Briefing Note
May 2018

Value Recovery from Solid Confectionery Waste

the waste biorefinery for resource efficiency in the confectionery industry

Whenever we deal with "waste" by throwing it away, we are *wasting resources* and *harming the environment*. The sugars, carbohydrates, proteins and oils in confectionery waste are ideal for conversion to compounds of interest by many microorganisms. These minute life forms often produce useful substances as part of the process of growing. A *waste biorefinery* uses bioprocesses to produce *bioenergy, biopolymers,* and *specialist chemicals* while getting rid of the waste.

Figure 1 Mixed waste from a confectionery factory

What is the fate and potential of waste from the confectionery industry?

In the confectionery industry, three types can be identified: sugar-based, chocolate-based and starch-based. South Africa produces over 300 000 tonnes per year of sugar-based confectionery which is estimated to result in nearly 30 000 tonnes of waste – and that is before counting chocolate- and starch-based waste.

Those millions of kilograms currently end up in South Africa's landfills

This is undesirable because of the space footprint of disposal. Also, the natural process of decomposition releases methane and carbon dioxide, contributing to greenhouse gases and climate change. Many ingredients and some of the products of decomposition of confectionery waste dissolve into the water running through the landfill, making an acidic leachate and increasing the transport of metals into the surrounding soils. This direct negative impact is important to avoid, as is the loss of thousands of tonnes of valuable resources which have cost water, energy and human effort to produce and are not used to their resource potential. This study explored the options for producing value from this "waste" resource.

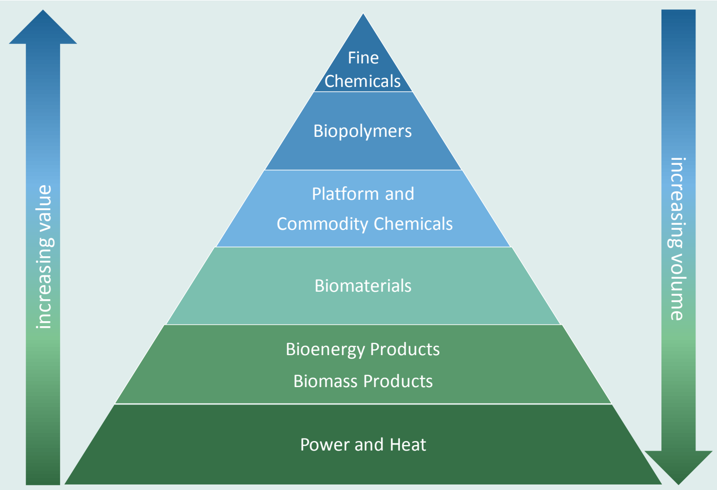

Figure 2 A value-volume pyramid of bioproducts: producing multiple products means we produce less waste

Making many products … …makes less waste

We considered the confectionery waste as a raw material and applied the concept of a waste biorefinery to its further use, thus reducing environmental burden and enhancing value generation. The concept uses mainly bioprocesses to produce a selection of products, some for use in the parent industry and others for sale.

The ultimate dream is to work towards zero waste (although we cannot get all the way)!

We chose to investigate products from different levels in the value-volume pyramid (Figure 2) so that we could envisage the potential of putting production together into a working waste biorefinery.

What can be made from candy, marshmallows, chocolate and biscuits?

We did experiments on sugars but concentrated on three types of confectionery representing three separated waste streams, and a mixture (Figure 3).

Figure 3 Three types of confectionery waste and a mixture

Figure 4 Making marshmallow into substrate for microorganisms

We chose to investigate five bioproducts from our confectionery waste.

1. A purple pigment is a "high-value-low-volume" product from the top of the pyramid.
2. Polyhydroxyalkanoates (PHA) are biopolymers and so a "second tier" bioproduct. PHAs are used to produce biodegradable plastics for multiple uses.
3. Poly-γ-glutamate (PGA) is a middle level biopolymer or biomaterial. Uses of PGA include as a (biodegradable) flocculant and use in soil amelioration.
4. Bioethanol is a biofuel, easily slotting into existing (petrochemical) product markets.
5. Biogas is also in the bioenergy tier but is often used to produce Combined Heat and Power for use on site.

We *really* can re-purpose confectionery waste!

Our experimental studies demonstrated that all these products can be made from confectionery waste. Valuable data about the growth and adaptability of microorganisms was collected through small-scale flask experiments. In some cases, the performance of pure strains of different microorganisms was compared, and in some cases the effect of different process conditions was evaluated.

In the investigations of the bioproduction of the pigment, PGA and ethanol, the studies included the stage of laboratory scale bioreactors (Figure 5), providing demonstration or 'proof of concept' of the viability of these bioprocesses using a confectionery waste feedstock. In the case of biogas and PHA production, there are international examples of use in this arena.

Figure 5 Laboratory scale bioreactor

Further research is required to optimise and scale up each process.

Each has been shown to "work" at "proof of concept" and requires optimisation of process performance. Early-stage technoeconomic studies of the PHA and PGA processes show that these have economic potential.

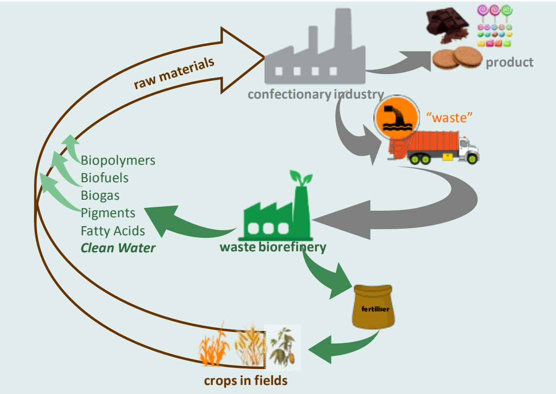

Figure 6 The confectioery waste biorefinery in context

Put these together into biorefineries

Although all these processes "work", it is when they are put together into a biorefinery that the synergy of variety can be leveraged. It is here that what is left over after production of one bioproduct can be used again as feed for the next. For this to move from concept to reality, each factory site must be treated as unique (Figure 6). The focus of the next phase of study is to use literature and laboratory studies to develop a flowsheet for a particular site. Some of the bioprocesses will need technological development before adequate readiness for pilot scale implementation.

CeBER | UCT

Contact details: http:// www.ceber.uct.ac.za
021 650 2759 ceber@uct.ac.za

CENTRE FOR BIOPROCESS ENGINEERING RESEARCH