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Report on

Valorising Apple Pomace

and

Bio-Fertiliser Production

for

Apple and Pear Australia Limited (APAL):

and

Bellevue Orchard

March 2024

Report Title

Valorising Apple Pomace and Bio-Fertiliser Production

Long Title

APAL & Bellevue Orchard Report on the conversion of wet apple pomace to a value-added biofertiliser, using aerobic Rapid Digester Technology supplied by BioNova Pacific

Prepared for

Clients:

Apple and Pear Australia Limited (APAL):

and

Bellevue Orchard

Prepared by:

Written by Primaform Pty. Ltd
Reviewed by Genesis Now (Geoff Andrews)

3 March 2024

Contents

1. SUMMARY

Overview – Bellevue Orchard innovating towards a Circular Economy

Bellevue Orchard places a high priority on improving its environmental performance in a Circular Economy, and the sustainability of the apple and pear juices, and ciders it produces.

Bellevue Orchard produces 1.5 million litres of nutritious juice each year, processing fresh fruit from a number of Australian horticulture operations.

Apples typically contain 50% juice (by mass) and so the juice operation traditionally results in 50% of the apple being wasted, mainly as pulp. In their operations, waste pulp has been sent to a relatively low value end use of animal feed.

Several recent trends provide a strong incentive to improve the sustainability and utilisation efficiency of their juice production operations and include:

- increasing electricity and gas costs.
- the need to transition quickly to renewable energy.
- consumers demanding higher environmental standards and transparency.
- governments encouraging progress toward a circular economy.
- large increases in fertiliser prices and supply uncertainty), increasing production costs and food security.
- multiple 'natural' disasters have destroyed crops or prevented harvesting, putting pressure on food security and prices.
- recent research findings and technology developments revealing the potential to add value to food processing 'waste' and creating the equipment to achieve the value uplift.

The Opportunity

Bellevue Orchard has started to develop and demonstrate a holistic food production and processing environmental upgrade. This will include analysing, trialling and refining the optimal combination of the following initiatives:

- Transforming the waste apple pulp to a rich soil conditioner using the BioNova aerobic treatment system, supplying the soil conditioner to their supplier growers, using the soil conditioner in their own nursery and orchard operations, and testing the effect on plant vitality and fertiliser requirements.
- Adding value to some pulp (in addition to that which is used for soil conditioner production), starting with analysing the technical feasibility and business case for value added products, including:
    - dietary fibre,
    - pectin, and
    - hydrogen.

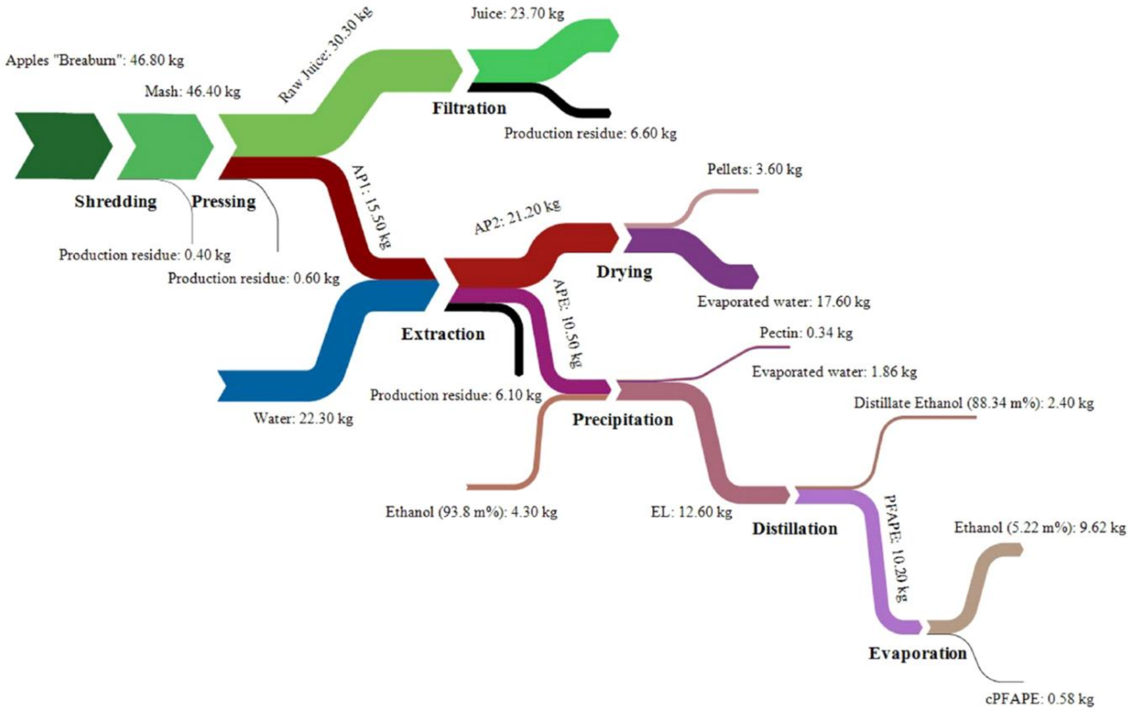

Figure 1 Apple mass balance.

Benefits

Bellevue Orchard aims to achieve significant improvements in the areas of:

- soil health,
- fruit tree productivity,
- greenhouse gas emissions (Scope 1, 2 and 3),
- operating costs,
- waste management, and
- food security.

The company plans to share the knowledge gained with other growers, both their suppliers and the wider industry through Apple & Pear Australia Ltd (APAL).

Apple Pomace waste conversion to a viable bio-fertiliser

Apple pomace waste conversion objectives agreed by the project team of Bellevue Orchard, Genesis Now and Primaform are to:

- Assess the viability of transforming waste apple pomace to a bio-fertiliser using the aerobic BioNova rapid digester technology,
- Assess the potential to supply the bio-fertiliser to their supplier growers,
- Assess the potential for using the bio-fertiliser in their own nursery and orchard operations.

Assessing the viability of transforming apple pomace has included basic chemical analysis by EAL, Southern Cross University and the basic fertiliser quality, with admixing appears to warrant small-scale pot trialling.

Additionally, a biochar admix to the initial fertiliser run is possible, subject to the quality of the bio-fertiliser. A biochar admix will only be tested in the event that the apple pomace substrate proves to have the potential for technical and commercial development.

Ongoing testing, fertiliser trialling and product development will be subject to ongoing funding and grant support.

Budget for converting apple pomace to bio-fertiliser

Following discussions with APAL, Bellevue Orchard was approved by APAL for an industry concept development grant of $6,380 incl GST. The grant enabled an initial investigation into the technical and commercial viability of converting the apple pomace waste from the Bellevue Orchard production lines.

The scope and budget can be adjusted according to further refinement of the goals of Bellevue Orchard and the availability of ongoing project funding and potential grants.

BioNova Pacific has offered to support the initial research phase by loaning a RDT C1 test unit at Bellevue Orchard for a period of 4-6 months and initially providing gratis support advice.

Summary of Project Findings

Apple pomace proved more difficult to process using the BioNova RDT system than mixed vegetable and other food scraps used in the Geelong trial in 2022, which produced a material like coffee grounds on the first attempt. However, pathways forward have been developed to deliver a value added stream for Bellevue Orchard's apple pomace resource including a biofertiliser range, pectin and potentially hydrogen.

The complex and expensive academic/consultant approach ($275-350K budget) - see Appendix D, has been deferred in preference to a more directly targeted 5-10 experiment, self-generated test program. The aim of the concentrated test program is to more rapidly identify product development pathways which can be progressively actioned, with a budget of $35 – 100k.

After initial apple pomace resource testing, Primaform recommends to Bellevue Orchard and the BioNova Pacific teams, that the aerobic BioNova C1 test unit should initially "dry" Bellevue Orchard's apple pomace substrate (high moisture content of 80+%) to a more workable substrate of approx. 55% moisture content, to enable a thermophilic process to occur within the bioreactor.

The test pomace sample after considerable drying in the C1 unit, did not provide the necessary "structure" that would enable the thermophilic digestion process to readily occur. To provide additional structure, a wheaten chaff admix was applied with the objective of forming a more friable, rather than a non-porous clay.

Regardless, the aerobic rapid digester process only partially occurred, and a testable apple pomace resource of chaff-intensive fertiliser was achieved. The amended process yielded a testable sample of approximately 90 l for initial laboratory testing and limited initial pot scale tests.

The base fertiliser warrants further processing, starting with removing the wheaten chaff by fine sieving to obtain a starter fertiliser which has a pH of approximately 4. Further minor admixing could produce a Blueberry fertiliser by admixing lime to a pH of 4.5. Addition of Nitrogenous matter could well produce a tailormade Blueberry fertiliser.

After approval by Bellevue Orchard's CEO, Nick Russo, Primaform forwarded three processed apple pomace samples to EAL, the soil research and testing arm of Southern Cross University, Lismore NSW campus as follows:

- A 72% MC wet production-line sourced apple pomace, and
- A processed and gas-fire dehydrated dry apple pomace
- The BioNova C1 processed wheaten chaff apple pomace mix

The EAL test results provides valuable insights into the chemical characteristics of the samples and enables further fertiliser development, particularly if a microbial evaluation of the admix straw-pomace fertiliser is undertaken.

Despite the three test samples having low pH, CN and NPK ratios, these characteristics may be able to be improved especially with further expert soil research and development inputs.

The existing apple pomace processing resulting in 80+% Moisture Content (MC) can be reduced to approx. 70% MC, if recovered prior to the current end-process which involves high-pressure water injection. Mechanical methods such as compression or pressure screwing, could also assist further moisture content reduction by say 15+%, to yield a moisture content of pomace resource to around 55% MC.

The low pH observed across the three samples could be readily increased to the preferred range of 5.8 – 6.5 more suitable for a fertiliser, by adding an alkaline input such as lime or gypsum prior to the bioreactor process. Biochar admixes generally are alkaline in pH and may also provide a pH balancing effect.

A drier, say 55% MC and balanced pH apple pomace substrate, may still warrant further chemical modification, and admix required for structure, to achieve a range of bio-fertiliser substrates suitable for aerobic RDT processing.

Then there is the option to further value add by co-mixing other feedstocks that add the required structure for a thermophilic process including other select Food Organic Green Organic (FOGO) feedstocks, as well as biochar and /or NPK concentrates.

In summary, the chemical composition of the three samples indicate that the Bellevue Orchard apple pomace will need further chemical, mechanical and microbiological investigation to proceed to a full product development stage.

The main issue is whether it is commercially viable for Bellevue Orchard to produce an output of 500 - 1,000 tonnes / year of fertiliser when the production line development is completed.

The fertiliser market is very complex and has capable, well-funded players nationally e.g. Incitec, along with large international producers in the USA and Russia. In Australia there are a number of well-established tailored fertiliser providers including Campbells, Neutrog, and Gibsons Groundspread.

Recommended Next Steps

Apple pomace digestion warrants designing a set of experiments, to refine a more targeted and efficient research development the process.

The next processing steps are not to be complex by initially describing the first 5 - 10 runs, analyse results, then decide on the next trial runs.

The digester operation needs to be changed to achieve two main goals:

1. the digestion process works effectively.
2. digestate having properties which make it useful for orchards, etc.

1. requires us to modify structure, so the pomace doesn't clump, and prevent bacteria accessing much of the material.
This could be a combination of:

- moisture content (initially mixing fresh moist pomace with pomace from the dehydrator, then once the lower moisture content is proven to work, modifying the MC of fresh pomace to achieve the same MC).
- adding material such as cardboard, or biochar.
- pH, so the bacteria thrive.
- Feedstock "structure" to be friable and not clay-like and impenetrable, to pick-up the benefits of the BioNova enzyme system

2. requires work on:

- pH
- C-N ratio.
- NPK ratio

It is recommended that the Next Steps in product development focus on delivering results in-house, at minimal expense and with initial minimal consultant input and expense.

There seem to be three quick options to proceed forward and get to the stage of being able to undertake initial small pot trials on a range of seeds starting with;

- A Blueberry fertiliser (low pH fertilisers assist Blueberry growth) – a BVO produced fertiliser could likely be achieved by fine sieving the existing 7 x 20 l. buckets of straw pomace digestate into say 10-20 litres of fine fertiliser feedstock, testing approx. 300 mg. of BVO fertiliser that enable further simple pH, N, C etc amendments to requirements to for a resulting tailored fertiliser.
- An apple fertiliser (pH of approx. 6.8) – a BVO produced fertiliser could be initially produced by continuously feeding the existing wet pomace (having 80+% Moisture Content (MC) reduced to approx. 55% MC either by slow dehydrating the wet pomace in the C1 over 2 days, or drying outside an initial wet pomace batch of say 250 l., then loading the C1 with the approx. 55% MC pomace, followed by Geoff Andrews seeding the BioNova enzyme system, and then loading the C1 with wet pomace progressively and then modifying the NPK, C/N ratios after the low % BVO fertiliser is produced according to tailored needs. This approach may benefit by either having Pectinase added to provide a more friendly structure for the BioNova enzyme system to activate, or admixed materials may assist (NR & GA to discuss)

- A biochar – apple pomace-based fertiliser (admixing biochar's high 7-11 pH with apple pomaces low 4 pH) could assist solve the MC, pH and structure issues if mixed prior to BioNova wet pomace processing. This material could also be tailor made to suit a variety of agriculture / horticulture applications and should attract a premium value.

  Initial tests can be simply undertaken at benchtop scale.

It is considered that the order of priority should be to start with the easiest and quickest which is the Blueberry apple pomace solution where Bellevue Orchard has base product in hand (8 X 20 l buckets of straw based digestate on hand) which simply require fine sieving to a coffee grounds like texture.

Parallel to Blueberry Apom fertiliser for small-scale pot testing, Bellevue Orchard can also readily proceed with the Apple pomace solution which could readily yield sufficient fertiliser to deliver a Biochar-Apom product, all offering small scale pot trial options with aligned agriculture / horticulture needs.

The key to success is the careful logging of input/outputs as we proceed which should be built-up progressively on-line, with all of the above providing considerable potential environmental and commercial benefits.

2. TEAM, PROCESS & METHODOLOGY

Project Team overview

APAL (Vic) – The Victorian branch of Apple and Pear Australia Limited, a horticulture industry peak organisation for the Australian apple & pear industry, and biodigester project funding grantor: see www.apal.org.au

Bellevue Orchard Pty Ltd - A medium scale Australian family-owned company, based in Officer, Victoria that has over 70-years' experience in successfully developing Horticulture and Beverage businesses: see www.bellevueorchard.com.au

BioNova Pacific Pty Ltd – The ANZ & Oceania distributor of the BioNova International (Sweden) technologies: see www.bionovapacific.com.au

Genesis Now –Project review and development advisory: see www.genesisnow.com.au

Primaform Pty. Ltd. – shareholder in BioNova Pacific and contracted to Bellevue Orchard to project manage the initial research into the potential to convert apple pomace to a biofertiliser using an aerobic BioNova RDT C1 test unit. Primaform is to provide a summary report on the initial research stage of the BioNova RDT C1 process and supporting laboratory tests by EAL, a division of Southern Cross University, Lismore NSW

BioNova International's previous experience in apple substrate conversion

BioNova International's founder, Lars Ebertsson advised his Australia colleagues in BioNova Pacific that the aerobic processing of whole fresh apple waste by a BioNova RDT system, had successfully converted apple substrate into a potential soil productivity enhancer: in effect, a biofertiliser.

However, the apple pomace used as a substrate for conversion at Bellevue Orchard has a very different moisture content and structure to the fresh apple processed in 2005 by BioNova International.

The main requirement for successful biomass conversion using the BioNova RDT technology is that Moisture Content of the substrate is ideally between 40-60%, and has an appropriate structure i.e. having the presence of fibre and micro air pockets to enable a catalytic enzyme reaction with apple pomace.

The right balance of moisture content and structure of the apple pomace encourages a naturally induced thermophilic bacterial process to occur.

The bacterial breakdown of the waste substrate substantially reduces the amount of heat power required to enable the “heating” reduction of the pomace to a potential value-added biofertiliser

It was noted that Moisture Content range could range between 30-70% by modifying the fibrous nature of the input organic substrate with moisture-absorbing and fibrous materials e.g. newspaper, shredded cardboard or dry mulched straw such as fine chaff.

Process -Technology selection

The search for a potential solution to commercially converting apple pomace waste produced at the Bellevue Orchard cider production line facility began by selecting a suitable FOGO technology.

Primaform’s experience with the proven aerobic BioNova RDT system provided one technically viable option. The aerobic BioNova RDT system was developed over 25 years by Lars Ebertsson, Sweden and was distributed throughout the EU, and recently in the USA, as a viable conversion technology to convert Food Organic Green Organic (FOGO) wastes – see **Appendix A**

The BioNova aerobic process is enhanced by a researched biological treatment of the biomass substrate – approved Enzymes provide a thermophilic reaction at approx. 70°C to thermo-efficiently convert FOGO and biosolids into valuable outputs.

The BioNova process enhances Microbial activity in the processed digestate and provides an important value adding benefit by enhancing soil productivity and consequent plant growth.

In summary, the aerobic BioNova RDT system generally offers competitive advantages over other FOGO processing technologies such as composting, dehydration and anaerobic biomass conversion.

Research and Emissions reductions opportunities

- Irish Government growth trials with Teagasc[1] produced excellent results – see the BioNova and Soil mixture on the right of the below image.
- Central Queensland regional waste research held research into feedstock conversion rates.
- Potential for R&D Value-Adding - by integrating with new technologies or generate “value added” waste streams.
- Potential to R&D a range of high value Biochar admixes with an aerobically converted apple pomace.
- Potential to have the fertiliser end-product certified as a Carbon Reduction solution.

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[1] Teagasc | Agriculture and Food Development Authority, https://www.teagasc.ie The Irish state agency providing research, advisory and education in agriculture, horticulture, food and rural development.

Initial feedstock and fertiliser testing

Adding value to a viable apple pomace substrate pulp starts by having a chemical and toxin assessment of the substrate, recognizing that this test alone does not provide a dynamic view of the potential for microbial generation essential for soil health and productivity.

The product development stage anticipated to follow the initial approved test and trial stage will warrant an initial assessment of production engineering solutions and estimates, feasibility and business case delivery.

Test Process overview

The initial aerobic conversion process applied to the waste apple pomace was based on creating a thermophilic reaction in the BioNova C1 RDT test unit based at Geelong. It was decided to temporarily relocate the C1 unit from Geelong to Bellevue Orchard, Officer anticipating the opportunity for ongoing apple pomace product development using the aerobic process.

However, Primaform encountered digester conversion difficulties within 4 hours of starting the apple pomace conversion process, discovering that the excess moisture content (over 80% MC) was unlikely to assist in developing a thermophilic reaction.

Primaform recommended to the client and the BioNova team, that the C1 test unit should initially "dry" the substate to a more workable substrate to enable a thermophilic process to occur within the bioreactor. The drying process was achieved by using the C1 unit's ability to dehydrate the substrate at temperatures over 160°C.

The amended process was assisted by the addition of wheaten chaff to reduce the MC of the substrate being processed, thus potentially enabling a thermophilic reaction in time.

At this point, a target of 50% MC was set by Lars Ebertsson, as a prerequisite to enable a possible thermophilic reaction, but the MC was only reduced to 65%, with further drying time and the addition of wheaten chaff at a 1:4 ratio to the pomace substrate.

Subsequently, after further trialling over 4 days, a chaff-intensive fertiliser was achieved yielding a testable sample of approximately 90 litres for initial laboratory testing and possibly limited initial pot scale tests if the fertiliser is considered of use.

It was considered that additional laboratory testing of comparative samples of both a production line derived wet pomace (approx. 72% MC), along with a prior gas-fired dehydrated dry sample of apple pomace, could yield useful results.

Primaform forwarded three processed apple pomace samples to EAL, the soil research and testing arm of Southern Cross University, Lismore NSW campus:

- A 72%MC wet production-line sourced apple pomace, and
- A processed and gas-fire dehydrated dry apple pomace
- The BioNova C1 processed dry wheaten chaff apple pomace mix

The objectives of the EAL tests were to obtain a chemical and potential toxicity profile of the range of possible substrate sources of apple pomace produced at Bellevue Orchard's production lines - see **Appendix B, for extracts of EAL samples report.**

EAL were selected as a NATA[2] ranked soil specialist, and the preferred soil analyst for the Biochar industry organization, ANZBIG[3]. ANZBIG's members provide multiple pathways forward to assist Bellevue Orchard develop premium bio-fertiliser with one senior member of the group prepared to assist Bellevue Orchard on its biofertiliser development journey.

Attached is a summary of the process undertaken at Bellevue Orchard to yield a testable form of the wet apple pomace as a potential bio-fertiliser - see **Appendix C, for the aerobic BioNova RDT Process undertaken at Bellevue Orchard Oct. 2023.**

3. TEST RESULTS

EAL Test Results - Summary

Refer to Appendix B for extract of the three apple pomace Test Results

Test result comments

EAL advised that determining whether the tested samples suitability as a potential quality fertiliser product could not be indicated by the NPK and C chemical availability, ratios and toxin tests alone - a full understanding of the potential for apple pomace as a fertiliser needs a complementary microbial generation assessment of the converted pomace.

Further, the chemical test approach alone does not capture some of the more dynamic relationships possible with comprehensive soil and microbial analysis – preferably the chemical and microbial regime investigations should be supported initially by small -scale test trials and possibly small-scale plot trials.

The opportunity for gaining a number of additional value streams was in admixing with other feedstocks , concentrates and especially with Biochar to potentially include valuable Carbon Certificates.

A general consensus on the three samples varied between three consultants but the general consensus follows;

[2] National Association of Testing Authorities. https://nata.com.au/
[3] Australia New Zealand Biochar Industry Group. https://anzbig.org/

pH – very low, and needs modifying by alkalising to a more neutral range of 5.8-7.0

N, P, K – chemical content not ranked highly, with the N content being considered low by 2 consultants.

N-P-K ratio - requires further discussion and likely modification if apple pomace used a substrate and is site specific to be a designed effective fertiliser application

Carbon – good carbon content but one consultant stated that the apple pomace warrants further investigation if the substrate is to be pyrolised for a biochar output

Minerals – good mineral content but needs further investigation as micro - nutrient benefits are site-specific.

Heavy Metals – content well within recommended safety levels in AS4454-201, but need further investigation

Pathogens – very low level of pathogens e.coli, faecal coli. and nil salmonella

One consultant recommended that “Available vs Total Nitrogen” requires further Investigation.

4. RECOMMENDATIONS

Options: aerobic, compost, dehydrate, pyrolysis

Ongoing Biofertiliser Product Development - Options

- Modifying the structure and chemical composition of the wet pulp substrate at 80% MC and 70% MC.
- Potential for mixing in other drying agents or mechanical processes to enable the enzymes to generate a thermophilic reaction. The structure of the mix into the biodigester requires increased structure and decreased moisture content.
- Potential to add biochar (2 types – frass and standard) to both the bio-digestate product and separately with the dehydrated dry pomace.
- Pot scale tests (initially with fast growing grasses or Blueberries then Apple seeds/established)

5. APPENDICES

Appendix A – Summary of BioNova RDT system advantages

The BioNova RDT solution - A cost, time and space effective technology to solve the problem of efficiently converting FOGO and Biosolids/Manures to value added products.

C1 – C50 Series

1,000 – 50,000 litres/week feedstock

XL1-XL5 Series (to be released in 2023)

5,000-25,000 tonne/annum feedstock

The above C & XL series offers a comprehensive range of biomass conversion technologies that suit multiple purposes. Installations and commissioning can be achieved within 2-5 days and generally offer minimum interruption to a customer's operations while installation occurs.

BioNova aerobic system advantages include:

- Machines can be fully automated with continuous output, no double handling and low energy requirements.
- Short Processing time - 24 hours
- Waterless process -Valuable water is not required and minimal waste-water produced.
- Waste volume & weight reduced by 70% to 90% within 24hrs.
- Combined mechanical and biological process ensures the complete breakdown of organic material, into a potential valuable output, including potentially a microbially enriched bio-fertiliser.
- Savings compared with current transport methods and business models.
- Energy Savings - Enzymes create 30% of the heat required by generating a thermophilic reaction
- Renewable energy systems can be readily integrated offering a modular off-grid energy solution
- No CH_4 emissions & possible CO_2 credits available particularly when admixed with Biochar
- No rodents or smells unlike windrow composting/anaerobic practices

- A range of complementary Feedstocks are available - All food wastes, cardboard or paper, some garden wastes and clippings when shredded, Cat 3 meat products, biosolids and others. The added feedstocks can provide additional nutrients, minerals and assist microbial activity when a bio-fertiliser.
- Quality Biomass output – safe, pathogen-free; good, healthy enzymes, use as a soil conditioner, or value add into biofertiliser to generate microbial activity in soils.
- Software Adaption – option to have a remotely monitored & controlled system.
- No new CO_2 is released during the process, so that all gases harmful to the atmosphere are stored in the digestate. This makes it a boost to Anaerobic Digestion or Pyrolysis processes, allowing 3-5 times more bio-gas production

Appendix B - Summary of EAL samples report

COMPOST 'TOTALS' ANALYSIS REPORT

Three samples supplied by Primaform on the 23 October 2023. Lab Job No. P6692.

Analysis requested by Peter Young. **Your Job: BVO-T1**.

		Sample 1	Sample 2	Sample 3	
	Product Name:	Pomace - Wet	Pomace - Dry	Digestate	***Guideline***
	Product Type:	Apple Pomace	Apple Pomace	Digestate	*AS4454:2012 Composted Product*
	Manufacturing Site:	BVO	BVO	BVO	
	Manufactured Date:	17/10/2023	17/10/2023	17/10/2023	
	Test Applicable:	CA-PACK-020	CA-PACK-020	CA-PACK-020	
Parameter	**Method Reference**	**P6692/1**	**P6692/2**	**P6692/3**	
Moisture Content (%)	**Inhouse S2 (105°C)	80	24	21	*> 25*
pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	3.55	4.03	3.94	*> 5*
Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	2.82	1.86	2.77	*< 10*
Chloride (mg/kg)	**Rayment & Lyons 2011 - 5A3a	105	..	..	..
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	49.6	47.9	44.8	*≥ 20*
Total Nitrogen (%)		1.05	0.74	0.84	*≥ 0.8*
Carbon/Nitrogen Ratio	**Calculation - Total Carbon/Total Nitrogen	47	64	53	..
Estimated Organic Matter (% OM)	**Calculation - Total Carbon x 1.7	84.3	81.4	76.1	..
Total Calcium (%)	Rayment & Lyons 2011 - 17C1 Aqua Regia Total Salts	0.15	0.10	0.27	..
Total Magnesium (%)		0.10	0.08	0.09	..
Total Potassium (%)		0.99	0.86	0.88	..
Total Sodium (%)		0.01	<0.01	0.04	*< 1 Na*
Total Sulphur (%)		0.08	0.06	0.08	..
Total Phosphorus (%)	Rayment & Lyons 2011 - 17C1 Aqua Regia	0.16	0.10	0.12	*≤ 0.1 P*

Total Zinc (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia Total Metals	10.4	6.77	15.8	*< 300 Zn*
Total Manganese (mg/kg)		15.9	7.27	27.9	..
Total Iron (mg/kg)		879	340	494	..
Total Copper (mg/kg)		5.10	3.75	4.91	*< 150 Cu*
Total Boron (mg/kg)		35.2	54.5	30.2	*< 100 B*
Total Silicon (mg/kg)		836	568	1,137	..
Total Aluminium (mg/kg)		344	<50	537	..
Total Molybdenum (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia Total Metals	<1	<1	<1	..
Total Cobalt (mg/kg)		<1	<1	<1	..
Total Selenium (mg/kg)		<1	<1	<1	*< 5 Se*
Nitrogen/Sulphur Ratio	**Calculation - Total Nitrogen/Total Sulfur	13.7	12.5	10.7	..
Nitrogen/Phosphorus Ratio	**Calculation - Total Nitrogen/Total Phosphorus	6.7	7.7	7.1	..

Nitrogen/Potassium Ratio	**Calculation - Total Nitrogen/Total Potassium	1.1	0.9	1.0	..
Total Cadmium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia Total Heavy Metals	<0.5	<0.5	<0.5	*< 1 Cd*
Total Lead (mg/kg)		<1	1.20	1.47	*< 150 Pb*
Total Arsenic (mg/kg)		<2	<2	<2	*< 20 As*
Total Chromium (mg/kg)		2.78	<2	9.93	*< 100 Cr*
Total Nickel (mg/kg)		1.00	<1	2.79	*< 60 Ni*
Total Mercury (mg/kg)		<0.1	<0.1	<0.1	*< 1 Hg*
Total Silver (mg/kg)		<1	<1	<1	..
Salmonella spp (Absent in 25 g)	Sub** - Symbio Laboratories B1411608 (M16.1 AS 5013.10)	ND	..	..	*Absent in 25 g*
E. coli (MPN/g DW)	Sub** - Symbio Laboratories B1411608 (M8.3 AS 5013.15)	<3.0 ND	..	..	*< 100 MPN/g*
Faecal Coliforms (MPN/g DW)		<3.0 ND	..	..	*< 1000 MPN/g*

Notes:

1. All analysis is dry weight – Samples reported on an oven dried basis at 105˚C (testing conducted on finely ground sample dried at 40˚C).
2. Methods from Rayment and Lyons, 2011. Soil Chemical Methods - Australasia.CSIRO Publishing: Collingwood.
3. Indicative guidelines are based on those in AS4454:2012 for a composted product.
4. Total Acid Extractable Nutrients indicate a store of nutrients.
5. Conversions for 1 mg/kg = 1 ppm; 1 % = 10,000 ppm
6. Conversions to kg/ha = mg/kg x 2.24
7. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
8. < LOR Less than limit of reporting. ND Not detected. NA Not applicable. NR Not required.
9. Testing completed in a NATA accredited laboratory.
10. Analysis conducted between sample arrival date and reporting date.
11. This report is not to be reproduced except in full. Results only relate to the item tested.
12. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer HYPERLINK "https://www.scu.edu.au/media/scueduau/eal/documents/EAL-Laboratory-Services-Terms-and-Conditions-FINAL.pdf"SCU.edu.au/eal/t HYPERLINK "https://www.scu.edu.au/media/scueduau/eal/documents/EAL-Laboratory-Services-Terms-and-Conditions-FINAL.pdf"& HYPERLINK "https://www.scu.edu.au/media/scueduau/eal/documents/EAL-Laboratory-Services-Terms-and-Conditions-FINAL.pdf"cs HYPERLINK "https://www.scu.edu.au/media/scueduau/eal/documents/EAL-Laboratory-Services-Terms-and-Conditions-FINAL.pdf" or on request).
13. This report was issued on 6/11/2023.

Quality Checked:
Brian Smith
Compost & Landscape Soils Co-ordinator

COMPOST 'AVAILABLES' ANALYSIS REPORT

Parameter		Method reference	Sample 1	Sample 2	Sample 3
		Product Name:	Pomace - Wet	Pomace - Dry	Digestate
		Product Type:	Apple Pomace	Apple Pomace	Digestate
		Manufacturing Site:	BVO	BVO	BVO
		Manufactured Date:	17/10/2023	17/10/2023	17/10/2023
		Test Applicable:	CA-PACK-020	CA-PACK-020	CA-PACK-020
Parameter		**Method reference**	**P6692/1**	**P6692/2**	**P6692/3**
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	812	273	1059
Soluble Magnesium (mg/kg)			688	432	603
Soluble Potassium (mg/kg)			6803	5264	5935
Soluble Phosphorus (mg/kg)			813.4	541.9	643.0
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	688.1	425.6	729.7
		**Rayment & Lyons 2011 - 9B2 (Colwell)	668	468	642
		**Inhouse S3A (Bray 2)	678	464	763
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	4.1	3.8	5.7
Ammonium Nitrogen (mg/kg N)			180.1	320.4	90.1
Sulfur (mg/kg S)			98	284	162
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	3.6	4.0	3.9
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	2.822	1.862	2.772
Estimated Organic Matter (% OM)		**Calculation - Total Carbon x 1.7	84.3	81.4	76.1
Exchangeable Calcium	**(cmol$_+$/kg)**	Rayment & Lyons 2011 - 15D1 (Ammonium Acetate)	1.42	0.98	3.52
	(kg/ha)		639	440	1580
	(mg/kg)		285	196	705
Exchangeable Magnesium	**(cmol$_+$/kg)**		1.63	1.57	1.58
	(kg/ha)		444	427	431
	(mg/kg)		198	190	192
Exchangeable Potassium	**(cmol$_+$/kg)**		2.21	2.76	1.73
	(kg/ha)		1935	2416	1514
	(mg/kg)		864	1079	676
Exchangeable Sodium	**(cmol$_+$/kg)**		<0.065	<0.065	0.10
	(kg/ha)		<33	<33	49
	(mg/kg)		<15	<15	22
Exchangeable Aluminium	**(cmol$_+$/kg)**	**Inhouse S37 (KCl)	0.17	<0.01	3.02
	(kg/ha)		34	<1	609
	(mg/kg)		15	<1	272
Exchangeable Hydrogen	**(cmol$_+$/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	14.11	9.59	5.07
	(kg/ha)		316	215	114
	(mg/kg)		141	96	51
Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation - Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	19.6	14.9	15.0
Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	7.3	6.6	23.4
Magnesium (%)			8.3	10.5	10.5
Potassium (%)			11.3	18.5	11.5
Sodium - ESP (%)			0.3	0.2	0.6
Aluminium (%)			0.9	0.0	20.1
Hydrogen			72.0	64.3	33.8
Calcium/Magnesium Ratio		**Calculation - Calcium	0.9	0.6	2.2

		/ Magnesium (cmol+/kg)			
Zinc (mg/kg)		Rayment & Lyons 2011 - 12A1 (DTPA)	9.1	17.7	19.1
Manganese (mg/kg)			13.0	32.4	46.3
Iron (mg/kg)			184	139	175
Copper (mg/kg)			3.8	9.2	8.1
Boron (mg/kg)		**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	23.6	42.1	16.1
Silicon (mg/kg Si)		**Inhouse S11 (Hot CaCl2)	121	40	435
Total Carbon (%)		Inhouse S4a (LECO Trumac Analyser)	49.56	47.89	44.77
Total Nitrogen (%)			1.05	0.74	0.84
Carbon/Nitrogen Ratio		**Calculation - Total Carbon/Total Nitrogen	47.4	64.3	53.2
Notes:					
1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.					
2. Methods from Rayment and Lyons, 2011. Soil Chemical Methods - Australasia.CSIRO Publishing: Collingwood.					
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).					
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.					
5. Guidelines for phosphorus have been reduced for Australian soils.					
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.					
7. Total Acid Extractable Nutrients indicate a store of nutrients.					
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centres,					
preschools, primary schools, town houses or villas' (NSW EPA 1998).					
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your test results'.					
10. Conversions for 1 cmol+/kg = 230 mg/kg Sodium, 390 mg/kg Potassium,					
	122 mg/kg Magnesium, 200 mg/kg Calcium				
11. Conversions to kg/ha = mg/kg x 2.24					
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate					
13. < LOR Less than limit of reporting. ND Not detected. NA Not applicable. NR Not required.					
14. Testing completed in a NATA accredited laboratory.					
15. Analysis conducted between sample arrival date and reporting date.					
16. This report is not to be reproduced except in full. Results only relate to the item tested.					
17. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer HYPERLINK "https://www.scu.edu.au/media/scueduau/eal/documents/EAL-Laboratory-Services-Terms-and-Conditions-FINAL.pdf"SCU.edu.au/eal/t HYPERLINK "https://www.scu.edu.au/media/scueduau/eal/documents/EAL-Laboratory-Services-Terms-and-Conditions-FINAL.pdf"& HYPERLINK "https://www.scu.edu.au/media/scueduau/eal/documents/EAL-Laboratory-Services-Terms-and-Conditions-FINAL.pdf"cs HYPERLINK "https://www.scu.edu.au/media/scueduau/eal/documents/EAL-Laboratory-Services-Terms-and-Conditions-FINAL.pdf" or on request).					
18. This report was issued on 6/11/2023.					
Quality Checked: Brian Smith					
Compost & Landscape Soils Co-ordinator					

Appendix C – Summary of the BioNova aerobic RDT process

Conducted at Bellevue Orchard, October 2023

Summary of the processes undertaken at Bellevue Orchard to produce a potential form of fertiliser from wet apple pomace. Please note that Primaform has supporting field notes and 126 images that provide a visual record of the processes.

Observations and Comments

- There were processing issues with wet pomace substrate due to the high moisture content and the structure/cohesive nature of wetted pulp from the extruded pomace source. This was noted during initial processing after the original substrate load was placed in the BioNova C1 bioreactor at 9 a.m. on Thursday 5-10-23
- The high moisture content (MC), approximately 80%+, in the substrate (wet apple pomace), well exceeded the recommended 40-60% MC preferred range for aerobic processing. BioNova advise that a MC range 30-70% is possible, subject to the substrate structure's density and porosity.
- We note the apparent high Pectin and Malic acid content of the apple pomace and the dense fibrous nature of the wet pulp provided as the substrate.
- Very dense apple pomace structure limits any penetration/distribution of enzymes into the substrate thus limiting the thermophilic reaction required to assist the aerobic RDT transforming the substrate into a potential biofertiliser.
- The recommendation to proceed with the testing for the nutrient and chemical composition of the wet pomace was adopted. Primaform expected that the BioNova C1 processing of the wet pomace would still yield a potential biofertiliser for testing particularly the NPK and C chemical profile (essential for improving soil productivity).
- To assist the wet pomace structure absorb the excess moisture, a drying agent of wheaten chaff was introduced on Monday 9/10/23 at a volume ratio of 4:1 adding slight modification to the relative density of wet pomace and chaff. The pomace substrate with added chaff recommenced processing in the C1 on Wed. 11-10-23, by adding a second batch of enzymes.
- Consequently, the C1 unit appears to have acted as a dehydrator, with the C1 RDT system being inefficient in this role.
- The result is a potential biofertiliser product that was considered by Primaform to warrant limited testing. Primaform further recommended limited testing of a biosolid form of previously dehydrated pomace. Primaform recommended more comprehensive testing of the wet pomace substrate as more useful information for Bellevue Orchard.
- Approval to test the three samples was given by Bellevue Orchard, Friday 20-10-23.
- The three potential biofertiliser samples were forwarded to EAL , Southern Cross University on Friday 20-10-23 with test samples due for arrival at the Lismore, NSW laboratory on Monday 23-10-23.

Summary of Tests Conducted

Lab tests on three apple pomace samples were conducted by EAL, Southern Cross University:

- Untreated, wetted Apple pulp
    - CA-PACK-020 – Total & available Nutrients plus Heavy Metals
    - SS-PACK-059 - Pathogens
    - SS SING-038 – Chloride-soluble

- Biosolid form of previously dehydrated pomace
    - CA-PACK-020 – Total & available Nutrients plus Heavy Metals

- Final output from the Left Hand chamber of the BioNova C1
    - CA-PACK-020 – Total & available Nutrients plus Heavy Metals

CA-PACK-020	**Compost Total and Available Nutrients plus Heavy Metals** Includes Moisture, pH, EC; TC, TN, TC/TN Ratio, Organic Matter; Total (Ca, Mg, K, Na, S, P, Zn, Mn, Fe, Cu, B, Si, Al, Mo, Co, Se, Cd, Pb, As, Cr, Ni, Hg, Ag; Soluble (Ca, Mg, K, P), Dissolved (NH_4, NO_3, S); Exchangeable (Ca, Mg, Na, K, H, Al, ECEC); Bray I and II Phosphorus; Colwell Phosphorus; Available Micronutrients (Fe, Cu, Mg, Zn, B, Si); TC, TN, TC/TN Ratio, Organic Matter. Note: 300 g of sample is required.	$231.00	$254.10

SS-PACK-059	**Pathogens** Includes Moisture, Ecoli, Faecal Coliforms, Salmonella.	$147.00	$161.70

SS-SING-038	**Chloride - Soluble**	$31.50	$34.65

Supporting Assessments undertaken by Primaform in October, 2023.

Density Assessment of two samples assessed– Refer to Field Notes

- Untreated, wetted Apple pulp
- Wheaten chaff

Moisture Content of wet pomace during processing assessed– Refer to Field Notes

- S1 - Granny Smith apples untreated, wetted pulp – ex-pile
- S2 - Pulp standing 3 days – de-airing
- S3 - Pulp standing 3 days processed 36+ hours in biodigester - temperature test
- S4 - Granny Smith – off-press - untreated, unwetted pulp
- S5 - 36 hr process with added wheaten chaff – S3 + chaff
- S6 – Pulp + wheaten chaff – pre-digester
- S7 - Pulp + wheaten chaff – processed- Final Output

Appendix D – Next Steps

Potential next steps to proceed with BVO bio-fertiliser plus development :

- **Amendments required to produce a suitable Apple-pomace substrate for bio-fertiliser plus production**

	Amendment Target	**Possible Solutions**
Low pH ie high acidity	pH at 3.9 to 6.5	lime/dolomite/ashes
High moisture content	80+ % to 55 %	screw compress, dry, admixes
Substrate structure	clay to friable	protein rich ashes
High CN ratio and low N content	CN ratio 50 to 22	add protein admix
NPK ratio	confirm 4:3:2 seed	recommend nutrient admixes
(Based on Neutrog Rapidr. & Seam.)	confirm 4:1:1.5 estab.	recommend nutrient admixes

- **Optional Consultant list**

Consultant options include – Dr. Mary Cole (Agpath), Dr. Ash Martin (Microbe Labs Australia – MLA), Dr. Sally Bound (UTAS), Dr. Vito Butardo (Swin. U), Barry Smith (EAL-U of Southern Cross)

3. Microbelabs Australia services summary

3.1 **Bio-prospecting** – Microbelabs Australia (MLA) can find the right microbes for a client's application through screening environmental samples for novel strains or selecting from MLA's in-house library of agricultural and environmental microbes.

A typical screening process includes:

- Initial Consulting to understand BVO's specific needs ($2,000)
- A professional, detailed project plan developed in consultation with BVO
- Isolation of target microorganisms from relevant environments
- Screening of microorganisms to select effective strains
- Laboratory-scale multiplication
- Laboratory scale demonstration of efficacy

3.1.1. Investment Estimated investment: $29,990 - 59,990 per solution (depending on the application) **Process Not required**

3.2 **Organic Fertiliser Product Design** – customised, fit-form-purpose design of products that meet your and your customers' needs; using MLA's extensive experience in designing, improving, recommending and using fertiliser products, to develop a customised, fit-for purpose fertiliser product to BVO, and its customers', needs. MLA to consult with BVO to determine the right characteristics of the product, the specifications of any raw materials and other inputs, and design a fit-for-purpose production system that produces a high quality, desirable, and consistent product that can be scaled up to commercial production.

Practical and economic constraints recommendations by MLA will include:

- Agronomic requirements and benefits
- User requirements and practicality
- Market demand and gaps
- Production economics and footprint
- Supply chain and transport to market

Using the prototype production system, MLA produce a prototype product that can be tested in a Standardised Product Evaluation (see 5.3), field trial, or both.

3.2.1. Investment Estimated investment $5,000 to 15,000 per prototype (depending on your requirements) **Provisional Budget - $25,000**

3.3. Standardised Product Evaluations Microbe Labs' Standardised Product Evaluation (SPE)-

Usees a bioassay under standard, controlled conditions to measure the effect of products and practices on soil microbiology and plant growth.

The SPE includes:

- A professional, detailed project plan developed with the client
- Two standardised soils (acid and alkaline) with moderately low fertility
- BVO's choice of crop, plant, pasture, etc.
- Soil microbiology status (Microbe Wise)
- Shoot dry weights
- Comparison to several generic conventional fertilisers

The bioassay is replicated to ensure statistical certainty of the results, which are presented in a professionally produced report.

3.3.1. Investment From $5,990 (one product evaluation) **Provisional Budget - $6,000**

3.3.2. Options MLA can also measure and report the following options:

- Yield
- Optimal application rates (using 3 different rates)
- Comparison products not covered in our generic database
- Nutrient concentrations
- Nitrogen (N) and phosphorus (P) use efficiency
- Soil carbon cycling
- Many other options as requested

Investment: From $2,490 per option per product treatment, plus any design costs.

Provisional Budget - $20,000

3.4. Quality Assurance

A major objective for BVO is to maintain desired biological, chemical and physical properties over time, due to variations in feedstocks and other factors. BVO to manage these variations have a major advantage over those biofertiliser competitors that can't, which becomes evident in greater customer satisfaction, repeat sales and word-of-mouth recommendations.

Two key components to quality assurance are:

- Quality standards to which products must conform
- Measurement of parameters related to those Standards.

Microbe Labs to develop for BVO appropriate Standards and implement cost-effective and practical measurements at critical points to guarantee product quality and consistency.

A typical programme consists of:

- Assessing the Situation – an audit of production processes
- Developing the Standards – Codifying the desired biological, chemical & physical properties
- Implementing the Standards – Design and documentation of control processes to ensure compliance with the Standards
- On-site Monitoring tools – Where needed, to help measure critical parameters
- Education and Training – For BVO staff, management and/or customers to help get the best out of your system

3.4.1. Investment Estimated investment: $14,990 **Provisional Budget - $15,000**

3.5. EzyQual

BVO to engage MLA to undertake EzyQual is a short version evaluation that is ideal for regular product quality assurance testing. The BVO Ezy-Qual will test and assess and cost-effectively measure the quality of products for using plant shoot growth and the soil microbial community.

Many biological products have multiple modes of action that can be difficult and expensive to measure, particularly as part of routine quality assurance procedures. Ezy-Qual overcomes these issues by using plant growth, the soil microbial community and visual observation as the ultimate measures of product quality.

The EzyQual evaluation includes:

- Plant germination and early growth
- Root zone microbial community analysis (Microbe Wise for Soil Pro)
- Biomass dry weight
- Other factors (can be customised to suit)

3.5.1. Investment Estimated investment: $749 per product **Provisional Budget - $1,500**

3.6. Education & Training

MLA to develop and deliver to BVO staff a purpose designed education and training packages to benefit the BVO personnel and customers in areas related to products and practices, including:

- Soil microbiology
- Soil health
- How products benefit these areas Education and training can be delivered on or off site, according to requirement.

3.6.1. Transition To Soil Health

MLA to develop and deliver a " Transition To Soil Health" programme to deliver unique value to BVO staff and customers for an introduction to horticulture opportunities and the Circular Economy

3.6.2. Investment Typical Investment: $1,500 to 5,000 plus expenses

Provisional Budget - $7,500

3.7. Microbial Identification

Microbiology to select for BVO appropriate techniques that optimise microbial dynamics to enhance soil productivity and stability.

Briefly, this work will be conducted in two stages:

1. Preparatory work – to assess, for example, microbial levels in your product to determine the correct dilution series to use for screening for target organisms, observe any microbial growth characteristics or problems that may affect the work; and,

2. Identification and quantification work – for example, morphologies that most closely resemble those of the target organisms will be isolated and identified using DNA sequencing, and the number of Colony Forming Units of each of these morphologies will be counted and reported with their identities. Sometimes, stages may overlap or run in parallel to meet your needs or for logistical reasons. **Provisional Budget - $10,000**

3.8. Routine Microbiology Tests

MLA has a supporting range of routine tests that can help growers, agronomists, composters, fertiliser manufacturers, ecologists and government, including tests for:

- Soils
- Composts
- Microbial products
- Fertilisers and soil conditioners
- Waters
- Other materials **Provisional Budget - $10,000**

3.9. Other Synergies

MLA may be able to assist with R&D strategies and grant applications.

- ## Biochar development

Engage Earth Systems to process a batch of say 500 kg of dry apple pomace and test as a commercial biochar in combination with the BVO biofertiliser.

Substrate to be pelletised in 1 cm cubes for biochar batch processing, dry mixed and the admix to be granulated or pelletised as a potential fermigated application.

Trial pot and small plot planting and product testing to be undertaken for a variety of seed/seedling types with a focus on tree scale horticulture.

TO BE CONFIRMED **Provisional Budget - $45,000**

Pectin development

Swinburne University budget to extract pectin- additional grant plus R&D tax support

Edlyn agreement re off-take of pectin (project management and legals)

IP possibility to be assessed

TO BE CONFIRMED **Provisional Budget - $65,000**

Genesis Now Inputs

Project management including reports

TO BE CONFIRMED **Provisional Budget –$47,500**

- ## BNP inputs

C1 processing & testing (3) and lease (6 months)

TO BE CONFIRMED **Provisional Budget –$14,500**

- ## Provisional Budget Summary for Bio-fertiliser Plus Development

		$, excluding GST
3.1. Microbelabs Australia (MLA) Bio-prospecting service	Process not required	
3.2. Organic Fertiliser Product Design		25,000
3.3. Standardised Product Evaluation (SPE)		6,000
3.3.2. Options for MLA to measure and report		20,000
3.4. Quality Assurance		15,000
3.5. EzyQual		1,500
3.6. Education & Training		7,500
3.7. Microbial Identification		10,000
3.8. Routine Microbiology Tests		10,000
Provisional MLA (bio-)fertiliser budget	`	$95,000
4.0. Biochar development-	To be confirmed	45,000
5.0 Pectin development -	To be confirmed	65,000
6.0 Genesis Now Inputs	To be confirmed	47,500
7.0 BNP inputs –	To be confirmed	14,500
8.0 Total Provisional Budget		267,000
9.0 Bellevue Orchard inputs -	To be confirmed	

