AUSTRALIAN MEAT PROCESSOR CORPORATION

FINAL REPORT – Public

Value Adding

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1.0 Abstract

This final report documents the findings of the project "Value Adding" (Project Code 2016.1037). Communications were made with a wide variety of supply chain stake holder companies at the meat processor, raw product manufacturing, bulk commodity, formulation and retail level. Extensive discussions have been held as documented in this final report. This project uncovered a large and unmet demand for biomolecules derived from sourced Australian bovine tissue / blood and that are also manufactured in Australia. Contact was made with a large number of companies that operate within the supply chain including red meat processors, raw product manufacturing (also called value adders or manufacturers) and the "end users" or those groups able to place orders for value added products (including Australian nutraceutical companies and specialty food/commodity suppliers; refer summary below). An industry working group will review findings to date and select biomolecule(s) for further commercial development leading to increasing the demand for Australian derived and manufactured value added products. Commercial development works have been designed to meet the requirements of potential off takers. The short list of biomolecules for which there is interest at the raw product manufacturing and/or retail level are, in approximate order of interest:

[1] Chondroitin Sulphate (CS) - strong existing demand and clear development pathway.

[2] Collagen - suffers from marketing / labelling ambiguity i.e. collagen versus soluble collagen versus hydrolysed collagen versus gelatine.

[3] IgG protein crude extract as a food supplement and for immunity boosting - earlier stages of efficacy / product development; longer term opportunity; by-product from other serum products.

[4] Crude enzyme protein fractions (e.g. pancreatin) – strong international demand for Halal pancreatin, however bovine derived pancreatin is expensive to manufacture and has lower enzymatic activity than porcine and an Australian based manufacturer was not found.

[5] Pure enzymes from pancreas tissue (e.g. trypsin, amylase, lipase) – same limitations as [4] above.

An "Expression of Interest" was conducted as part of Milestone 1/2, with a processor selected as the processor collaborator to work with on this project. The intent is to generate site specific businesses cases, then to further develop the business cases via associated interactions with value adders and retailers / off-takers to document and understand the opportunities.

Budget pricing was sought from manufacturers to produce biomolecules from Australian sourced tissue with simultaneous business cases developed for biomolecules of interest.

The manufacture of biomolecules in Australia is more expensive than in other countries, however an Australian sourced and manufactured biomolecule is able to command a premium of up to approximately 200% compared to biomolecules manufactured in a low cost base country.

2.0 Project Objectives

2.1 Milestone 1

Briefing document summarizing technical and economic review of previous works. A desk-based review of previous technical and economic works. Case studies of potential products were presented. Survey results of stake holders were analysed and to determine technical interest. An "Expression of Interest" briefing document was generated for potential meat processing companies.

2.2 Milestone 2

Milestone 2 encompasses release of an Expression of Interest with associated case studies. Management of responses including interviews. Short listing of businesses willing to engage in the process. An analysis of the supply chain stake holders was completed to understand drivers and to start framing communications with businesses up and down the supply chain.

2.3 Milestone 3

Milestone 3 encompassed an independent cost-benefit analysis (CBA) which required definition of a high level, basis of design to clarify key assumptions of the work such as scale, product purity and quality requirements, and discussion of the suuply chain from a specific site, sent to a specific value then to a specific retailer.

From a meat processors perspective, completion of a more detailed CBA taking into account what would be required at a meat processing facility to capture, segregate, document and transport the feedstock to meet the value adders and retailers requirements. Sensitivity analysis to determine the variables and scenario assumptions that have the greatest impact on the overall economics.

2.4 Milestone 4

Independent reviews of any workshops / bi-partisan discussions. Final Report and Snap Shot

3.0 PROCESSOR SURVEY SUMMARY

This report documents the preliminary works for the investigation into "Value Adding" for Australian abattoirs. An on-line survey was sent to the AMPC membership, with respondents asked to rank a list of 13 value adding opportunities on a scale of 5 (high) to 0 (no interest).
The results from 17 respondents representing 31 facilities were analysed. Of interest was that the lowest score was 53.8% of the maximum possible score and very few (0 or 1) respondents with no interest in the opportunities. Hence it could be concluded that all of the options were of medium to high interest to processors. The top two "Value Adding" opportunities not otherwise being progressed by other AMPC program (e.g. Environment & Sustainability) were:

[1] Frozen organs for export (72% of the maximum score).
[2] High value bioactives from tissue (71.8% of the maximum score).

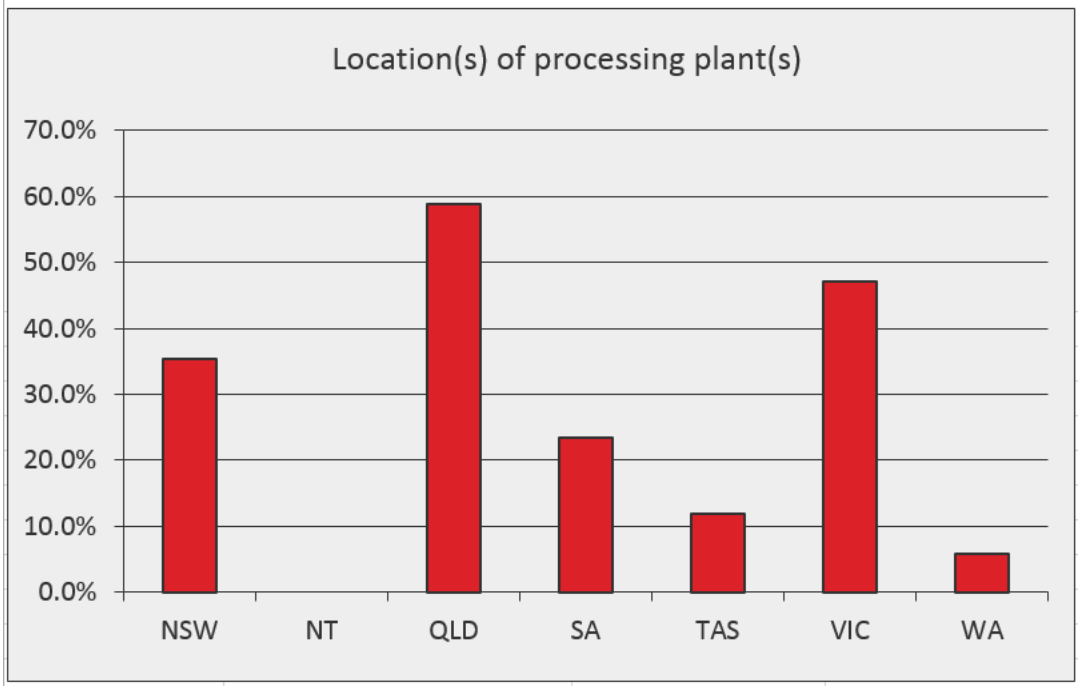
A draft "Expression of Interest" (EoI) request was sent to interested processor. The intent of the EoI was to enable AMPC to select a specific facility to have a businesses cases completed for a specific opportunity, then to further develop the business case via associated interactions with value adders and retailers / off-takers to document and understand the opportunity.

Further, a summary of potential value adding targets completed during Milestones 1 and 2 is presented in Appendix 1.

3.1 Processor Survey Results

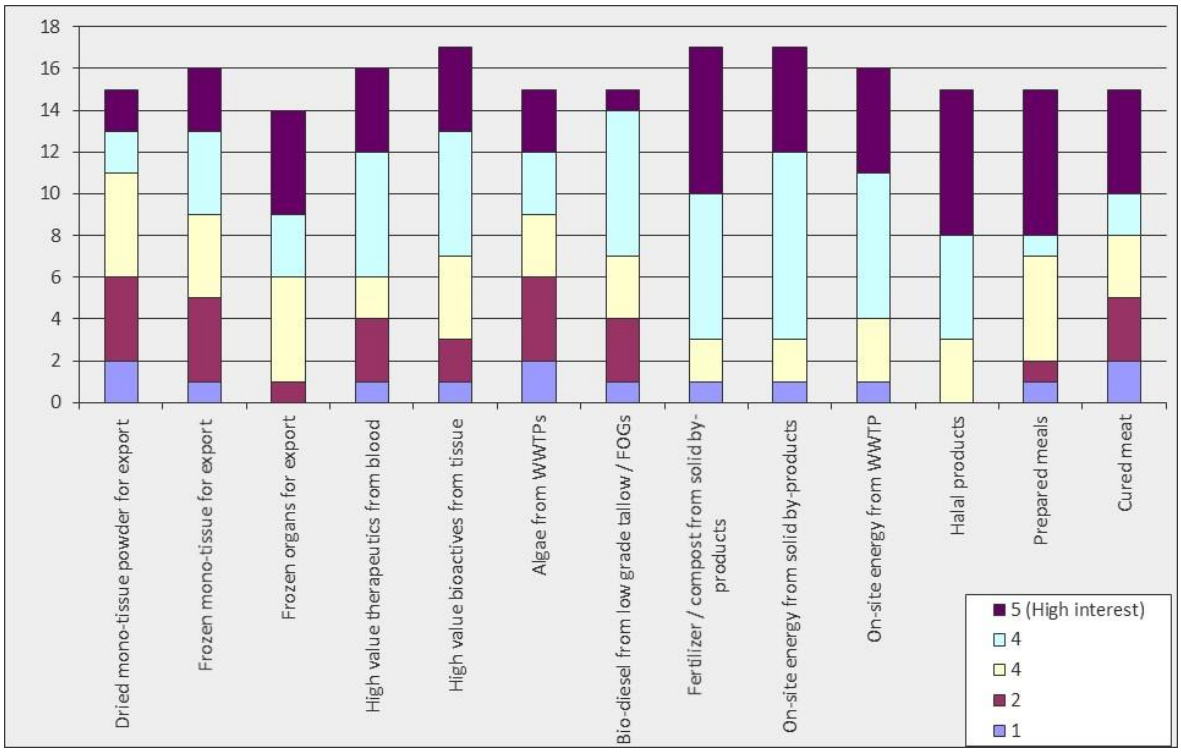
3.1.1 Respondent Location

1. Location(s) of processing plant(s)		
Answer Options	**Response Percent**	**Response Count**
NSW	35.3%	6
NT	0.0%	0
QLD	58.8%	10
SA	23.5%	4
TAS	11.8%	2
VIC	47.1%	8
WA	5.9%	1
	TOTAL:	31



3.1.2 Raw Response Data for Value Adding Options

2. Rate the following "Value Adding Products"							
Answer Options	**5 (High interest)**	**4**	**3**	**2**	**1**	**N/A (No interest)**	**Response Count**
Dried mono-tissue powder for export	2	2	5	4	2	1	16
Frozen mono-tissue for export	3	4	4	4	1	1	17
Frozen organs for export	5	3	5	1	0	1	15
High value therapeutics from blood	4	6	2	3	1	1	17
High value bioactives from tissue	4	6	4	2	1	1	17
Algae from WWTPs	3	3	3	4	2	1	16
Bio-diesel from low grade tallow / FOGs	1	7	3	3	1	1	16
Fertilizer / compost from solid by-products	7	7	2	0	1	0	17
On-site energy from solid by-products	5	9	2	0	1	0	17
On-site energy from WWTP	5	7	3	0	1	0	16
Halal products	7	5	3	0	0	1	16
Prepared meals	7	1	5	1	1	1	16
Cured meat	5	2	3	3	2	1	16



Raw Respondents Data from Value adding Survey.

3.1.3 Analysis of Results

Answer Options	Aggregate Score	% of maximum possible score
Dried mono-tissue powder for export	43	53.75%
Frozen mono-tissue for export	52	61.18%
Frozen organs for export	54	72.00%
High value therapeutics from blood	57	67.06%
High value bioactives from tissue	61	71.76%
Algae from WWTPs	46	57.50%
Bio-diesel from low grade tallow / FOGs	49	61.25%
Fertilizer / compost from solid by-products	70	82.35%
On-site energy from solid by-products	68	80.00%
On-site energy from WWTP	63	78.75%
Halal products	64	80.00%
Prepared meals	57	71.25%
Cured meat	50	62.50%

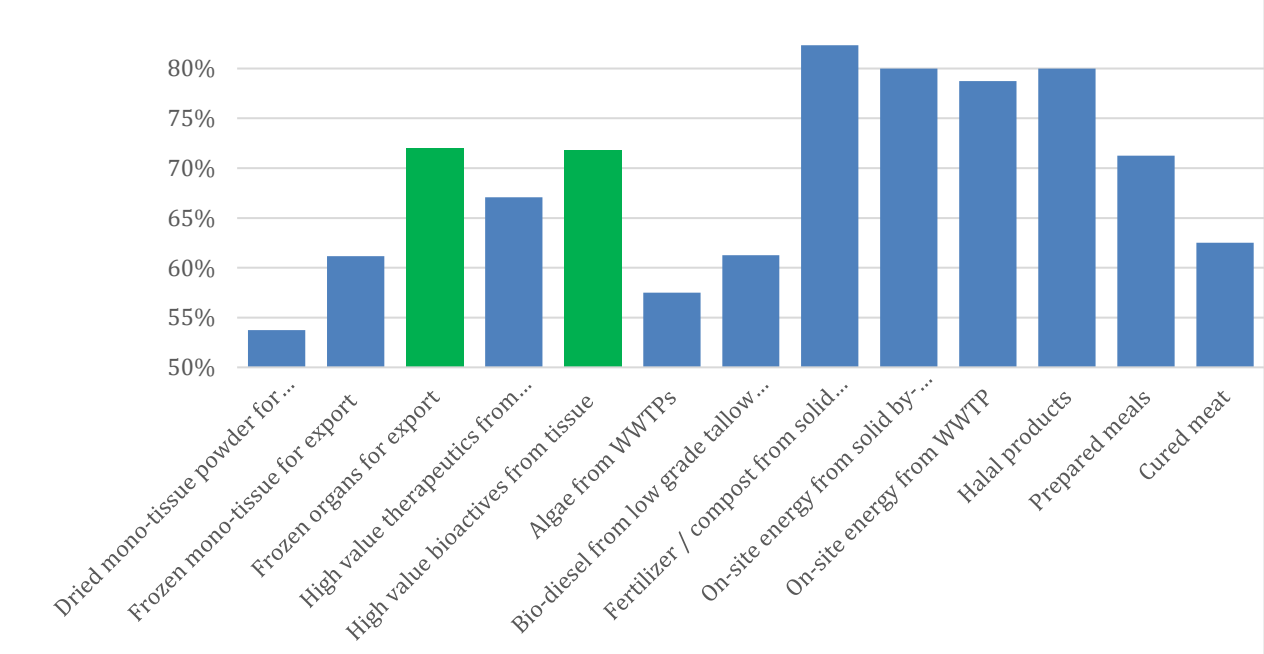


Figure 10: Plot of percentage of maximum score. Highlighted in green are the highest ranked opportunities not being progressed by another AMPC program (e.g. Environment and Sustainability).

4.0 SUMMARY OF KEY FINDINGS

Investigations completed by All Energy Pty Ltd (AMPC project 2016.1037) have aggregated input from:

- Survey responses representing 31 meat processing facilities (refer table and figure below).
- Manufacturing / value adding companies spanning a range of products.
- A range of end users and topic matter experts have been contacted including health supplement, neutraceutical, research, industry, university and policy groups.

Based on feedback of available / undervalued tissues / blood from red meat processors, interest from the supply chain and, in particular, end user interest, it is recommended that the biomolecules to be explored further through this project be, in order of recommendation:

[1] Chondroitin Sulphate (CS) - strong existing demand and clear development pathway.

[2] Collagen - suffers from marketing / labelling ambiguity i.e. collagen versus soluble collagen versus hydrolysed collagen versus gelatine.

[3] IgG protein crude extract as a food supplement and for immunity boosting - earlier stages of efficacy / product development; longer term opportunity.

Note that the project budget has been itemized to show the budget for development works for three separate biomolecules. There is no requirement to develop all biomolecules simultaneously, however development at the same time enables a better comparison to be made between new Australian bovine derived biomolecules. Based on feedback from final off takers of biomolecules in the supply chain, the recommend stages for new molecules to enter the market are:

Stage 1: small scale production for 3rd party lab testing and creation of a data sheet for retailers / end users. Associated estimation of commercial scale production costs.

Stage 2: pilot scale production to support formulation testing. This would require approximately 2 kg of purified biomolecule. Associated estimation of commercial scale production. Business case to be further refined with the aim of estimating the cost of production at a full commercial scale to ensure that the cost of production is in an acceptable price bracket.

Stage 3: commercial scale procurement of biomolecules by off takers from manufacturers (e.g. at tonnes per annum scale).

A specific requirement for molecules to be considered is evidence based research that it has a positive health effect. Otherwise, commercialization may require 5 - 10 yrs plus for clinical trials, etc.

4.1 Cost-Benefit Analysis and Commercialization Budget Estimates

4.1.1 Chondroitin sulphate (CS)

The CS content of trachea depends on the quality of the trachea trimming completed at the abattoir (i.e. meat, membrane and other non-cartilage material). Assuming a clean trachea, the expected CS content is approximately 3-5% on a wet mass basis, at an assumed wet trachea weight of 250 g (the dry content of trachea varies between 25-30%). 100 kg of wet trachea is expected to yield 3 – 5 kg of CS at >80% purity. At an assumed recovery rate of 80% during the value adding stages, 2.4 to 4 kg of CS is expected to be produced (from 100 kg of wet trachea).

In addition to CS, collagen hydrolysate can be produced by this process. Collagen hydrolysate is a soluble, non-gelling collagen ranging in size from 500 to 10,000 Da and averaging 3000 Da.

4.1.2 IgG

Research into serum-derived bovine immunoglobulin/protein isolate (SBI) examined the health effects of SBI on early weaned piglets that had developed intestinal inflammation, intestinal barrier dysfunction, and general enteropathy. These issues often manifested in diarrhoea, dehydration, and death for young piglets[1,2], with SBI offering a non-antibiotic option.

SBI in piglets improved digestion, metabolism, and feed intake, increasing lean muscle mass and protein utilization. Gastric infection and diarrhoea were also reduced in the post-weaning phase. EnteraGam, a "medical food" formulation for people that can be mixed with water and ingested, was introduced into the US market in 2013. EnteraGam retails for $464 per 10g.

[1] *Peace, Ralph Michael; Campbell, Joy; Polo, Javier; Crenshaw, Joe; Russell, Louis; Moeser, Adam (July 2011). "Spray-Dried Porcine Plasma Influences Intestinal Barrier Function, Inflammation, and Diarrhea in Weaned Pigs". Journal of Nutrition* ***141*** *(7).*

[2] *Pierce, JL; Cromwell, GL; Lindemann, MD; Russell, LE; Weaver, EM (December 2005). "Effects of spray-dried animal plasma and immunoglobulins on performance of early weaned pigs.". Journal of Animal Science* ***83*** *(12): 2876–85. PMID 16282627.*

4.2 Testing

Testing requirements are recommended to be completed via a third party to ensure transparency of results.

Quotations were received from ALS Food and Pharmaceutical

Contact: Tina Papadopoulos, Sales and Marketing Manager, ALS Life Sciences Division | Food and Pharmaceutical

Sales Item description (Report Schedule name)	Analyte Order	ANALYTE
BP Chondroitin Sulfate Sodium	1	Appearance
BP Chondroitin Sulfate Sodium	2	Solubility
BP Chondroitin Sulfate Sodium	3	Identification A
BP Chondroitin Sulfate Sodium	4	Identification B
BP Chondroitin Sulfate Sodium	5	pH
BP Chondroitin Sulfate Sodium	6	Specific Optical Rotation
BP Chondroitin Sulfate Sodium	7	Intrinsic viscosity
BP Chondroitin Sulfate Sodium	8	Protein
BP Chondroitin Sulfate Sodium	9	Chlorides
BP Chondroitin Sulfate Sodium	10	Heavy Metals
BP Chondroitin Sulfate Sodium	11	Loss on Drying
BP Chondroitin Sulfate Sodium	12	Assay

5.0 Discussion - Summary of Communications

5.1 Meat Processor

The general requirements of a meat processor include:

- There must not be a substitution product available (e.g. recombinant enzymes replacing bovine sourced enzymes).
- The final product must have purity requirements and hence cannot be easily “watered down” thereby eroding the economic viability of the bovine derived product
- There needs to be supply chain integrity (i.e. that values and Australian bovine source and providing appropriate returns)
- The risks and costs of supplying into a regulated market must be understood
- The tissue must be easy to collect and at an appropriately low cost to collect
- The demand must be at a suitably large volume to warrant the effort to segregate the tissue.

5.2 Nutraceutical Companies

Australian nutraceutical companies such as Blackmores Limited (Blackmores) and Vitaco are experiencing strong growth.

It is a general requirement evidence based, clinical studies exist to establish and approve claims. Clinical testing is extremely expensive and has a long lead time.

5.3 Food Ingredients and Additives

There exists an unmet demand for Australian derived and manufactured food ingredients, such as Halal enzymes for toothpastes. Trypsin and pancreatin have a market driven demand which is currently not being met. To gain entry to this market, data sheets showing activities and purities that can be achieved must be generated.

Assuming a trypsin activity of 15,100 U in lyophilised powder per 20 g of pancreas tissue. Assuming a bovine pancreas weighs 5kg, it is estimated that at a manufacturing recovery of 70%, that 189,215 cattle are required to produce 2 t of 250 U/mg trypsin.

Bovine derived enzyme fractions, especially from the pancreas, have less activity and less track record than porcine derived enzymes, hence the reticence of Australian manufacturers to create these products.

6.0 Conclusions / Recommendations

It is recommended that “round tables” be held to align the technical knowledge and goals of each of the stakeholders. This could be completed at part of a proposed scope of works under consideration by AMPC. It is proposed that the meeting occur at the facilities of the value adder in order to enable a site visit. Invitees to the round table would include:

- AMPC staff
- Meat processor(s)
- Value adder (and commercialization / scale-up partner where appropriate)
- Facilitator

The development of a new biomolecule requires several stages. The scope of this work relies on there being well documented commercial uses and/or health benefits and efficacy for a particular biomolecule, but there being a gap in the market for that molecule to be Australian derived and manufactured. The development of a new molecule that has no documented benefits could be in the order of decades, whilst the development of a molecule for which the benefits are well defined could be in the order of months to years.

End users have nominated the following stages of development: Development Stage 1: small scale production for 3rd party lab testing (e.g. purity, DNA, compliance with British Pharmacopoeia, etc.) and creation of a data sheet for retailers / end users. Associated estimation of commercial scale production. This stage will include the mechanics of how the feedstock is collected, custody supply chain and transport / storage.

Development Stage 2: pilot scale production to support formulation and trial testing (i.e. for CS, ~2 kg of free flowing powder product is required). Associated estimation of commercial scale production.

Development Stage 3: off take agreements and small scale commercial procurement. Each molecule will have unique requirements as to amounts required for testing and formulation, however the above provides a guide. There is no requirement for all biomolecules to be progressed simultaneously (i.e. a single biomolecule could be selected), however developing more than 1 biomolecule provides the opportunity to complete a comparative cost benefit analysis.

The key elements of this project are recommended to be:

[1] The establishment of an industry working group with AMPC to identify and confirm molecules of most interest and support industry engagement with supply chain partners to progress to pilot scale trials.

[2] “Fixed and firm” budget pricing from manufacturing companies and lab testing companies. “Round table” sessions where all stake holders are brought together to align the various goals of the project for AMPC, meat processors, value adders and the end user. Ranking then selection of biomolecules for further development. Such sessions will enable groups to talk through anticipated demand, price points, feedstock collection / custody supply chain / transport / storage

and elements of safety and quality documentation.

[3] Biomolecule A (Chondroitin (CS)): Development Stages 1 and 2 (refer above).

[4] Biomolecule B (Collagen): Development Stages 1 and 2 (refer above).

[5] Biomolecule C (IgG): Development Stages 1 and 2 (refer above).

[6] Detailed cost-benefit analyses on biomolecules as to technical and economic viability for the Australian red meat industry (RMI). The challenge is to have a “like with like” comparison between different opportunities for the RMI – completing work on multiple biomolecules simultaneously will enable this like with like comparison to be completed. A process for enabling clear and optimized decisions will be defined. Once this method is set up, updates can be made routinely to track improvements in economic viability due to changes in market demand, technology, capex, costs or other drivers. This will be summarized into a final report.

There is no requirement to develop all biomolecules simultaneously, however development at the same time enables a better comparison to be made between new Australian bovine derived biomolecules.

Appendix 1 Industry and Literature Review

The table below summarizes a number of "Value Adding" opportunities, where Value Adding was considered to be any activity increasing the value of a material that is not part of red meat or traditional rendering activities.

Product	Feedstock	Technology	Scale tpa	Retail value ($/t)	Example
Bioactive					
Chondroitin sulphate (CS)	Trachea	Bulk purification GMP purification	High Low	$51,000 $1,063,000 (pure)	Supplement Neutra-ceutical
Pancreatin	Pancreas	Protease >200 USP u/mg Lipase >35USP u/mg Amylase >200USP u/mg Loss on drying <5.0% Fat <20mg/g Aerobic bacteria <5000 CFU/g Yeast and moulds <100 CFU/g E. coli negative Salmonella negative Particle size 80 mesh max	>150 tpa	$100,000 – 145,000	Medicine for digestive issues. Neutra-ceutical
Bovine serum albumin (BSA)	Blood	GMP purification	Medium	$1,450,000 (98% pure therapeutic)	Therapeutic
Bovine Immunoglobulin A (IgA)	Blood	GMP purification	Very low	High	Therapeutic
Bovine Immunoglobulin G (IgG)	Blood	GMP purification: human therapeutic. Crude extraction: health / food supplement. Immune booster for animals.	Low Medium Medium	2,005,500,000 46,400,000 Unavailable	Therapeutic Health supplement Animal health.
Bovine Immunoglobulin M (IgM)	Blood	GMP purification	Very low	385,000,000,000	Therapeutic (pure; aqueous saline)
Haemoglobin	Blood	GMP purification	Medium	640,000	Therapeutic, Binding Therapeutic
Globulin	Blood	GMP purification	Low	23,300,000	Therapeutic
Plasma	Blood	GMP purification	Low	7,497,000	Therapeutic (liquid)

Fibronectin	Blood	GMP purification	Very low	138,924,000,000	Therapeutic (pure powder)
Fibrinogen	Blood	GMP purification	Low	104,000,000	Therapeutic (65% protein)
Other blood derived products	Blood	GMP purification	Low		
Heparin	Intestinal mucosal tissue	GMP purification			
Cortisone	Adrenal gland / synthetic	GMP purification		53,400,000	
Export product					
Dried mono-tissue powder	Organs (liver, kidney, etc.)	Simultaneous particularization and drying		220,000 - 270,000	
Frozen organs - mono-tissue	Frozen organs	New supply chain / Plate freezers			
Frozen organs - multi-tissue	Frozen organs	New supply chain / Plate freezers			
New product					
Algae	Waste water	"Polishing" ponds		1,600	Aquaculture
Greaves	Unmeltable residue from rendering	Centrifugation			
Cured meat	Red meat				
Prepared meals	Red meat				
Off-site Energy					
Bio-diesel	Tallow	Biocube		1,300	
Low grade tallow for bio-diesel	DAF sludge	Separate rendering;			
Product	**Feedstock**	**Technology**	**Scale tpa**	**Retail value ($/t)**	**Example**

		enzymatic transesterification			
Excess low grade heat	Additional heat from rendering, etc.	Heat exchangers / closed water circuits			
Fertilizer / compost					
Fertilizer / compost	Paunch, sludge, DAF	Windrows / aerated	20 ktpa	60	
Fertilizer / compost	Paunch, sludge, DAF	In-vessel, high rate composting	20 ktpa	60	
On-site use					
Power, heat and compost	Solid organic wastes	Dry Anaerobic Digestion		60	
Power, heat and compost	Liquid organic wastes	Mixed vessel anaerobic Digestion	5200		
Power, heat and compost	Liquid organic wastes	Covered anaerobic lagoons			
Power, heat and char	Dried organic wastes	Pyrolysis	4t/h		
Power and heat	Paunch	Fluidised Bed combustion	110,000		
	Dried organic wastes	Combustion	440,000		

Power and heat					
Power and heat	Dried organic wastes	Gasification and syngas burner	~5,000		
Power and heat	Biogas from organic waste	Gasification and syngas CHP engine	900		
Power, heat and compost	Crop Residues	Dry Anaerobic Digestion	11000		
Power and heat	Chipped wood	Biomass boilers			

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