional ingredient for breadsticks. International Journal of Food Science & Technology 47(8). DOI: 10.1111/j.1365-2621.2012.03032.x

Based on the conducted interviews, wastes from sugar fermentations and distillation can be digested anaerobically and the methane generated used as an energy source.

Progression from low risk/low return opportunities to this level of waste use for BSG is influenced by a variety of factors most notably, justifiable waste volume accumulations and technological challenges that exist.

Many individual Irish breweries are also located in rural regions and have small outputs, with over 50% currently producing less than 1000 hl per year. Currently, the smaller volume of spent grain being generated by Irish microbreweries reduces the feasibility (both commercially and environmentally) of developing an onsite AD plant, without the intake of third-party feedstock, which adds regulatory complications, as well as transportation requirements and organisational barriers.

The feasibility of anaerobically treating brewery by-product to provide a supplementary energy source would be best supported by a “hub and spoke” industrial symbiosis business model approach with a bio-refinery (see Figure 3). The model approach is best suited to large scale breweries located in centralised regions (Buffington,2004)³

3 Buffington, J. (2014) The Economic Potential of Brewer's Spent Grain (BSG) as a Biomass Feedstock. Advances in Chemical

Micro-breweries located in the NPA region tend to rural based, producing small amounts of beer and hence small amounts of spent grain. There are too few cluster groups of breweries located throughout the NPA region to justify the existence of a bio-refinery facility to service the small amounts of waste volumes that these breweries produce. The NPA region is also spread out along the west & north of the country, making a geographically acceptable centralised location that little bit harder to establish. The large-scale breweries in Ireland tend to be located in urban environments in the east of the country, most notably Dublin and greater volumes of BSG occur in this region (outside the NPA). A justified centralised bio-refinery located to service breweries in the NPA region would necessitate a joint-up and/or a co-operative attitude to exist among the breweries operating in the region. This is however lacking at the moment as each brewery are working independent of each other when it comes to tackling their waste streams including BSG.

Currently, larger breweries such as Guinness and Heineken Ireland, whilst keen to achieve zero waste to landfill have yet to explore routes beyond traditional animal feedstock with any surplus grain considered not palatable to livestock being reprocessed at offsite-composting sites and sold as gardening compost.

Engineering and Science, 4, 308-318.

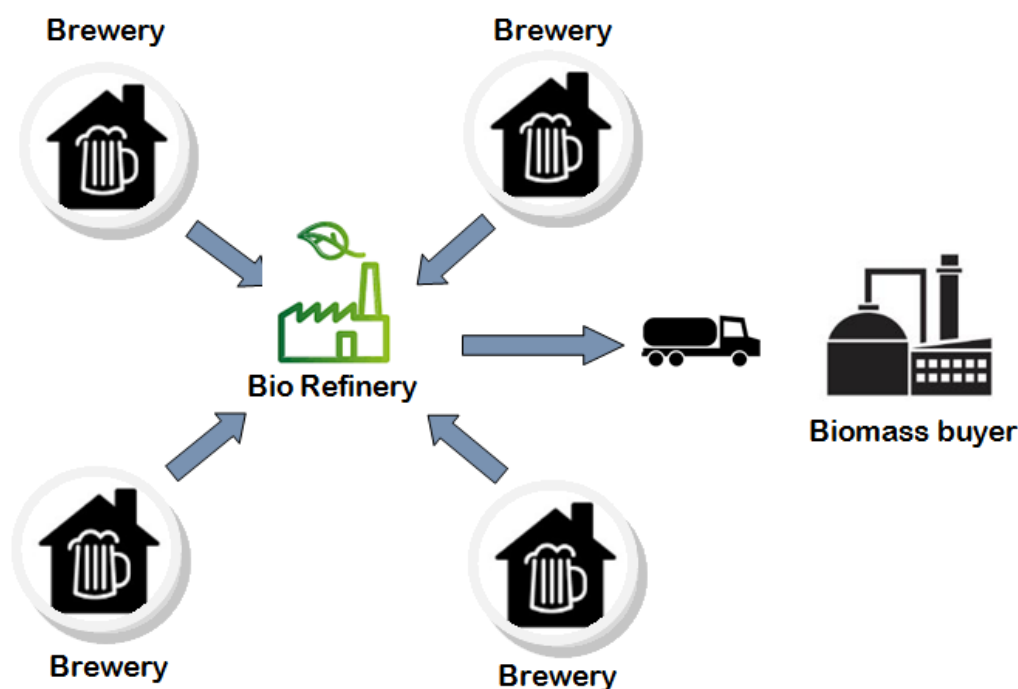


Figure 3: Industrial Symbiosis 'Hub & Spoke' BSG supply chain material flow (borrowed from Buffington,2004).

1.1 Case 1: Distillery

Established in 1784 in Northern Ireland. Their product is triple distilled from 100% malted barley with spent grain sent to local farms as animal feed. Animal feed with its high value end use was considered the best option for the company for by-product use, featuring high on the waste hierarchy – preventing the arising of waste and reducing the need for virgin resources to feed animals.

In order to improve efficiency, an onsite evaporator was installed to facilitate for greater transport efficiencies and increasing shelf life of grain before distribution.

The company have also carried out research along with Queens University Belfast (QUB), to investigate the feasibility of converting their BSG from a biological waste (lignocellulosic biomass) to synthesize activated carbon (AC) and carbon nanotubes (CNTs) for use in water remediation applications.

1.2 Case 2: Brewery

It is a microbrewery who have brought numerous beers to market and is a typical example of how some Irish microbreweries are finding niche markets for their waste streams.

Equipped with a degree in chemistry, the company CEO qualified as Ireland's first female beer sommelier and was awarded the prestigious gold medal by The Institute of Brewing and Distilling in London. Over the past two years they have realised novel innovative approaches to the processing and reuse of their nutrient rich brewing waste that involves converting their spent grain and nutrient rich water from the brewing process into dog snacks, granola bars, and mediums for cultivating mushrooms by inoculating BSG with mushroom spores. The grain is then placed in a high humidity environment and the mushrooms yield in a month, particularly Oyster mushrooms which have witnessed significant growth yield.

2 Future opportunities for waste handling:

There are numerous alternative opportunities available for utilising organic matter generated from brewing and distilling processes in Ireland. Figure 8 illustrates potential utilisation of BSG based on Nigam (2017)¹ and Buffington (2014)². The majority are considered niche markets, or are only suitable for either very small volumes, or large joint aggregated collections. Regardless, downstream benefits exist from brewery waste stream products for the agricultural and other sectors.

The use of distillation and brewing by-products as animal feed has a long-established tradition between the alcohol and farm industries in Ireland, and which has evolved alongside each other specifically in rural regions resulting in an efficient and effective localised infrastructure with high value use of by-product generated. For brewery production in urban environments, the transport distances to farms are significant.

Breweries with a particularly high-volume production on site are beginning to value higher risk/higher return by-products equally or more highly as feasible alternatives to animal feed. Biofuel production or anaerobic digestion are useful markets for by-product, with growth in AD facilities anticipated as being the main opportunity in coming years.

- BioGas: In light of the EU's 2020 goals for new sources of renewable energy. Brewer's spent grain (BSG) is an appealing waste product for conversion to biogas.
- Composting: Spent grain is nitrogen-rich and acts as a good composting material. Other organic arisings, where smaller volumes are being handled (for example, plant extracts from gin production), are very well suited to composting.

1 Nigam, P.S. (2017) An overview: Recycling of solid barley waste generated as a by-product in distillery and brewery. *Waste Management*, 62 : 255-261. DOI: 10.1016/j.wasman.2017.02.018

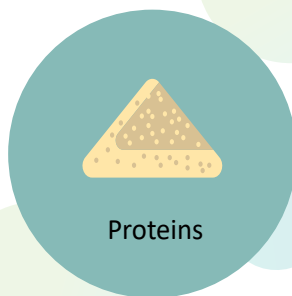
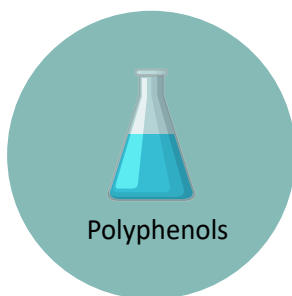
2 Buffington, J. (2014) The Economic Potential of Brewer's Spent Grain (BSG) as a Biomass Feedstock. *Advances in Chemical Engineering and Science*, 4, 308-318.

- Absorption of heavy metals and pollutants: The hydroxyl, carboxyl and amine groups in spent grains have a high affinity for metal ions. This makes them a useful medium for use in treatment of wastewater high in these pollutants, such as textile and dye industries.
- Cereal/Bakery Products: The health benefits of dietary fibre and investigation into novel low-cost sources of fibre have highlighted the potential of BSG to enhance the nutritional value of cereal/bakery products. The Irish Department of Agriculture, Food and the Marine (DAFM) continue to research BSG potentials to increase the fibre content, decrease the calorific content and increase the protein content of food products.

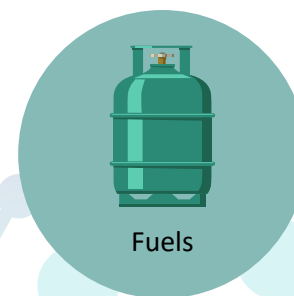
3 Bottlenecks / challenges for efficient waste handling:

- The availability of brewers' grains is not always consistent due to a seasonal brewing practice exercised by some brewery companies. Prices during the winter months reflects the peak demand for the feed. During the summer period, brewery production generally reaches its peak while demand at farm level for fresh feeding is low. This results in a lower price and need for specialist storing. Long-term storage requires adding an absorbent.

Example of valuables from by-products:



...that can be used e.g. in:



However due to its lower dry matter content, higher rates of the absorbent are needed to ensure that the product stacks correctly and to mitigate nutrient loss due to 'run-off'. Some farmers have reported grains dry matter as low as 16% moisture content ultimately impacting storage and feeding value leading them to seeking transparency on all feeds purchased. The low dry matter requirement thus leads to the need for large amounts of absorbents to stabilise it, consequently adding a higher cost to the product. Despite this, with a current delivered price of €35/ ton, brewers' grain represents good value for money on an energy and protein basis, provided dry matter content is kept above 22% (moisture content).

- Microbrewing is a much more labour-intensive activity than conventional large-scale brewing and is subject to substantial economies of scale and higher operational costs. As plant size increases, operational personnel do not necessarily increase in line. This situation can make it difficult for microbrewers to justify additional labour output into developing by-products from waste volumes that are small by comparison to macro breweries, preferring instead to use additional labour to increase beer production.



Figure 4: Valorisation possibilities of brewing and distilling by-products

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