NATIONAL
FARM WASTE
COORDINATION
SERVICES

FACT SHEET – MARCH 2024

ORGANICS CO-PROCESSING

WHAT IS ORGANICS CO-PROCESSING?

Organics co-processing is where multiple residual organic materials are combined and processed together to achieve a final product of higher value than if it was processed alone. Technologies suitable for co-processing include vermicomposting, black soldier fly composting, composting, anaerobic digestion and pyrolysis.

Products are usually soil amendments and/ or energy that a farmer can sell or reutilise on farm, adding a revenue stream or reducing input costs in their operation.

This fact sheet focuses on:

1. **Composting producing compost; and**
2. **Wet anaerobic digestion producing biogas and digestate.**

The aim of co-processing is to mimic the diversity of feedstocks in the natural cycle. Intentionally combining organic residue streams with different properties allows development of a product with balanced carbon to nitrogen (C:N) ratios and a diversity of nutrients.

The end product is designed to enhance production and aid the improvement of soil health. For example, while a single feedstock such as chicken manure will produce a higher value product by composting it, combining this with hay and wood chips will give a better overall product as this will increase the organic carbon content, which is desired in the end product.

For anaerobic digestion, co-digestion (simultaneous anaerobic digestion of multiple organic wastes) can achieve higher nutrient value of the produced digestate.

KEY MESSAGES

- Organics co-processing can help farmers increase production and improve soil health by beneficially re-using organic materials that would otherwise go to waste
- Feedstock for organics co-processing can be derived from a wide range of agricultural and food processing materials
- Technologies exist to support organics co-processing approaches, including composting and anaerobic digestion
- Planning a co-processing project is complex and many factors must be considered before implementation, including the availability of quality feedstock, technologies and vendors, site selection and overall viability.

CONSIDERING CO-PROCESSING

Primary producers and processors create a wide range of organic residues including remaining crop material post-harvest, animal manure and excess or spoilt food which are often disposed of in a range of ways.

Practices can include leaving residues in the field, spreading animal manure on land, and burying or stockpiling on-site. These can lead to adverse environmental outcomes but are also not using the untapped potential of those organic materials. Therefore, the value proposition of co-processing is to consider the 'organic waste' as a resource that can provide production benefits and save input requirements and cost.

Additionally, there is an element of risk management that is addressed by having proper co-processing. For example, spoilt fruit and vegetables can attract vermin, become odorous and pose a biosecurity risk if stockpiled.

AVAILABLE TECHNOLOGIES

The co-processing technology to be implemented is determined by the availability of feedstocks. The quantity and quality of feedstock and the location determine the process and quality of the output.

In broad terms, composting can utilise a wide range of organic materials as long as there is a balance of carbon to nitrogen and the moisture is not too high. Anaerobic digestion is more suited to 'stronger' organic streams that are liquid and are highly liable to decay or spoil and become putrid (putrescible).

The table below provides a guide to what should be considered when determining the most suitable processing method/s for your farming business (Table 1).

Table 1 A guide to key considerations when selecting organic waste processing methods

Parameter	Composting	Anaerobic digestion
Organic material type	Any plant or animal material, including mortalities	Highly putrescible material that is hard to handle onsite (e.g manures) Liquid material preferably with less water (e.g. oils, blood)
Feedstock characteristics	Ideal C:N ratio between 20:1 and 60:1 Lower moisture (<65%). Moisture can be added but it is harder to remove	High methane potential – highly degradable materials High moisture > 80% [1]
Products	Composted products	Biogas and digestate
Footprint	Needs space and relatively flat topography	Can be more flexible with land requirements
Complexity	Lower complexity	Higher complexity
Equipment	Chipper, loader, turner, temperature control, composting pad, mobile aerated floor, screen	Loader, crusher, digestor, separator, gas scrubber, thermal control
Distance from houses/towns	Large distances are required	Although distance is preferable some are operated in urban settings
Can this be on farm?	Yes	Yes

1 Wet anaerobic digestion have 5% to 15% dry matter. Source: Tim Pullen, *Anaerobic digestion – Making Biogas* (2015) Routledge.

Figure 1 Composting site operated with a loader.

COMPOSTING

Composting is an aerobic biological process applicable to any biodegradable solid organic material with a final product of pasteurised stabilised organic matter (Figures 1 and 2).

Composting mimics the natural decomposition of biomass in diverse natural systems providing microbial activity, nutrients, carbon, soil organic matter and increased water holding capacity which can benefit soil and plant growth.

Composting is most rapid when conditions that encourage the growth of the decomposer microorganisms are met. These conditions include when:

- Organic materials are mixed and sized appropriately with a balance of carbon and nitrogen (C:N ratio)
- Moisture permits biological activity without obstructing aeration
- Oxygen is at levels that support aerobic decomposition
- Temperatures encourage microbial activity.

Feedstocks for composting tend to be quite flexible compared to other technologies as all organic matter will be able to decompose.

However, time of decomposition is a critical factor as this will impact turnover rates and space requirements. The C:N ratio and moisture are key when selecting feedstock. Ideal C:N ratios are between 25:1 and 40:1, although ratios up to 60:1 are also acceptable. Optimal moisture is below 65%. Usually, nitrogen rich feedstocks are selected first and the balancing carbon source, structure and aeration component is sourced second.

Contaminants, although sometimes invisible, can be a major issue when reusing or selling the composted products. The source of the material is an indication of the possible contaminants which are classified as physical, chemical or biological. While physical contaminants such as plastic bags can usually be visually identified, chemical and biological contaminants such as pesticide residue, pathogen and weed seeds cannot.

Developing a composting method requires planning, experience and iteration as feedstock, technology, site context and financials need to align.

When co-processing, having good relationships with other waste producers in the area is effective as collaboration leads to better co-processing outcomes. This can aid in identifying feedstock sources nearby, managing contaminants in the waste, communicating expectations of noise, getting recommendations for hiring and identifying customers for the composted products.

Figure 2 Windrow turner. Image: Peats Soil & Garden Supplies.

Figure 3 Loader turning compost on-farm.

For example, if a farmer's waste supplier continuously delivers the organic waste contaminated with plastic packaging or mulch, a good relationship and open communication will enable the waste supplier to understand the composter's needs and the farmer to understand why the waste is contaminated so the issue can be resolved and a quality product delivered.

On-farm composting benefits from wide open spaces with distance from houses and other sensitive receptors (e.g. waterways). Composting uses simple technology that is available on many farms given that piles or windrows can be formed and turned using a loader (Figure 3), and moisture can be added using a firefighting pump. Operations range from simple to more specialised equipment such as turners (Figure 3) and screens that can lead to higher efficiencies.

Land availability is crucial to successful composting as sites must have designated areas to receive waste, process compost, mature compost and store finished product. A leachate dam which is used to supply water and prevent leachate from leaving the site is also common.

ANAEROBIC DIGESTION

Anaerobic digestion is the controlled decomposition of organic material in a vessel or lagoon that contains no oxygen (Figure 4). Under these conditions, anaerobic bacteria grow and consume carbon contained in the organic matter, converting it to methane and digestate (liquid fraction of undigested organic matter).

Anaerobic digestion favours highly biodegradable feedstocks as the size of the tanks are determined by the time that it takes to convert feedstock into gas. These are common in piggeries and feedlots as the manure can be handled through the digestors to generate heat or energy for the farm and the digestate can be spread as a soil amendment.

Figure 4 Anaerobic digestion unit (left) and slurry from a water treatment plant (right).

Feedstocks are mostly assessed as suitable when they have a high biomethane yield. That is the amount of biomethane produced per amount of feedstock. This is usually an indicator of high-carbon and dry matter in the feedstock and can be tested in labs around Australia.

Although manures are usually the most common feedstock for anaerobic digestion in Australia, grass and hay have higher biomethane yields (in manure, energy from the grass has been previously extracted through the cow's digestion – see Table 2 on the following page). Similar to composting, finding the right mix of feedstocks can improve the operation of the digestion unit and achieve higher nutrient value of the produced digestate.

Anaerobic digestion is most efficient when the needs of the anaerobic bacteria are met including:

- Consistent and constant feedstocks as the microbial culture needs constant feed and requires time to adapt
- Moisture that allows the bacteria to move freely and find feedstock
- Low concentration of fibrous materials containing lignin, hemicellulose and cellulose (e.g. wood)
- Temperatures that encourage microbial activity.

Physical, chemical and biological contaminants can also be an issue in anaerobic digestion. Physical contaminants can be hard to spot and must be removed to prevent damage to the digestor. This is usually done through screens.

Of greater concern are chemical compounds such as antibiotics, pesticides and detergents that damage the microbiology of the unit inhibiting methane formation. These materials are used extensively for cleaning and sanitising equipment and facilities in the food processing industry and milking yards on dairy farms. Assessing the risk of feedstock from these sources is important in co-processing operations and another example of how good relationships with waste suppliers can lead to better co-processing outcomes.

On-farm anaerobic digestion units are usually sold as a package and will come with support on how they should be managed. Compared to composting it is less restrictive with the use of space but is more complex as the biomethane must be managed safely. Often, biodigesters will be designed with expected future volumes of feedstock and as such have capacity to receive other materials. Farmers usually choose high strength materials like residual food and oils that may be hard to manage but make high gate-fees.

The methane generated by the digestion process should be harvested and either used to generate heat or electricity. The greatest value is derived when the methane is used to produce heat, as there are efficiency losses when converting to electricity. Co-generation engines that convert methane to electricity greatly reduce the efficient use of the energy embodied in the methane and can be problematic to operate.

Digestate is a by-product of anaerobic digestion and can be a valuable soil amendment, rich in nutrients, but the right regulatory framework and treatment processes need to be in place for this to occur.

FEEDSTOCK VALUE AND SUITABILITY

The following table lists the resource values that can be derived from a wide range of agricultural and food processing materials, and their suitability for composting and anaerobic digestion (Table 2).

Table 2 Resource values from organic material

Feedstock	C and N source [2]	Moisture [3]	Biogas yield (m^3/t) [4]	Composting	Anaerobic digestion
Straw and dry leafy materials	C	Low	242-324, 417-500	Yes	No
Chicken manure (with or without bedding)	N	Optimal	30-100	Yes	Yes
Dairy shed effluent	N	High	N/A	Yes	Yes
Piggery effluent	N	High	15-25	Yes	Yes
Horse manure	B	High	N/A	Yes	Potentially
Grape marc	C	Low	N/A	Yes	Potentially
Woody wastes	C	Optimal	N/A	Yes	No
Spoilt fruit and vegetables, skins/peels	B	High	N/A	Yes	Yes
Animal mortalities	N	High	N/A	Yes	No
Bagasse	C	Low	N/A	Yes	Potentially
Grain hulls/ husks	C	Low	N/A	Yes	No
Cardboard packaging	C	Low	N/A	Yes	No
Cull potatoes	N	High	276-400	Yes	Yes
Grass clippings	N	High	298-467	Yes	No
Corn cobs and husks	C	Low	N/A	Yes	Potentially

2 Where C is for carbon, N is for nitrogen and B is balanced
3 C:N ratios and moisture were extracted from *The Composting Handbook: A how-to and why manual for farm, municipal, institutional and commercial composters* (2021), Robert Rynk, Ginny Black, Jane Gilbert, Johannes Biala, Jean Bonhotal, Mary Schwarz, Leslie Cooperband
4 Biogas yield was extracted from Tim Pullen, *Anaerobic digestion – Making Biogas* (2015) Routledge.

GETTING STARTED

Most operations will start with a farmer processing their own material and using external sources to balance their feed. Once this is established, operations can grow to take external feedstock charging a gate-fee.

Planning a co-processing project is complex and usually outside the normal day-to-day of farming operations. The following is an overview of the key steps to undertake if considering co-processing:

1. **Feedstock mapping and selection:** The viability of these enterprises depend on feedstock sources being in proximity of the processing and end users. Understanding the area and the feedstock – including the moisture, carbon and nitrogen ratios and biomethane potential – is key to later determining the technology and quality of the end product.
2. **Site selection:** An ideal site is close to the source of material, mostly flat, accessible to transport and away from the general public. The site should consider intended volumes to be received, connection to utilities and environmental impacts (groundwater and surface water).
3. **Technology and vendor selection:** Available feedstock and site requirements will determine the technology and scale. Putrescible liquid materials tend to favour anaerobic digestion while solid materials tend to favour composting.
4. **Business case:** The viability of the operation must consider capital and operational costs, gate-fees as well as savings in transport, inputs and energy.
5. **Feedstock security and site layout:** Feedstock security must be determined through relationship building or contracts with suppliers. The site layout should consider the available land, the receival of material, processing, maturation and storage of end products.
6. **Planning permits and environmental approvals:** Approvals may be required depending on the state, quantity and type of material to be treated.
7. **Construction and/or installation:** As per the site layout and regulatory requirements.
8. **Labour and equipment:** Purchase equipment consistent with the technology acquired and hire qualified labour.

REFERENCES

Composting

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- Anaerobic Digester/Biogas System Operator Guidebook, US EPA (2020)

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