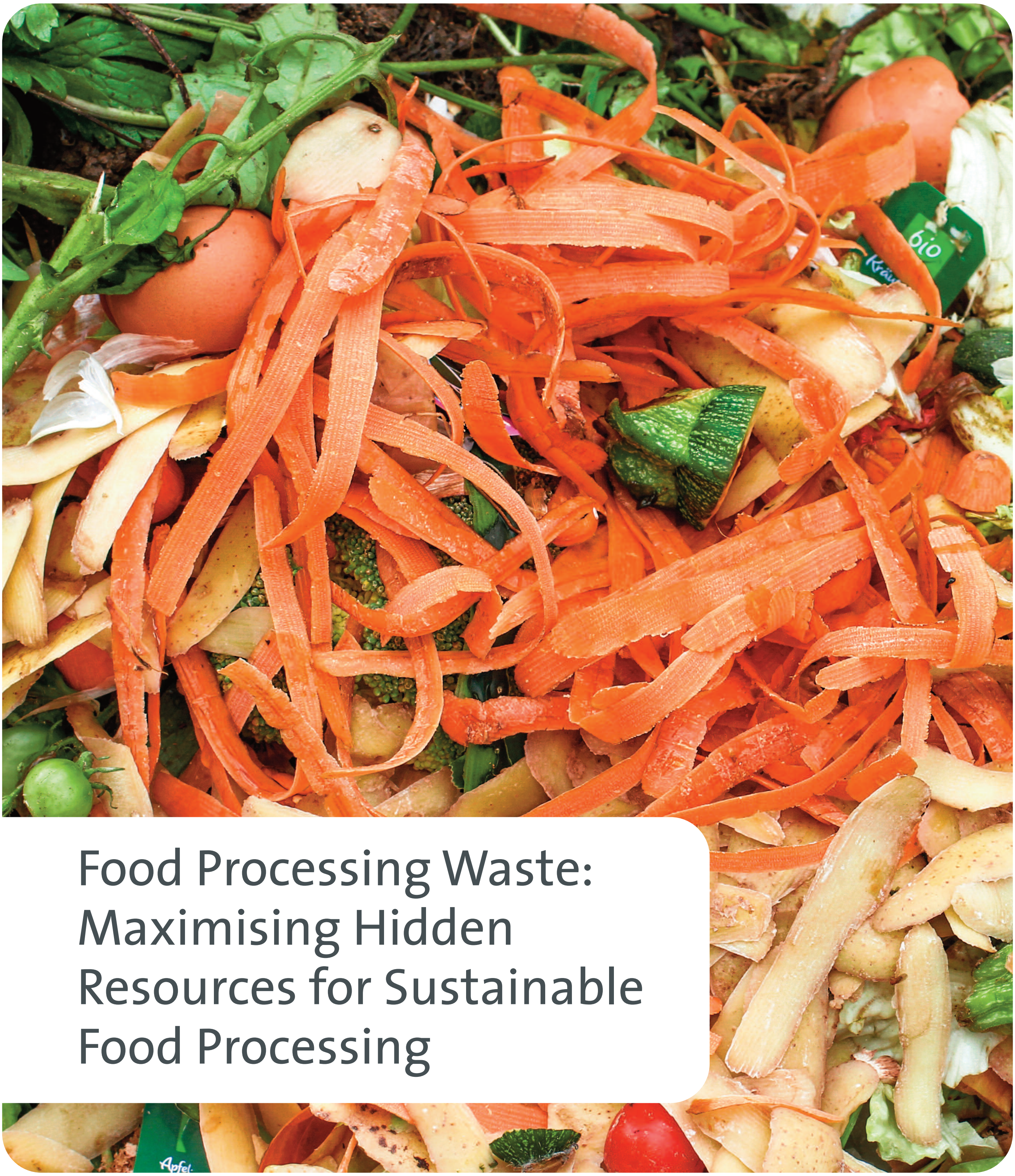
UCD DUBLIN

UCD Institute of Food and Health Policy Seminar Series



Food Processing Waste: Maximising Hidden Resources for Sustainable Food Processing

esai
Environmental Sciences Association of Ireland

FOREWORD

The UCD Institute of Food and Health wishes to translate and extend the impact of its research activity into both the economic and policy spheres of Irish society. In order to advance issues of major significance to industry and the consumer, on a yearly basis we hold a policy workshop at which we bring together key international and Irish opinion formers on a subject area which is of relevance to all stakeholders.

Food waste along the food chain has become a growing concern for all stakeholders. Not only from what the consumer ultimately wastes in the kitchen but right back up the chain through the retailers, processors and the producer. Added to this are the concerns of a rapidly expanding world population and its requirements for food and also potential added-value lost through not recycling or upgrading. The environmental impacts of food waste can also not be underestimated. Energy costs in the production of food to not only have a financial impact, but also an environmental cost in terms of emissions of greenhouse gases in the face of the global challenge of climate change. Discarding of food packaging is of great concern to all users and recycling of packaging is now an industry and research focus in itself. A challenge for the food industry is to minimise the overall volume of packaging used and to look for alternatives to those materials cannot be recycled and whose manufacture in the first place can have a significant environmental impact. By working together to reduce all aspects of food waste, all those who have a vested interest in ensuring the sustainability of our food systems, including the consumer, can take significant steps to reduce waste and in doing so, they can benefit the environment from a climate change perspective.

The focus of the workshop was to review the potential for generating value from waste while staying within regulatory frameworks. Case studies from across the food chain were included as exemplars of what can be achieved through programmes and initiatives designed to help reduce food processing waste.

In this report, the papers presented on the seminar day are summarised. The presentations are also available on the UCD Institute of Food and Health website (www.ucd.ie/foodandhealth). I would like to thank all our speakers, the Chairs and the invited audience for their contributions to the seminar. A special thank you to Dr Tom Curran who was instrumental in putting the programme together and organising the event, and to Professor Ronan Gormley for his work in summarising the presentations for this report

Dolores O'Riordan

Professor Dolores O'Riordan
Director
UCD Institute of Food and Health

PROGRAMME

Date:	Monday 8th June 2015
Venue:	George Moore Auditorium, UCD O'Brien Centre for Science, UCD, Belfield, Dublin 4

9.30AM	Registration
10.00AM	*Welcome & Opening Address:* Professor Dolores O'Riordan, Director, UCD Institute of Food & Health
SESSION 1	Chair: Dr Niamh Harbourne, UCD Institute of Food & Health
10.10 AM	*An overview of the current problem of waste across the food chain.* Dr Dimitrios Charalampopoulos, Head of Food and Bioprocessing Sciences Research Group, University of Reading, UK
10.30AM	*A regulatory and enforcement perspective on food processing waste.* Mr Patrick Byrne, Senior Inspector, Environmental Protection Agency
10.50AM	Case Study 1: *FoodCloud.* Ms Aoibheann O'Brien, Co-Founder, FoodCloud
11.05AM	Coffee and networking
11.35AM	*Is "Food Waste" waste?* Professor Nicholas Holden, UCD School of Biosystems Engineering & UCD Institute of Food & Health
11.55AM	Case Study 2: *Dairy Streams as a source of bioactive oligosaccharides.* Dr Mariarosaria Marotta, Teagasc Food Research Centre, Moorepark
12.10PM	*Extracting value from fat, oil and grease (FOG) waste.* Dr Tom Curran, UCD School of Biosystems Engineering and UCD Institute of Food & Health
12.30PM	*Enrichment of bioactives from food by-products: A luxury or a necessity?* Dr Nigel Brunton, UCD School of Agriculture & Food Science and UCD Institute of Food & Health
12.50PM	*Discussion Session and Summary*
1.00PM	Lunch
SESSION 2	Chair: Dr Shane Colgan, Environmental Protection Agency
2.00PM	Case Study 3: *Getting value from beverage and food industry wastes.* Mr Michael Clancy, FDT Consulting Engineers and PUReOPE
2.15PM	*Sustainable polymers for packaging.* Dr Kevin O'Connor, UCD School of Biomolecular and Biomedical Science
2.35PM	Case Study 4: *Sustainable waste management in the meat processing industry.* Mr Robert Kirwan, Irish Country Meats
2.50PM	*Biosecurity in the food and feed chain.* Mr Justin Byrne, Department of Agriculture, Food and the Marine
3.10PM	Case Study 5: *Reduction of fossil Fuel Dependency through the utilization of anaerobic digestion (Waste to Energy).* Dr Gabriel Kelly, Group EHS Manager, Dairygold
3.30PM	*Forum Discussion*
4.00PM	Close

CURRENT PROBLEMS OF WASTE ACROSS THE FOOD CHAIN

Prof Dimitrios Charalampopoulos, Head of Food and Bioprocessing Sciences Research Group, University of Reading, UK

Food waste occurs throughout the food chain i.e. at agricultural production, post-harvest handling and storage, manufacturing, wholesaling/retailing and finally in the home. Food waste in the EU 27 countries was circa 89 million tonnes (Mt) in 2006 and is predicted to rise to 126Mt by 2020. Food waste breakdown by sector in the EU 27 in 2010 was households (42%), manufacturing (39%), food service/catering (14%) and retail/wholesale (5%). The global carbon footprint of wasted food has been estimated at more than twice the total greenhouse gas (GHG) emissions of all road transportation in the US in 2010. GHG emissions in 2010 were circa 170Mt CO2 equivalent per annum and are estimated to rise to about 240Mt by 2020.

It is estimated that the cost of food wasted is €1250 - €1650/tonne. The waste includes vegetable trimmings, pulps, fruit peels, spent grains, vegetable oilcakes, dairy waste streams, meat and fish waste and starch based waste (segregated or mixed), and also out of specification material. Products/processes with large amounts of waste include fresh soft and cooked cheese production (85-90%), sugar production from sugar beet (85%), potato starch production (80%), fish filleting, curing, salting and smoking (50-85%), vegetable oil production (50-70%). Waste levels in the UK grocery retail and manufacturing areas are estimated at 6.3Mt per annum with percentage breakdown of food waste (60), packaging waste (21), food in mixed waste (8), packaging in mixed waste (3) and other waste (8). In addition, about 1.5Mt of food processing by-products (molasses, sugar beet pulp, confectionary by-products, spent grains from distillery and brewery) go into animal feed.

Management routes for food waste in the UK grocery/retail (0.4Mt) and manufacturing (3.9Mt) sectors are land spreading (47%), recycling (30%), unknown (13%), thermal (4%) and landfill (1%). A preparatory study on food waste across the EU 27 by the European Commission (2010) highlighted a number of EU policies to tackle food waste (e.g. Waste Framework and Landfill Directives) and a targeted reduction of the amount of food waste sent to landfill from circa 40Mt to 4Mt by 2020. Options from the most to the least favoured are prevention, preparation for re-use, recycling, other recovery and disposal. In 2014 the European Commission initiated a zero waste programme for Europe to be implemented by the end of 2015. Called 'Towards a Circular Economy', it has targets of reducing material inputs by 17-24% with a consequent saving of €630bn by 2030. Food waste and by-products as a resource were also discussed i.e. the bio-refinery concept embracing feedstocks, processes and by-products and their many downstream outputs. Potential products include bioactive compounds, flavours, biopolymers, natural colours, biofuels and fine chemicals. Valorisation of dried distillers' grains was given as an example and their resulting products such as functional carbohydrates, dietary supplements and animal feeds. Business challenges cited included raw materials availability (volumes, seasonality), logistics, market potential of products (volumes, value), investment and risk reduction, business models and economic and environmental impact. R&D challenges included detailed compositional data of food waste materials, implementation of green processing technologies, integration of processing technologies (enzymes, microbes), process scalability and process economics, and tailoring the functionalisation of molecules to suit market applications.

REGULATORY AND ENFORCEMENT PERSPECTIVES ON FOOD PROCESSING WASTE

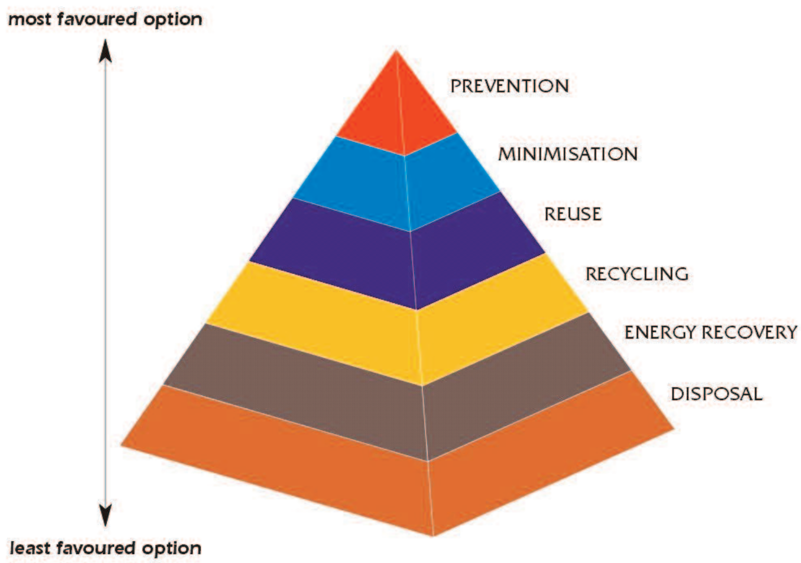
Patrick Byrne, Senior Inspector, Environmental Protection Agency

Regulatory and enforcement perspectives on food processing waste was discussed under the headings: (i) EPA regulated activities; (ii) waste; (iii) waste hierarchy; (iv) best available technologies/techniques (BAT); (v) by-product/end of waste; and (vi) EPA supports to business. EPA regulated activities embrace Class 7 of the First Schedule of EPA Act relating to processing of milk, brewing, distilling, malting, slaughterhouses, manufacture of fish meal, rendering of animal carcasses, and treatment and processing of animal or vegetable raw materials for production of food and feed. Waste is defined as any substance or object which the holder discards, or intends to, or is required to discard. European Court of Justice judgements led to EU Commission paper 2007 'Waste and By-products' which lists processing waste as out-of-date product, contaminated product, packaging, washing effluents, waste water treatment plant sludges and other materials. Annual food waste in Ireland is estimated as 450kt (during production), 380kt (during distribution/retailing) and 300kt (by households). The following waste hierarchy applies as a priority order in waste prevention and management legislation and policy i.e. prevention; preparing for re-use; recycling; other recovery (including energy recovery); and disposal.

Relevant BAT Reference Documents (BREF) are available on food/drink/milk, slaughtering, emissions from food storage, and energy efficiency. Key environmental issues include waste water, solid waste and water/energy. BAT conclusions relating to waste are: (i) identify options for minimising waste production; (ii) implement programme to minimise waste production; (iii) ongoing monitoring of waste production levels; (iv) sectoral benchmarking; and (v) re-use of water (sterilisation may be necessary). Requirements under BAT include: (a) follow waste hierarchy – reuse, recycle, recover; (b) store appropriately on site in designated areas; (c) waste monitoring/analysis; and (d) waste recording - this embraces European Waste Catalogue code/type of waste, quantity exported, names of agent/carrier, collection permit details, final destination for recovery/disposal, permit/licence, confirmation of acceptance and rejected consignments etc. BAT conclusions, associated with BREF documents finalised since 2010, will be published as Commission Implementing Decisions and must be implemented by industry within four years following publication (BREF documents and BAT Conclusions can be downloaded from the IPPC Bureau website at http://eippcb.jrc.ec.europa.eu/index.html). The Food, Drink and Milk BREF is currently being reviewed.

By-product/end of waste are covered by Articles 27 and 28 of European Communities (Waste Directive) Regulations, 2011 as follows: a substance or object can be a by-product (and not a waste) under certain conditions (see Article 27(1) of Statutory Instrument 126 of 2011); further use is certain, can be used directly without any further processing other than normal industrial practice, is produced as an integral part of a production process, and further use is lawful. If regulatory controls under waste legislation are needed to protect the environment and human health, waste status should remain.

Green Business (greenbusiness.ie) is a free and confidential resource efficiency service for all types of SMEs in Ireland and is funded by the EPA under the National Waste Prevention Programme. It is delivered by the Clean Technology Centre and is partnered by Enterprise Ireland, SEAI, Repak and Bord Bia. Case studies with companies include energy usage/balance by/in a feed mill, meat processor and pig processor. The EPA's Green Business Programme in association with IBEC hosted a national conference in June 2015 entitled 'Financing and Funding Opportunities for Greening your Business'. Stop Food Waste is the EPA's programme promoting food waste prevention and supporting home composting. It is aimed at householders, communities and small retailers and is delivered in collaboration with local authorities (stopfoodwaste.ie).



CASE STUDY 1

FoodCloud

Ms Aoibhinn O'Brien, Co-Founder, FoodCloud

The mission of FoodCloud is to connect those that have too much food with those that have too little. Over 800 million people suffer from food shortage globally. Food waste equals money and one million tonnes of food is wasted in Ireland each year and one in ten people are suffering from food poverty. Such a level of waste raises moral issues when so many people have little or no food.

At the start-up of FoodCloud there was only one centre in Ireland for the redistribution of excess food. This compared poorly with the situation in other countries. For example, in the USA there are Good Samaritan Laws and also tax incentives for the recycling of excess food to charities. At the outset FoodCloud linked farmers' markets with local charities and with the aid of financial support created a website and app to enable donations to be made to FoodCloud. A donations tracker showed 16,700 donations of 431 tonnes of food in one year; this is equivalent to almost one million meals.

The big breakthrough was the partnership between Tesco and FoodCloud in the area of redistribution of excess short shelf life food. Tesco have 146 stores in Ireland and food that would be wasted is forwarded to charities via an alert scheme whereby the charities pick up the food and distribute. This development has helped those suffering from food deprivation but has also reduced the environmental impact of excess short shelf life food in stores. There are over 300 registered charities in Ireland and so there is a ready sink for excess food provided the logistics of collection and distribution can be overcome. Food must be moved quickly because much of the recycling is near the end of shelf life of the food and high standards of food safety are essential. Obviously 'best before' is better than 'use by'. Other food producers, processors and retailers are expressing interest in the FoodCloud system as a solution for their excess food.

FoodCloud is also receiving support from the EPA, FSAI and from companies who handle food. Another development is the BIA Food Initiative which is operational in Cork, Galway and Dublin. Food donations are received from food growers, producers, distributors and from the distribution centres of the large retailers. Donations are warehoused and re-distributed to charities across the region. A shelf life of at least three days is necessary which means that the foods available are a consequence of a particular range being discontinued, or being incorrectly labelled or being an excess order. The biggest challenges for FoodCloud going forward are those of controlled temperature storage/warehousing of the donated foods coupled with the logistics of redistribution while maintaining top level of food safety. The enduring vision of FoodCloud is a world where no good food goes to waste.

IS 'FOOD WASTE' WASTE?

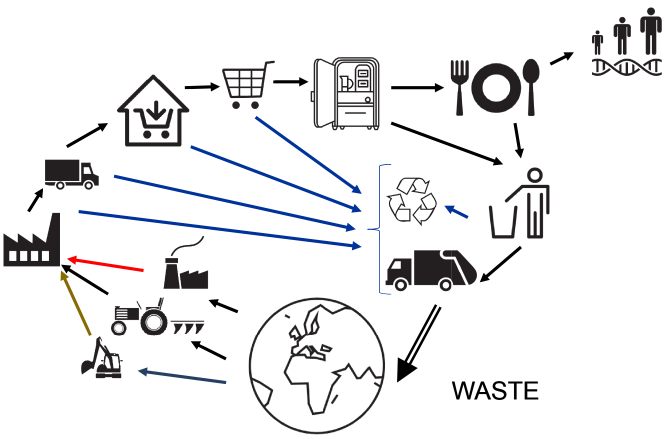
Prof Nicholas Holden, UCD Institute of Food and Health and UCD School of Biosystems and Food Engineering

The EU Waste Directive 2008/98/EC defines waste as "items that people no longer have any use for, which they either intend to get rid of or have already discarded". Any definition or discussion on waste is by nature subjective, inconsistent, of variable state and status, ambiguous and actor dependent. A life cycle assessment (LCA) conceptualization can be used for waste with input flows drawn from the biosphere. Output flows are wastes that are discarded to the biosphere without subsequent human transformation [ISO14040 (2006)]. If our idea of 'waste' is limited to the output flow then the concept of waste is unambiguous, objective and actor independent. The definition of waste is very important because material that is a resource is treated differently. For example, carbon containing waste is now a "resource" for some actors and a UK government report recommends ministerial responsibility for "waste as a resource" in the bioeconomy. The well accepted waste hierarchy lists prevent, reduce, reuse, recover and dispose. But why prevent and reduce if waste is a resource?

The upstream concept in waste LCA has two aspects: (i) typical "food" LCAs do not consider whether the food becomes "waste" and (ii) typical "waste" LCAs do not consider details of the "waste" generation. Review of recent literature shows that the Zero Burden Assumption (ZBA) is used in nearly all food waste LCA studies. Food waste is always assumed to have no impact when making technology assessments. It is known to be heterogeneous and its composition can be quite unpredictable. It is known that there is economic value via tax, disposal payment, financing and sale of downstream products. Many mass flows are only waste in the subjective opinion of the actor, and remain a resource in the system. However it is no longer clear what the function of the system is. A plot of value versus mass (or volume) shows four scenarios: (i) food waste (low mass, low value), (ii) wasted food (high mass, low value, (iii) bioresource (low mass, high value), (iv) co-product (high mass, high value).

Proposed terminology for "food waste" is as follows: (a) "waste" – used strictly to describe those materials that are not utilizable and are disposed of in the biosphere sink – prevent to minimum possible and dispose; (b) "residue" – materials that are unavoidable but not consumable; can be regarded as a bioresource – prepare for reuse, recycle, compost or energy recovery; (c) "wasted food/product" – material that has been mismanaged and should never end up in secondary processing – prevent to a practical minimum, then prepare for reuse.

In conclusion, the best policy and management solutions for food waste require more strict use of the terminology and due consideration of the role of the bioeconomy in primary and secondary resource markets.



CASE STUDY 2

Dairy streams as a source of bioactive oligosaccharides

Dr Mariarosaria Marotta, Teagasc Food Research Centre, Moorepark

Milk oligosaccharides are the third largest component in human milk after lactose and lipids and are based on five monosaccharide building blocks (galactose, glucose, N-acetyl-glucosamine with fucose and/or sialic acid in terminal position). The combination of these 5 monosaccharides through several different linkages generate unique chemical structures, of which more than 200 have been identified. The chemical structures are responsible for the unique bioactivities ascribed to Human Milk Oligosaccharides (HMOs), which benefit the infant, such as prebiotic, anti-infective and immunomodulatory effects. While it would be beneficial to add HMOs to infant formulae, commercialization is not feasible and so the focus shifts to alternatives.

In recent years, infant formula manufacturers included galacto-oligosaccharides and fructo-oligosaccharides as substitute of HMOs in their formulations. However, fructo-oligosaccharides and galacto-oligosaccharides lack fucose, N-acetyl-glucosamine and sialic acid and the variety of linkages found in HMOs; consequently they are unlikely to have the same bioactivities as HMOs. However, similar oligosaccharides are present in animal milk, and given the wide availability of bovine milk and the importance of the dairy industry globally, bovine milk is being considered as a potential source of oligosaccharides. Although HMOs (10-15 g/L) are more abundant when compared to the levels of oligosaccharides found in bovine milk (BMOs) (< 0.5 g/L), both are characterized by lactose at their core structure and both contain sialic acid and fucose, although at different percentages. Furthermore, recent studies have shown that bovine milk and whey permeate contain BMOs with some structural similarity to HMOs, which may imply shared functionalities.

Teagasc and the University of California, Davis investigated mother liquor as a potential source of oligosaccharides. Mother liquor is derived from whey permeate after lactose crystallization and is currently considered a by-product by the dairy industry. Following clarification, membrane filtration and diafiltration, the diafiltered oligosaccharide-enriched retentate had a sialyllactose to lactose ratio of 14.1%, which represents a 40-fold enrichment of sialyllactose based on the sialyllactose/lactose ratio. Evaporation and spray drying of the retentate yielded 2.8 kg of BMO enriched powder from 2000 L of mother liquor. MALDI FT-ICR mass spectrometry analysis of the enriched-powder demonstrated the presence of 25 neutral BMOs, four of which had identical composition of those found in human milk. Furthermore, structural analysis revealed the presence of previously unreported high molecular weight BMOs including some fucosylated structures. This research suggests that opportunities exist to add value to dairy by-products by extraction of valuable oligosaccharides. It is hoped that research such as this could lead to development of bio-functional oligosaccharides ingredients with similar structure to HMOs in contrast to what is currently commercially available.

Currently Teagasc as part of Food for Health Ireland (www.fhi.ie), is continuing to investigate and develop processes to enrich BMOs from whey streams with a view to industrial scale production by combining membrane filtration and chromatographic technologies.

EXTRACTING VALUE FROM FAT, OIL AND GREASE (FOG) WASTE

Dr Tom Curran, UCD Institute of Food and Health and UCD School of Biosystems and Food Engineering

Increasing urban population gives rise to more urban food waste. FOG (Fat, Oil and Grease) is a waste residue from food production and enters the drainage network in solution when performing washing activities on site. It accumulates and forms a hardened solid in sewer infrastructure leading to a loss of serviceability in the pipeline. FOG is a contributing factor in 50-75% of sewerage blockages which range from minor to major. It is estimated that FOG accounts for up to 25% of treatment costs at waste water treatment plants (WWTPs) and amounts to €0.44-0.99 per litre for plant operators. FOG is a global problem and has featured in the media in a number of countries. For example, London's 'fatberg' problem was featured on BBC News with three examples cited: (i) in Kingston (2013) a sewer was almost completely clogged with over 15 tonnes of fat and took six weeks to repair; (ii) in Shepherd's Bush (2014) a fatberg formed under an 80-metre stretch of Shepherd's Bush Road and took four days to clear; (iii) in Chelsea (2015) a 10 tonne fatberg broke the sewer pipe and it cost £400,000 to replace the damaged sewer. The New York Times reported that the city is by necessity stepping up enforcement on restaurants dumping grease in sewers while Australian media reported that Melbourne's sewage system got clogged by a fatberg and that restaurants are being monitored on the frequency of grease trap emptying. The ultimate failure was in the River Trym, Bristol (2013) where an estimated 90% of river invertebrates were killed by FOG.

A solution to the problem is a FOG control programme backed up by reuse technologies and safe disposal which embraces licensing and inspection. Dublin City Council (DCC) has such a programme embracing grease interceptors and grease recovery units. Both are classified as grease trap systems (GTSs). There are more than 2,200 licensed food service (FSOs) outlets in the DCC programme and they are required to apply for a trade effluent discharge licence. More than 7,000 inspections are performed per annum and there are less than 50 blockages per annum compared with over 1000 in 2008. There has been no major blockage since 2010.

A case study of simplified guidelines for determining an FSO's FOG risk category was presented. Category 1 (unacceptable) - premises has GTS installed. Category 2 (high risk) is where premises has undersized/unsuitable GTS which is in poor condition and does not meet the required maintenance standards. Category 3 (medium risk) is where GTS is overdue minimum maintenance requirements but is not in serious breach of requirements and where FOG disposal records are not available for inspection, or are incomplete, or inaccurate. Category 4 (low risk) is where the GTS is in good condition and all required information is available and up to date.

Scatter diagrams for GTS installations and maintenance compliance in Dublin case study area in a range of FSOs show a huge improvement between 2008 and 2014. Risk categories 1-4 are represented by colours red (category 1), orange (category 2), yellow (category 3) and green (category 4). In the plot for 2008 there were virtually no green dots in the study area whereas they predominated in the 2014 plot. Total quantity of GTW recovered in the study period was 40 (2008), 96 (2012) and 110 kL (2014). Corresponding volumes of used cooking oil recovered were 129, 146 and 194 kL. The next phases of the project are: (i) a smart phone app which will help restaurants log their FOG data; (ii) use FOG (GTW and UCO) as a resource for the production of biodiesel, biogas, biochemicals and biopolymers; (iii) put the Dublin experience into practice in other parts of the country i.e. develop a national FOG management strategy.

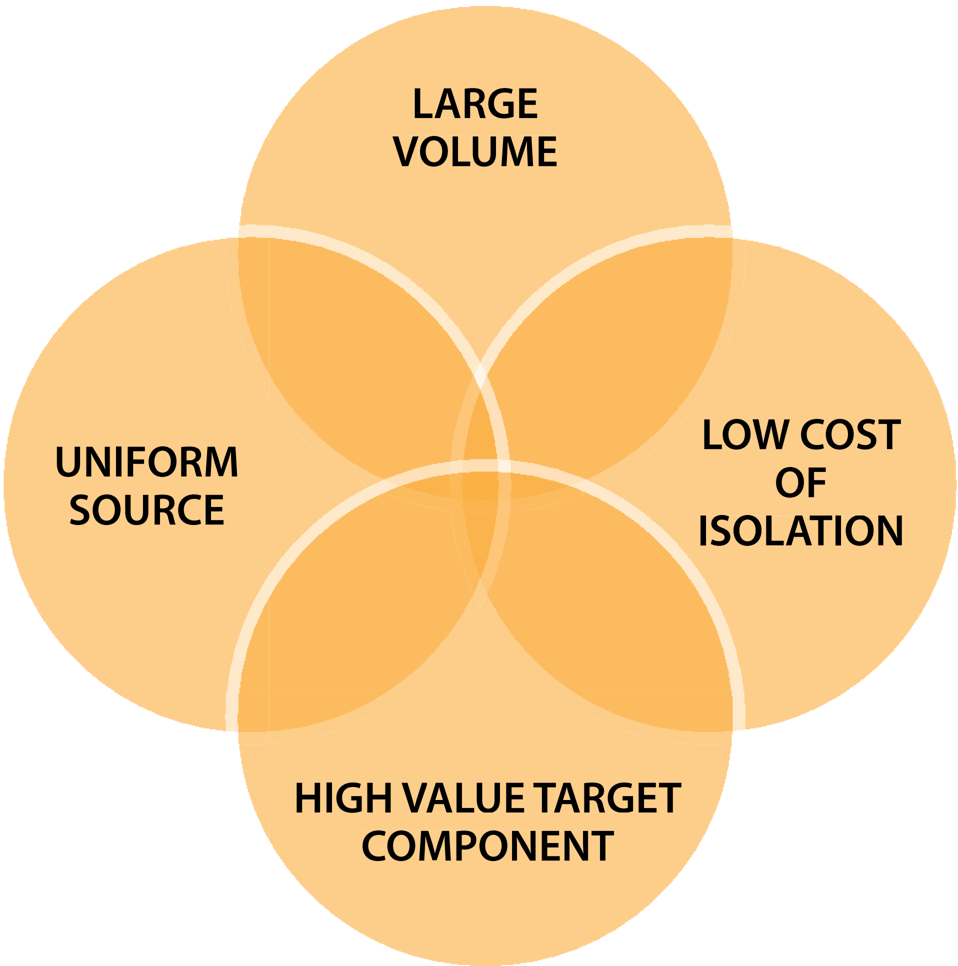
ENRICHMENT OF BIOACTIVES FROM FOOD BY-PRODUCTS: A LUXURY OR A NECESSITY?

Dr Nigel Brunton, UCD Institute of Food and Health and UCD School of Agriculture and Food Science

Enrichment of bioactives applies to valuable compounds in waste or other natural sources which are present at very low levels. It selectively extracts and isolates target compounds and thus increases their concentration which may be a necessity depending on their end-use. In some cases enrichment may go all the way to the isolation of the pure compound. This may involve up to 14 steps with the purity of the target compound increasing with each step. The need to enrich/purify may be necessary for a number of reasons: (i) to enable structure determination of new compounds and to measure their concentration in a source; (ii) to provide pure samples for toxicity studies by regulatory authorities. For example, the European Food Safety Authority (EFSA) may need to link biological or other activity to a particular concentration. In the past many health claims have been rejected by EFSA because of poor characterisation of the active compound.

The ideal properties of a waste source can be depicted by four overlapping circles representing large volume, uniform source, low cost of isolation and high value target component. If all four circles overlap the zone of common overlap can be considered the 'hot zone' i.e. that a particular waste source fulfills all four requirements and should be a target for exploitation. The road to enriching a valuable component may involve solid-liquid extraction, solvent partitioning, molecular weight cut-off dialysis, column chromatography, flash chromatography, preparative chromatography with the purity of the target compound increasing at each stage. This complex sequence demonstrates that it can only be used for high value target compounds. Examples of compounds derived from waste/by-products are hydroxytyrosol (Article 13 EFSA Health Claim), phytosterols (Article 13 EFSA Health Claim) and beta-glucan (Articles 13 and 14 EFSA Health Claim). Case study examples showed: (i) the extraction/purification sequence for the isolation of glycoalkaloids from potato peel and (ii) the procedure for the isolation of 4-hydroxyphenylacetic acid derivatives of inositol from dandelion roots.

The cost of enrichment increases steeply with the level of compound purity required because expensive equipment and a high level of expertise is necessary. The high usage of solvents required for such extraction must be monitored as they can potentially cause environmental damage. The conclusions from this work are that many successful natural products have been isolated/derived from by-products/waste. However, looking for new products is a long, laborious and costly exercise and requires long term thinking and significant investment in expertise and equipment. The potential of Irish natural product research to isolate new compounds, products and extracts is high and these can be exploited via EFSA validated health claims. A high level of compound purity (100%) is needed for product characterization but a lesser level of purity will often suffice thereafter.


LARGE VOLUME
UNIFORM SOURCE
LOW COST OF ISOLATION
HIGH VALUE TARGET COMPONENT

CASE STUDY 3

Getting value from beverage and food industry waste

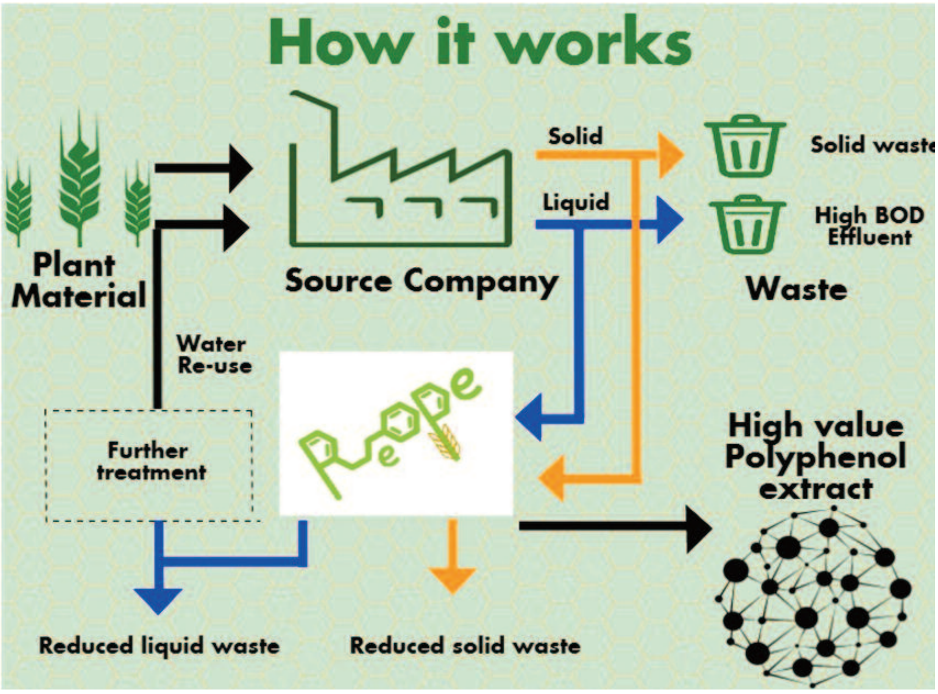
Michael Clancy, FDT Consulting Engineers

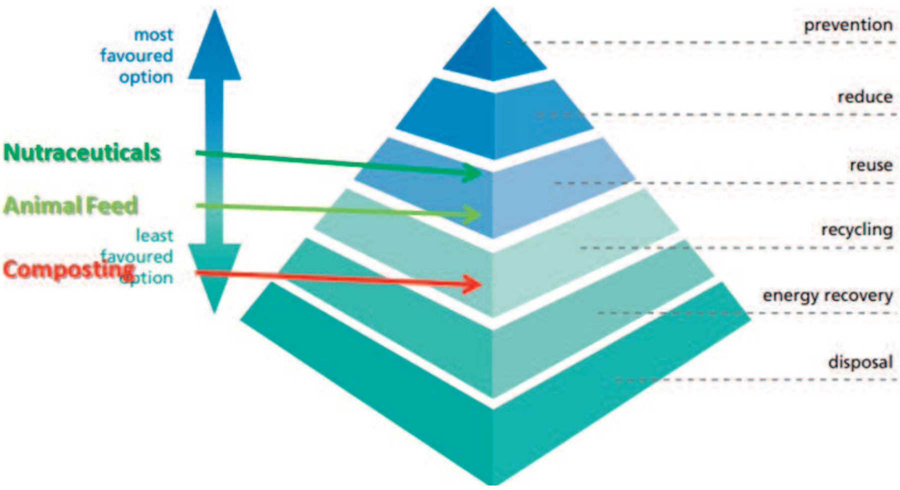
Food waste can be considered as a valuable opportunity. The food waste pyramid is used to depict how to reduce waste, with prevention (most desirable) at the top, and disposal (least desirable) at the bottom. The main components of interest in the pyramid in order to prevent waste, are nutraceuticals (reuse segment), co-products for animal feed (reuse segment) and composting (recycling segment). Of the three, nutraceuticals have the most value potential followed by animal feed and, at a much lower level, composting. There are potentially large energy costs, and significant capital outlay associated with producing co-products for animal feed.

There is a major renaissance in Irish whiskey production with a plethora of small distilleries and therefore larger amounts of 'waste' distillery products including draff, pot ale and spent lees. Draff(spent) is what is left after the sugars are extracted from the malt in the brewhouse. Pot ale is the residue of fermented wash left in the wash still after distillation of the alcohol. Spent lees are the remaining water left in the low wines (2nd) and spirit (3rd) stills after the alcohol has been driven off. Co-product and "waste" stream ratios are typically cask whiskey:pot ale (1:6.1-6.6), cask whiskey:spent lees (1:1.1-2.1) and cask whiskey:draff/grains (1:1.8-3.4). Outcomes for distillery co-products include high value nutraceuticals, possible co-operative ventures with other distilleries to minimise capex for producing co-products or with other symbiotic industries e.g. use pot ale for nutrition in pig, dairy and fish farms; for anaerobic digestion and potentially for fertiliser. The reuse of waste heat should also be considered with potential use in greenhouses, swimming pools and other heat sinks.

The PUReOPE (Process for Upgrading and Recovery of Polyphenol Extracts) project is coordinated by FDT who is also the lead partner. There are project partners in the UK, together with expert consultants in Ireland, the UK, Germany and Italy. The partnership has capabilities to address barriers including regulation, manufacturing, market assessment, technological development and support, financing and dissemination.

Polyphenols cause haze in beer and have effluent treatment plant issues i.e. a high BOD (Biological Oxygen Demand) and an antimicrobial effect. However, on the positive side they are powerful antioxidants and as such are anti-inflammatory and are associated with reduced risk for a wide range of diseases. The PUReOPE project is best described as two streams. Stream 1 has four sequential components: (i) evaluation and quantification; (ii) confirmation of recovery process for each site; (iii) industrial demonstrator; and (iv) demonstrate process on two sites. Stream 2 also has four sequential components: (v) establish preferred routes to market; (vi) life cycle analysis; (vii) life cycle costing; and (viii) establish business model and polyphenol extract customers. The two streams feed into the final project platform which is the commercial rollout of the PUReOPE business model to multiple sites and customers. The driving forces behind PUReOPE are the environmental benefits from recovery in terms of reduced biological oxygen demand (BOD); technology innovation in terms of recovery at source sites rather than from virgin material; potential for water recovery; intellectual property around recovery and upgrade process and applications; high value reuse i.e. nutraceuticals, supplements, functional molecules; animal feed; cosmetics and a projected market of 1,000 million US dollars for polyphenols by 2020.





fdt consulting engineers and project managers
Co-funded by the Eco-innovation Initiative of the European Union

SUSTAINABLE POLYMERS FOR PACKAGING

Dr Kevin O'Connor, UCD Earth Institute and UCD School of School Of Biomolecular & Biomedical Science

Resource exploitation, energy consumption and waste generation are major elements of human behaviour. The impact of these can be felt economically, socially and environmentally. An undesirable consequence of human activity is the environmental impact in relation to water quality, deforestation, air pollution, greenhouse gas emissions (GHG), waste generation and resource management. While modern society is concerned about depleting fossil based resources, other resources such as water, air quality, and waste prevention and management are equally important. Society can replace fossil derived products and energy through the use of renewable resources such as biomass and waste, which can be converted to (bio)chemicals, biopolymers, biofuels, and bioenergy. Biochemicals are the building blocks for biopolymers and thus they serve society as biochemicals and in polymers e.g. Lactic acid is a biochemical used in food but when polymerised it can be used to make plastic products such as bottles. This will allow society to move from a fossil based economy to a biobased economy. Society also has the possibility to produce non-carbon based energy through the use of wind, hydro and wave energy. However, we will need carbon based materials to make biochemicals and biofuels. A biobased society can and will produce polymers, paints/dyes, chemicals, adhesives, fuels/energy, food and medicines. In 2000, over 98% of the energy and chemicals were based on fossil resources as raw materials whereas in 2100 over 95% of the chemicals and polymers were based on renewable resources; there is strong government support for the latter in many countries around the world. The question for bio-based products is not if, but when?

Biorefining can convert complex biobased resources into simple chemicals that can be processed and converted into valuable commodities. Corn is a source of starch, which can be hydrolysed to form glucose. The latter is a major starting material for industrial fermentation. A corn harvest also yields lignocellulose (stover), which can be used to make paperboard. Fractionation of the stover, which is composed of lignocellulose, gives rise to cellulose, hemi-cellulose and lignin. Cellulose and hemicellulose can be hydrolysed to simple sugars such as glucose, arabinose and xylose which can be converted via fermentation to polymer building blocks such as lactic and succinic acid.

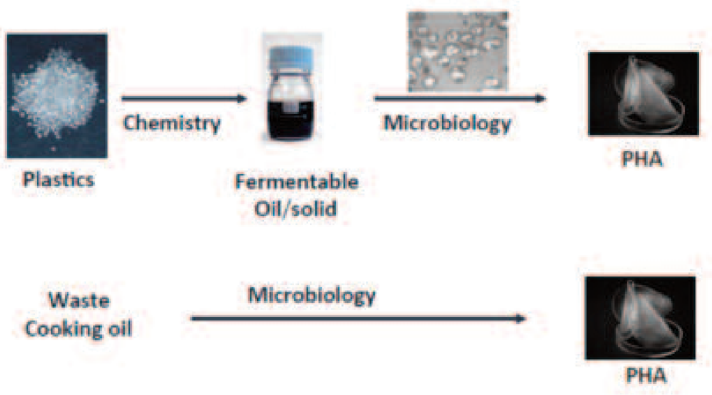
In sustainable packaging, the focus is on resources, design, production process, end-of-life management, labelling, and standards (e.g. EN 13432 for compostability of packaging). Sustainable packaging design is challenged with building in protection and preservation of the product, product display and packaging durability during transport, but also end-of-life management in terms of reuse, recycling and composting. Therefore, packaging choices have to be made on an on-going basis. Cognisance must also be taken of the fact that biobased or fossil based products does not necessarily mean biodegradable or compostable. For example, a biobased resource such as sugar can be converted to ethanol, which can be chemically converted to ethylene. The polymerisation of ethylene gives rise to polyethylene, which is biobased due to the source of biological carbon, but it is not biodegradable. Biodegradability has to do with the accessibility or susceptibility of the bonds in a polymer to biological breakdown and not with the source of carbon used to make the polymer.

Polymers for packaging were considered under four headings: (i) fossil non degradable/non compostable - this includes polyethylene (used for trays and films), polypropylene (bottles and trays), polyethylene terephthalate (PET) (bottles, trays, films); (ii) biobased and non compostable - biobased PET, biobased polyethylene; (iii) fossil based and compostable - polybutyrate adipic terephthalate (PBAT), polycaprolactone (PCL); (iv) biobased and compostable - polylactic acid films (bottles, trays), thermoplastic starch (TPS) (films, bags, adhesives) and polyhydroxyalkanoates (PHA) (films, bottles, trays, adhesives).

The conversion of wastes and by-products to polymers is a relatively recent R&D focus. For example, non-degradable plastics and food waste can be converted to biodegradable polymers by combining chemical and microbiological processes.

Policy and human behaviour have a major role in food packaging usage. For example, a plastic bag levy reduced plastic bag use in Ireland by 90% in one year, which has had a positive impact for tourism (less plastic bag pollution) and social evolution. Growing crops for food use versus fuel use is a debate that has been on going for over a decade. However the production of lower volume higher value biobased products compared to biofuels can reduce competition with food. Indeed it is likely that biobased polymers will not cause any strain within the EU on agricultural land requirements in the near future. Given the fact that the biobased economy is complex and generates multiple interrelated products such as chemicals, polymers, fuels and energy, the policy framework has to be carefully designed so that we can build a sustainable and economically viable society. Policy designed for bioenergy alone is counterproductive to the market entry of other biobased products and such policy needs revision to avoid distortive effects.

In conclusion, there are biobased options for making new polymers for packaging. Performance and sustainability of new polymers is still a challenge. Sustainable packaging advances are not only affected by technology but also policy, standards, and labelling which are key pillars of a sustainable society.



Wastes and by-products to polymers

CASE STUDY 4

Sustainable waste management in the meat processing industry

Robert Kirwan, Irish Country Meats

Irish Country Meats (ICM) is Ireland's leading lamb processor. As a founding member of the Bord Bia, Origin Green programme, the corporate sustainability philosophy is a key factor in all company activities, products and services. IPPC licence compliance has been approved as has accreditation to ISO 14001 Environmental Management Systems and the company has Origin Green objectives and targets.

Irish companies need to promote sustainability initiatives to legislatively comply and compete in world markets. Ireland has a sustainability advantage through grass with the capacity to produce 15 compared to 11 tonnes of dry matter per hectare. Key pillars in sustainable waste management for the meat industry include: (i) efficient waste water treatment plant using new technologies; (ii) product and market innovation to reduce animal by-product and packaging waste; (iii) integrated waste management i.e. service provider giving full solutions based on the waste hierarchy applied to all general waste streams with complete traceability compliance.

Sustainable waste management initiatives at ICM include increased recycling, zero waste to landfill policy, reduced solids in waste water discharges, reduced rendering waste via new processes/products, reduced general waste per unit produced, compliance with international standards, chemical sterilisation, and all electricity from renewable resources.

Sustainable waste management at ICM correlates with Bord Bia's Origin Green targets: (i) reduce water consumption by 25% by 2017; (ii) reduce energy consumption by 10% by 2017; (iii) reduction in waste and packaging by 20%; (iv) target environmental and social sustainability via ISO 14001 and OHSAS 18001; (v) achieve a sustainable supply chain. Key factors to ICM successful sustainable waste management include commitment by senior management, cultural change among employees via increased awareness of waste management issues, redefining waste as a resource, participation of each ICM department in waste management, improved liaison between new product development, procurement and sales/marketing sections in-company.

The Lamb Specialists

BIOSECURITY IN THE FOOD AND FEED CHAIN

Justin Byrne, Department of Agriculture, Food and the Marine

Animal by-products (APBs) are defined under EU regulation as "bodies or parts of animals or products of animal origin.....not intended for human consumption". There are three categories of APBs:
- Category 1 – brain, spinal cord (for disposal only);
- Category 2 – fallen animals, manure, contaminated milk (not for human consumption);
- Category 3 – catering waste, former foodstuffs, milk, eggs. Catering waste is all waste food including used cooking oil originating in restaurants, catering facilities and kitchens, including central and household kitchens.

The use of ABPs is regulated for five main reasons: (i) to control disease (BSE, FMD etc.); (ii) to avoid contamination of food chain; (iii) to avoid contamination of feed chain; (iv) to protect "brand Ireland" and (v) to protect the farming industry, especially the beef sector. There are three main regulations: EU1069/2009 – ABP and derived products; EU142/2011 – implementing regulation; and SI187/2014 – ABP regulation. These apply at collection, transport, storage, handling, processing and use/disposal stages in the ABP chain with the goal of preventing ABPs presenting a risk to animal or public health. ABPs are part of the feedstock used in composting (aerobic conditions) and biogas production (anaerobic conditions) plants. Plant approval and validation has three stages:
1) Application – 1st stage approval in principle;
2)Validation – conditional approval,
3) Full approval.

ABP regulation requirements in relation to plants apply at/include: (i) HACCP; (ii) biosecurity, plant structure, hygiene, transport; (iii) intake; (iv) processing/ transformation, and (v) storage, dispatch, traceability.

Composting is a complex process and depending on the plant may involve three curing bays, two pasteurisation bays, and mixing, holding and clearing bays. Humidity is high in composting sheds due to 'steam heat generation' and air from the plant goes through facility and drier bio-filters en route to release to the outside atmosphere. There is strict control of birds and vermin in composting sheds and care is taken that truck wheels do not become contaminated with ABPs. The final compost goes to farms or is packed in sacks for retailing as garden compost. If composted material is being used on-farm as organic fertilizers/soil improvers and farmed animals are present then grazing restrictions and herbage usage apply and end-users must be registered with the DAFM (Department of Agriculture, Food and the Marine). If farmed animals are not present (i.e. tillage or horticultural farms) then registration is not required.

Biogas production is the opposite to composting in that it is produced under anaerobic conditions. Substrate is fed in at the bottom of the reactor where it is mixed. As it mixes the material rises and becomes the sludge zone. As the bio-reaction proceeds, the sludge zone rises and becomes the fluid zone and bubbles of biogas are produced and rise to the top which is the biogas zone. The biogas is bled off from the top of the reactor and effluent is removed at the interface between the fluid and biogas zones. There are three transformation standards for biogas production: (i) EU standard is 70°C for 60 min, particle size 12 mm (type 1); all permitted feedstocks; (ii) National standard is 60°C, 48 hr twice, particle size 40 mm max (type 2); feedstocks permitted are catering waste, manure, milk, digestive tract content; (iii) alternative standard produced by the European Food Safety Authority (EFSA).

CASE STUDY 5

Reduction of fossil fuel dependency through the utilisation of anaerobic digestion (waste to energy)

Dr Gabriel Kelly, Group EHS Manager, Dairygold

The need and pathway for the development of an anaerobic digestor was based on a long term strategic development taking into account that milk production quotas would be abolished in 2015 leading to a pressing business need due to increased milk processing, increased energy demands and increased treatment requirements for waste. The technology solution was an integrated anaerobic digestion system. The alternative was to do nothing and to use the existing treatment model which had large aerobic tanks that were energy intensive, had a larger CO_2 footprint, and required a high level of manpower. Other alternatives were autothermal thermophilic aerobic digestion (ATAD) but this was shown to have problems with odours and other factors, or advanced fluidised co-digestion and co-generation which is a largely unproven process. The anaerobic digester was the system of choice due to its low energy electrical energy requirements, unmanned automated system, mesophilic operation at less than 50°C, high quality gas stream (typically >65% methane), self-heating in low loading conditions, free useful energy and reduced carbon footprint.

On a process inputs and outputs basis, the system is suitable for the treatment of medium to low strength process waste waters from milk powder production. It can reuse an existing boiler to generate steam and is a stable self-sustaining process that can deal with shock loading if required. Temperature is important in the process and heat exchangers are used to heat incoming waste water to maintain reactor temperature. Heat is generated by burning gas from the process during lower loading conditions. The majority of the biogas is used in steam production. The system uses anaerobic digestion of organic materials by microorganisms under controlled conditions with the production of biogas i.e. natural waste to energy process; the system is particularly suitable for low solids water. It is the largest industrial digester in the Irish dairy industry and represents an €8 million investment in waste to energy. The system is BAT (best available techniques) compliant and the design provides for future expansion. In 2013, the digester generated excess energy of 9.1 million KWh of thermal energy. This 'free' energy represents 107 therms of natural gas or 3,135 KWh per 1,000 kg of COD (chemical oxygen demand) treated; 70% of gas produced is sent to a second boiler for reuse. Waste sludge production is typically 10% of an aerobic process. This means lower disposal costs and in particular transport costs. The biogas generation reduced CO_2 emissions by 1,900 tonnes in 2013.

In the future, the anaerobic digestion project has the potential to treat wastes from other Dairygold facilities such as waste water treatment sludge, thus reducing dependence on land spread and further reducing environmental impact and carbon footprint.

OUTCOMES AND POLICY IMPLICATIONS

- Reducing, recycling, redistributing and utilising excess food and food waste as a route to alleviating food poverty in Ireland and to adding value to waste that is currently discarded, should receive a high priority on the Government's agenda.

- The best policy and management solutions for food waste require stricter use of the terminology and due consideration of the role of the bioeconomy in primary and secondary resource markets.

- Research and innovation needs to have a focus on minimising food waste, while also recovering resources that can result in value added products.

- Isolating and purifying bioactive new compounds/products/extracts is a long, laborious and costly exercise, requiring long term thinking and significant investment in expertise and equipment.

- Focusing on 'green chemistry' in the recovery and identification of bioactives from waste and other streams, should be the future in terms of minimising solvent and chemical use.

- Comprehensive feasibility and market studies should be an integral part of all new projects on the reprocessing and utilisation of food waste, minimising failure rates and ensuring maximum economic outcomes.

- A National Management Strategy for Fat Oil and Grease (FOG) Waste should be a priority in order to increase awareness in food service outlets of the importance of implementing and maintaining FOG control programmes in their operations.

- Performance of new packaging polymers is a major challenge. Policy, standards, and labelling must become and remain key pillars of sustainable packaging.

- Ensuring that treatment facilities exist to deal with the increased waste emanating from the expanding food industry, particularly milk production as a result of quota removal should be a national priority.

- The management of food waste should not just be a matter of meeting minimum compliance with the legislation. All stakeholders need to play a more pro-active role ensuring that Ireland meets its obligations in relation to the global climate change challenge.

UCD Institute of Food and Health
University College Dublin,
Belfield, Dublin 4, Ireland
Tel: +353 1 716 2808
Email: foodandhealth@ucd.ie
www.ucd.ie/foodandhealth