

# Final report

**Project code:** A.BIM.0040  
**Prepared by:** Dr Dianne Glenn  
Corelli Consulting  
**Date published:** January 2015

**PUBLISHED BY**  
Meat & Livestock Australia  
Locked Bag 991  
NORTH SYDNEY NSW 2059

## **Blood-based proteins: A market review**

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

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# 1 Background

There are potential commercial opportunities to be derived from the utilisation of by-product streams from meat processing, which may add value for stakeholders within the Australian meat and livestock industry. MLA has commissioned research which has led to the development of a compendium of animal-based compounds and extracts with potential commercial value [16]. The priority compounds and extracts are immunoglobulin G (IgG) and haemoglobin, as well as bovine serum albumin (BSA), with a well-established history of use within the pharmaceutical and research sectors as a growth medium component to support the growth and maintenance of eukaryotic cells including stem cells.

This report reviews the commercial opportunity for these three blood-based bioactive<sup>1</sup> products across other industry sectors. To this end, MLA has previously invested in specialist reports to clarify the opportunity to expand revenues for industry stakeholders from the production of these compounds: “An analysis of the gaps in the bioactives supply chain” by Innovation Dynamics Pty Ltd, May 2006; “Bioactives market study of beef, sheep and goat meat: value chain analysis for Meat and Livestock Australia” in 2006 (PRBIO.009) and the subsequent report “Value chain models for the ‘top five’ bioactives” (A.BIM.0033) in 2012, both by Professor Mike Vitale; and MLA’s “Bioactive opportunities for the Australian red meat industry”, January 2011.

These reports prepare the ground for this current project, which will consider the market opportunity for these blood-derived products from the Australian meat industry within the food, nutraceutical and other industries, the competitive landscape and the potential supply chain. Of significant interest are those commercial opportunities that represent a high volumetric demand and may therefore make use of large volumes of meat by-products. Consequently, MLA anticipates being positioned to provide the necessary information for the Australian red meat industry to make a decision on the commerciality of BSA, IgG and haemoglobin within the food, nutraceutical, veterinary and animal feed industries.

This report will consider the market opportunity for the blood products from the Australian red meat industry within the food, nutraceutical and other industries such as veterinary and animal feed industries, the competitive landscape and the potential supply chain.

The recommendations that follow are the opinions of Corelli Consulting based on high level review, and may require further research, confirmation and comparison prior to a strategic decision being made by the Australian red meat industry.

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<sup>1</sup> Bioactives include biological compounds which have a stimulatory or otherwise beneficial effect on animal wellbeing, independent of any nutritional benefit. Examples of bioactives include antibiotics and probiotics. Compounds with a solely nutritional benefit include proteins, carbohydrates and sugars, and fats and lipids.

## 2 Executive Summary

### 2.1 Key findings

Review of the competitive landscape and interview with industry respondents suggest that the best opportunity for volumetric consumption of blood products from the Australian red meat industry is in the context of commercial application within the key sectors of animal feeds and pet foods and supplements. Key drivers are the acceptance and uptake of comparable blood-based ingredients, the need for new bioactives in animal feeds, as well as the trend to animal-derived pet food ingredients. Key targets are poultry and pig feeds, fish and shrimp feeds, and pet foods and supplements (Figure 1). While animal-derived blood products have long been used in the food and food ingredients industry, this report considers the regulatory hurdles and cost competition are disincentives for new entrants to this market. In addition, consumer resistance to blood-based ingredients limits uptake of these products by the nutraceutical industry.

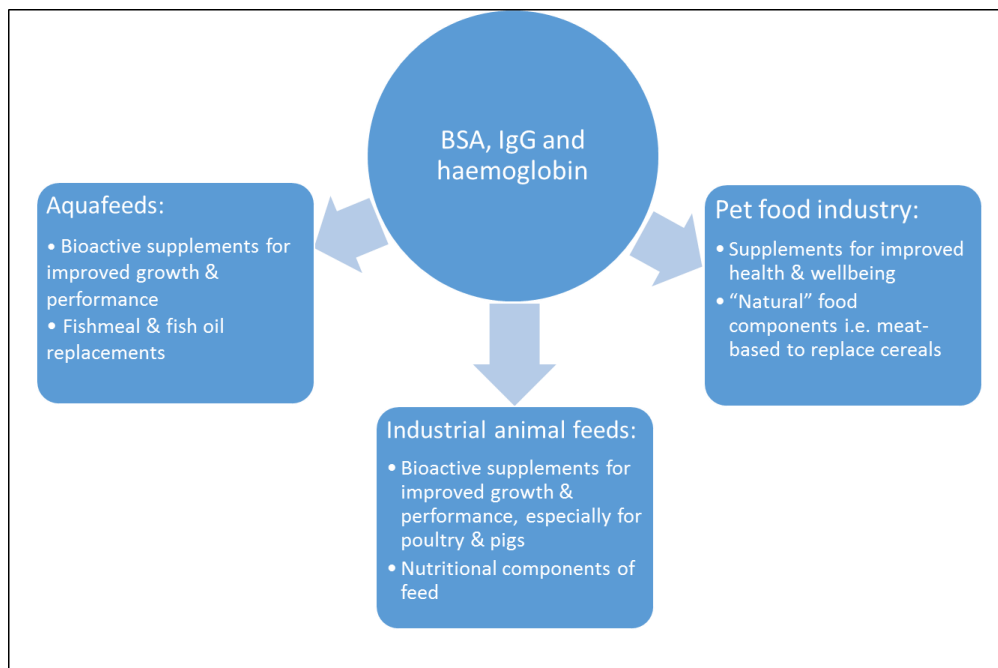


Figure 1: Opportunities within the animal feed and pet food markets for value-adding blood from meat processing.

- **Opportunity:** There is opportunity to refine valuable bioactive components, bovine serum albumin (BSA), immunoglobulins and haemoglobin from blood, a by-product of meat processing.
- **Value proposition:** There is potential for commercial application of these blood-based bioactive ingredients in the key sectors of pig and poultry feed ingredients, in fish and prawn feeds, and in pet foods, based on the acceptance and uptake of comparable ingredients. This is driven by market demand for bioactive ingredients to improve animal health and growth performance. These and related blood products potentially have additional value as nutritional feed ingredients.

- **Target markets:** The prioritised target markets are:
  1. Pet foods and supplements: based on the large scale of the market, the high margins reported and consumer demand for “natural”, meat-based products to support pet wellbeing;
  2. Animal feeds: for improved growth and performance and to mitigate the stresses of industrial production, especially of pigs and poultry;
  3. Aquafeeds: for improved growth and performance in a burgeoning global market, as well as potentially a sustainable replacement for fishmeal.
- **Key partners:** The key partners within the value-adding venture are:
  - Meat processing operators for provision of feedstock.
  - End-users of the blood-based bioactive proteins, specifically pet food and supplements manufacturers; animal feed compounders<sup>2</sup>; and aquafeed compounders.
  - Manufacturers, especially contract manufacturers, to translate the lab-scale refining technology to commercial scale.
- **Key activities:** The key activities within the proposed blood-based bioactives refining venture are:
  - Aggregation of feedstock;
  - Processing and refining feedstock to the extent demanded or preferred by the end-users; and
  - Sales and distribution to end-users.
- **Gaps and hurdles:** Investment is need to:
  - *Build an evidence pack of blood-based bioactives in target animals and to determine an optimal inclusion rate within the feed and/or supplement.* Currently, none of the proposed proteins (BSA, IgG and haemoglobin) are used in animal feeds or pet foods in a refined form. Therefore, commercial development of bovine-based blood products may require investment in innovation in ingredient composition, with benefits in health and growth performance substantiated to the end-user by an evidence pack from trials in target animals. Industry would accept an evidence pack that leverages existing published efficacy data on comparable products such as haem and serum albumin. Nonetheless, this will necessitate bioequivalence with existing feed ingredients being established for the blood products;
  - *Demonstrate the refining technology at large pilot-scale operation:* Industry requires evidence of sustainable production of these products at a scale to meet commercial demand, by means of a transparent supply chain.
  - *Understand the product characteristics* (purity, concentration and formulation) to satisfy each end-user and application.
- **New prospects and future directions:** There may be future opportunities for the Australian meat industry to supply a broader portfolio of new animal-derived ingredients to the animal and aquafeed industry to reduce or replace traditional feed components in terms of both nutritional and bioactive ingredients. For example, animal-derived proteins (and potentially other animal bioactives) under consideration as feed ingredients for commercial production of various fish species include:

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<sup>2</sup> Compound feed has ingredients to meet the animal’s nutritional requirements including protein, lipids, carbohydrate and micronutrients.


- Nutrient supplementation: Provision of amino acids and/or proteins, vitamins and minerals can address poor animal production performance that results from deficits in immune-competence, and stress and disease resistance; and
- Nucleotides: Dietary supplementation with nucleotides, also extractable from meat by-products, has demonstrated benefits in fish production.


*Summary of opportunities and challenges for animal-derived bioactive blood-based proteins: note indicative only.*


### A

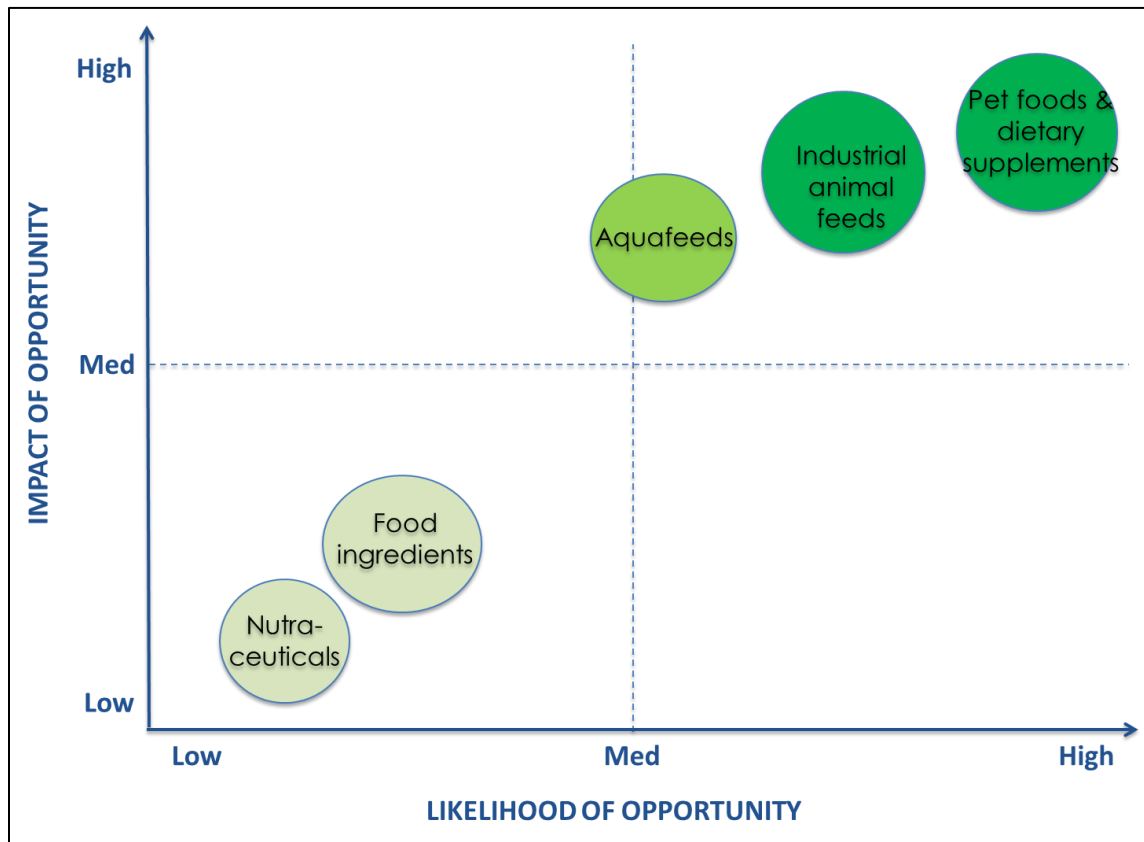
Market	Segment	Industry challenge	Opportunity for Blood-based Products		Obstacle to reach the market		Volume
Food	Ingredients	None	Low	Functional ingredients	Med-High	Regulatory Consumer acceptance Cost competition	Low
	Nutraceuticals	None	Med-High	Muscle wasting in the aged market	Med-High	Regulatory Consumer acceptance	Low
Animal feed	Animal feeds	Species-to-species feeding	High	Pig, Poultry feeds	Low	Safety and efficacy data for industry	High
		Bioactives to improve growth & productivity					
	Fishmeal replacement	High	Aquafeed	Med-High	Palatability Evidence of bioactive's efficacy & growth performance	Medium-High	
Bioactives to improve growth & productivity							
	Pet foods & supplements	Consumer demand for designer food and bioactive health supplements	High	Grain-free pet food	Low	Safety and efficacy data for industry	High

Priority of opportunity for blood-based products (indicative only):

 lowest volume and/or highest obstacle to market;

 intermediate opportunity based on volume and/or obstacle to market;

 highest volume and/or lowest obstacle to market.

**B**

Priority of opportunity for blood-based products (indicative only):

- Lowest volume and/or highest obstacle to market;
- Intermediate opportunity based on volume and/or obstacle to market;
- Highest volume and/or lowest obstacle to market

Table(A) and figure (B) summarise the market segments in which animal based blood products may have the greatest opportunity to solve an existing need with the lowest regulatory or other hurdle to market entry, and potentially at volumetric demand. Note that the evaluation of opportunities is indicative only – further work is required to quantitate those opportunities for direct comparison.

## 2.2 Next Steps

This report recommends that the new blood-based refining business be established using a staged approach (Implementation Strategy) to provide the time for development of a full-scale manufacturing process from the technology and assessment of the market readiness of the product. The values of the staged approach for both operational deployment as well as product rollout are comparable: there is time allowed to develop the market readiness of the bioactive products; to prepare for commercial release of the bioactive ingredients into their target markets, and to integrate these new value-adding technologies into the existing refining operations.



**Implementation Strategy:** To access this market opportunity, the Australian meat industry needs further investment to establish and evidence the production of animal-derived blood-based products, with:

- Scalable manufacturing processes;
- Sustainable production from a transparent and auditable supply chain;
- Reliable product supply at appropriate volumes to meet end-user needs;
- Quality and price targets;
- Innovation in feed ingredient composition, with benefits substantiated by an evidence pack in target animals; and
- Bioequivalence established for its blood products, leveraging existing published efficacy data on comparable products, such as haem and blood meals.

Therefore, an implementation strategy for the Australian meat industry to value-add meat processing streams as products for the industry animal and pet feed markets can be framed as a sequential series of 'go/no go' stage gates. Each stage gate is designed to meet critical development and decision-making goals, while providing a risk management strategy for the meat processors and other investors:

- Stage Gate 1: Define & demonstrate the product, in collaboration with end-users; confirm a scalable production technology; and estimate industry uptake.
- Stage Gate 2: Define the supply chain based on feedstock aggregation: consider a hub and spoke precinct model for feedstock processing within the meat producing regions, with the refining hub at the centre of the spokes of meat processors.
- Stage Gate 3: Define the business structures to achieve: feedstock aggregation, technology deployment and end-user alliances
- Stage Gate 4: Staged technology rollout: scale-up of proprietary technology to a commercial-ready process, assessment of the market readiness of the product, its performance and chemical documentation, and secure or outsource the skill sets needed to operate the refining operation, for full-scale commercial manufacturing.

**Implementation Team:** The implementation team will support the staged implementation strategy and be responsible for:

- Strategic partnerships: Identification of strategic partners, and the development and management of relationships, on behalf of the meat processors and the refining venture. Strategic relationships are as essential as supply chain optimisation to overcoming the barriers and uncertainties that the meat industry may face in developing a sustainable and competitive value-adding venture;
- Independent research: Engagement of independent, third party researchers to conduct animal studies and to compile efficacy data for the blood-based bioactives; and
- Strategic modelling: Project management of the modelling needed to assist the meat processing industry to define and initiate a successful value-adding bovine-derived blood business with input from all partners:
  - *Strategic logistics modelling* to manage feedstock aggregation over the national meat processing footprint.

- *Production scenario model* to enable optimisation of the product mix of meals and bioactive ingredients from the refining operation, and define the volume of feedstock required.
- *Financial modelling*: to support commercial decision making by the meat processing industry.



Figure 2: Blood-based products: strengths, opportunities, threats and weaknesses.

## 3 Opportunity

### MARKET SCOPE

Where are the markets for BSA, immunoglobulins and haemoglobin, refined as a value-add from meat processing by-products? Consider the food and feed industries, both of which currently use animal proteins and other products, including those derived from blood.

### 3.1 Food industry

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The food industry is an existing volumetric market for bovine-based blood. The use of animal protein in human food and food ingredients, including bioactive ingredients, is currently common in:

- Bulk food ingredients: the market is established for refined proteins (such as colour and stabilised haemoglobin) as well as less refined animal products (such as plasma, spray dried red blood cells (RBCs)); and
- Specialty food ingredients and nutraceuticals: Uptake of ingredients by this market requires functional differentiation, i.e. the association of the product with distinct claims about function and benefit. Ingredient uptake in the nutraceutical industry, in particular, may be driven by a strategic association of the bioactive ingredient (BSA, IgG, and haemoglobin) and its confirmed health benefits with a condition or disease, such as muscle wasting in ageing populations.

The proposed refined blood products would represent new market entrants in the food and nutraceuticals market, and consequently, there are high regulatory hurdles for these “new” bulk or specialty food ingredients. Industry demands a high level of substantiation of health benefit claims and demonstration of safety for the entry of new ingredients. In addition, there are other hurdles to entry of new ingredients into the bulk food and nutraceuticals ingredients market such as:

- Consumer resistance to blood-derived ingredients: Any opportunity for market uptake of these new ingredients by food and nutraceutical industry may be offset by poor consumer perception of blood as source of new food protein or nutraceuticals;
- Intense competitor pressure: from existing ingredients manufacturers; and
- Cost: Refined new blood-based products may need to compete on a cost basis with less refined products for existing roles as structural ingredients (such as gelling agents or stabilisers) in food manufacture.

### 3.2 Animal Feed industry

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There may be opportunities for the use of the proposed blood-derived animal products within feeds and feed market in:

- Animal production; and
- Pet market.

In animal production, uptake of unrefined animal products, such as meat and bone meal as well as plasma, has already been established in the key market segments of pig, poultry and fish feeds. Australia bans the feeding to all ruminant meals that are of animal origin, including that from fish and birds (the Australian Ruminant Feed Ban). The ban is designed as a “fail-safe” control measure of bovine spongiform encephalopathy (BSE) infection [17]. Consequently, there may be

an opportunity for the Australian meat industry's proposed blood-based products (bovine serum albumin (BSA), IgG and haemoglobin) to address the problems faced in the animal production industry, such as:

- Replacement protein sources to avoid species-to-species feeding<sup>3</sup>, especially in pig feeds;
- Sustainable and palatable replacements for fishmeal in the global aquafeeds industry; and/or
- Supply of bioactive ingredients to reduce or replace the use of prophylactics (such as antibiotics) and medicines to manage animal health under intensive farming practices.

### 3.2.1 Market size

In 2013, the total world volumetric production of compound animal feed<sup>4</sup> was ~1 billion tonnes, of which ~300 million tonnes was produced directly by on-farm mixing or feedlot, with the remainder produced by commercial feed manufacturers. Global commercial feed manufacturing generates an estimated annual turnover of over US\$370 billion at a CAGR<sup>5</sup> of 3.7% in 2013 [18].

Globally, swine feed has the largest share of the compound feed market at 31%, estimated to be worth US\$81.1 billion by 2017, and the fastest growing segment at a CAGR of ~4% (2012-2017) [19].

The cost of compound feed accounts for an estimated 70% of livestock production costs, and consequently has a significant impact on the farmers' production costs and returns, as feed use to a large extent determines the output of meat, eggs and milk.

North America leads the compound feed market with revenues of US\$72.3 billion in 2010. Asia has the most promising growth potential for the compound feed industry as the consumption of animal-derived products is increasing on account of the rise in disposable income within the region [19, 20].

Feed additives to improve animal health and nutrition are used in compound feed to improve the performance and production efficiency of animals, and to modify the feed in terms of digestibility. The global feed additives market is expected to reach US\$18.3 billion by 2017 at a CAGR of 3.9% over the period 2012 to 2017, with Europe accounting for the largest share (33.5%). To date, the largest segment of the additives market is feed amino acids at 30%, which, together with vitamins, fats and minerals, has a growth rate of ~3% [19, 21]. Food industry companies such as DSM and Ajinomoto dominate the feed ingredients market for amino acids, vitamins and colourants. The largest producer of bioactive proteins for animal feeds and pet foods from animal blood and other abattoir by-products is reportedly American Protein Company (APC).

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<sup>3</sup> Species-to-species feeding describes the use of ingredients derived from an animal species being used to feed that same animal: for example the feeding of porcine plasma to pigs, or fish waste to fish.

<sup>4</sup> Compound feed has ingredients to meet the animal's nutritional requirements including protein, lipids, carbohydrate and micronutrients.

<sup>5</sup> CAGR Compound annual growth rate is the growth rate of a business averaged over a period of several years (typically the last five). In this way, CAGR provides a better indication of the growth trend within a business, than does reflection on one year's growth rate.

*Case study: Ridley Corp*

*Ridley Corporation (RIC:AU, market cap A\$252.4 million [1]) is an Australian-owned public company, and a global producer of animal feed and salt, with a sales turnover exceeding A\$734 million in 2012FY [6]. The principal activities of the Ridley group are: stockfeed manufacturing and marketing; production of crude salt, salt refining and marketing; manufacturing of animal health products, manufacturing of consumer pet food products, and provision of rural products and services.*

*Australia currently produces ~12 million tonnes pa of animal feeds: both commercial (free trade) and integrated feedlot production. In Australia, Ridley AgriProducts Pty Ltd (Ridley) has 22 manufacturing plants, producing 1.62 million tonnes or 25-30% of the total national compound feed production of approximately 4-5 million tonnes. Ridley supplies animal feed to all Australian animal industries including poultry, pig, dairy and beef. The predominant feed produced by Ridley is poultry feed (933,000 tonnes pa or 57.6% of total production), dairy and beef cattle (~30%), and pig (197,000 tonnes pa or 12% of total production). Poultry and pig feeds are further segregated into those tailored for layers or meat birds, and for weaners, growers or breeders respectively [6, 12, 13].*

*Ridley has commented that there is an interest in bioactive ingredients in general in the animal feed industry, for both pig and poultry feed manufacture. Porcine plasma is routinely used overseas to improve gastrointestinal health and basic immunity in piglets, although to date it is not widely used in Australia; bovine plasma also has a record of use in piglets. Currently, the addition of porcine plasma as a bioactive additive to feeds for piglets is being assessed, with the expected benefit for these intensively farmed animals of:*

- improved general and gastrointestinal health;*
- improved immunity;*
- reduced incidence of conditions that require medication as treatment; and therefore*
- reduced use of prophylactic treatments or medication*

### 3.2.2 Drivers

Blood proteins are an accepted addition to animal feeds and pet foods, and are conventionally added as dried whole blood or plasma from bovine, ovine, porcine or chicken processing as cheap protein sources. There may be a high level of interest within the animal feed industry in the use of dried plasma or serum as well as the bioactive attributes of plasma proteins in commercial feeds. For example, scientific studies have reported the benefit of porcine and bovine plasma and plasma fractions in young pigs: in these studies, the performance stimulation resulting from the addition of spray-dried plasma was attributed to the immunoglobulin G fraction [22]. Similarly, bioactive additives for poultry feed are of high commercial interest to improve the health of animals within an intensive farming system and to reduce the cost of treatment and/or prophylactics.

In commercial feed manufacture, the price for porcine plasma as a bioactive feed ingredient is ~A\$5-6/kg i.e. \$5000-6000/tonne, and the level of incorporation is anticipated to be 2-5% of the

feed<sup>6</sup>. Other animal-based nutritional ingredients for pig feed are blood meal at ~A\$900-1000/tonne, and meat and bone meal at ~A\$600-700/tonne, the price of both being linked to the price of grain proteins and the export market. Bioactives are regarded by industry to have the potential to reduce the costs of managing animal health under conditions of intensive farming; consequently, industry may consider a price for effective bioactive compounds estimated at ~A\$7,000-8,000/tonne, comparable with the price of antibiotics, for demonstrable health benefits as well as the additional nutritional value, which bioactive feed ingredients are anticipated to provide [22, 23].

Bioactives are regarded by industry to have the potential to reduce the costs of managing animal health under conditions of intensive farming

An area of concern within feed manufacture is species-to-species feeding. Overseas, this issue for feed manufacturers and animal producers is driven to a large extent by supermarkets, which decline animal food products produced by species-to-species feeding. While this is a message that has not been picked up in Australia as yet, it may do in time [22, 23]. Avoidance of species-to-species feeding in pig production, especially of weaners, represents an additional driver for potential market interest in the Australian meat industry's bovine-derived bioactive proteins, particularly BSA and IgG, as health and performance supplements for poultry and pig feeds.

However, evidence of the effectiveness of blood-derived bioactives to improve animal health and production outcomes still needs to be demonstrated. Therefore, to achieve market penetration in the animal feeds sector, the Australian meat industry should anticipate the need to work with a strategic industry partner in supporting animal studies to substantiate claims for bioactivity and to establish traceability protocols for the blood products supply chain. Industry end-users expect to see evidence of efficacy for a bioactive feed ingredient in the target animal species and age category, carried out by an independent and reputable animal research group by means of local trials [22, 23].

To achieve market penetration in the animal feeds industry, the Australian meat industry should anticipate the need to work with a strategic industry partner in supporting animal studies to substantiate claims for bioactivity as well as to establish traceability protocols. Industry end-users expect to see evidence of efficacy for a bioactive feed ingredient in the target animal species and age category, carried out by an independent and reputable animal research group by means of local trials.

<sup>6</sup> Based on the assumption that the pig feed market is 12% of the 12 million tpa Australian compound feed market, then at an inclusion rate of 2% and a value of \$5000/t, the total potential value of pig plasma as a feed additive is estimated at A\$144 million pa. Similarly, at 58% of the same compound feed market, the total potential value of pig plasma as a poultry feed additive is estimated at A\$690 million pa. 6. Ridley Corp, *Annual Report 2012*, 23. *Industry respondent, this report.*

These estimates are prospective: porcine plasma has only recently been considered and assessed as a bioactive additive in piglet feeds, so the use of dried plasma as a bioactive feed ingredient is not established in Australia as it is overseas. This report recommends that the Australian meat industry undertake modelling using assumptions that are more reflective of the realities of the feed industry to better assess the value proposition.

### 3.3 Aquafeed

The aquafeeds market may also be a target market for the Australian meat industry's blood-based products.

#### 3.3.1 Market size

The global market for aquafeeds was estimated at US\$106 billion in 2009 and growing at 12.1% from 2013 to 2018. By 2020, global aquaculture is expected to contribute about 120–130 million tonnes of fish to meet projected demand; current production estimations are 68 million tonnes. The market for aquafeeds is well-established in North Europe and in Asia. Growth is particularly high in countries with established and/or expanding table fish industries such as China, Vietnam, (Table 1) and Ecuador based on an increasing awareness in those countries of the impact of quality aquafeeds on fish yield and production efficiency [24, 25] to meet the burgeoning demand for quality, high protein table foods. China alone is projected to account for 38% of global consumption of food fish by 2030 [26].

*Table 1: Estimated total aquafeed consumption in Asia (2003-2005) and projected demand in 2013, 2020 and 2030 (million tonnes)*

Country	Quantity used	Projected requirements		
		2013	2020	2030
China	18.68	33.69	52.87	57.36
India	6.40	8.62	8.69	10.05
Indonesia	0.77	1.36	NA	NA
Philippines	0.59	1.49	NA	NA
Thailand	1.58	3.73	NA	NA
Vietnam	1.50	4.00	NA	NA

(Source: Rana et al 2009, World Bank 2014)

Europe and Asia-Pacific are the major aquafeed-consuming regions, followed by North America. Moreover, animal feed industries are expanding their domains to meet the requirements of a growing aquafeeds market, and so aquafeed composition is tailored to meet the demands of the distinctly different varieties of fish cultivated in those two major jurisdictions [24]. Aller Aqua, Ridley Corporation Limited, Nutreco N.V., Norel Animal Nutrition, Dibaq Acuicultura and BioMar Group are key players within the global aquafeed industry [26, 27]. The aquafeed industry in Europe is highly consolidated, with three companies, Skretting, Ewos and BioMar, dominating the salmonid feed market: in 2007, these companies manufactured over 96% of the 2.1 million tonnes of industrial feed used for salmon and trout production in northern Europe [24].

#### 3.3.2 Drivers

The aquafeeds industry is looking for acceptable alternative aquafeed ingredients to fishmeal and fish oil, now in diminishing supply, to meet increasing demand for farmed fish in Europe and Asia. Common aquafeed ingredients currently used in commercial aquafeeds are shown in Table 4. The ingredients profile is dominated by fishmeal and fish oil: an indicative price for fishmeal is

~US\$1,184/tonne (2008)<sup>7</sup> and ~3 million tonnes of fishmeal and 0.7 million tonnes of fish oil are used globally in aquafeeds [24, 25]. The inclusion level of fishmeal in commercial feeds varies from 10-50% depending on the variety of fish [25].

Table 2: Ingredients used as sources of protein, lipids and carbohydrates in aquafeeds

Nutrient	Ingredients used in Asia	Ingredients used in Europe
Protein	Fishmeal, soybean meal, soy protein concentrate, maize gluten, wheat gluten, sunflower, CPSP*, blood meal, meat meal	Fishmeal, soybean meal, soy protein concentrate, maize gluten, wheat gluten, sunflower, CPSP*, blood meal, meat meal, krill meal, gelatin, brewer's yeast
Lipid	Fish oil, vegetable oil, tallow	Fish oil, vegetable oil, tallow
Carbohydrate	Wheat meal, extruded wheat meal, wheat remillings, extruded gelatinized starch	Wheat meal, extruded wheat meal, wheat remillings, extruded gelatinized starch

\*CPSP: Fish hydrolysate as a soluble protein concentrate. (Adapted from Rana et al 2009)

Fishmeal and fish oil remain highly favoured ingredients in aquafeeds and are relied upon in all jurisdictions to provide both nutritional and health benefits [24]:

- high protein levels, essential amino acids, minerals and essential fatty acids;
- high palatability and digestibility, thus increased growth of fish and less feed wastage (high feed conversion ratio); and
- health benefits such as improved immunity, survival rate and reduced incidences of deformities.

The global demand for fishmeal and fish oil by the aquaculture (as well as livestock industries) is unlikely to be met by an increase in production of these ingredients. Fishmeal production is now tightly constrained by limited supply of the resource: consequently, the price of fishmeal roughly tripled between 2002 and 2010 and continues to rise, widening the gap between the supply of that ingredient and the market demand for aquafeeds.

Therefore, the aquaculture industry is actively pursuing alternatives to fishmeal and fish oil that are cost effective, palatable, sustainable as well as delivering added benefits such as maintaining acceptable growth rates, breeding and animal health. Bioactive as well as nutritional ingredients are desirable [22, 23]: in contrast to expectation, some fishmeal replacements have generated poor growth and reduced immunity. Palatability is a critical hurdle for new aquafeed ingredients to meet fish growth performance metrics: rendered animal meals and proteins as nutritional additives can result in palatability issues depending on pre-treatment temperatures and times [22, 23]. In addition, the cost of aquafeed additives is also constrained in a low margin aquafeeds product: raw ingredient costs can account for 75% of feed production costs; additional costs of raw materials must be borne by the feed manufacturer [24, 27]. In Australia, alternative animal meals such as spray-dried haemoglobin meal as a nutritional component need to be cost competitive with established meals such as blood meal (A\$800-900/tonne). The inclusion rate of blood meals in

<sup>7</sup> In Australia, fishmeal varies in price from A\$1600 to A\$2500/tonne (Industry respondent, this report)



aquafeeds is 8-10%: local aquafeeds producers manufacture 40-45,000 tonnes pa of feeds which uses 3,200 to 4,500 tonnes of blood meals or equivalent pa [22, 23]. In addition, animal feed compounders may consider paying a premium price for nutritional and/or bioactive proteins if one supplier provided all the requirements for those components as a single high quality and secure supply.

To address diminishing supplies of fishmeal and fish oil, the aquaculture industry is actively pursuing alternatives that are cost effective, palatable, sustainable, as well as delivering added benefits such as maintaining acceptable growth rates, breeding and animal health. Palatability is a critical hurdle for new aquafeed ingredients: rendered animal meals and proteins as nutritional additives can result in palatability issues depending on pre-treatment temperatures and times. In addition, the cost of aquafeed additives is constrained in a low margin aquafeeds product. Therefore, there is an opportunity for Australian meat processors to consider partnering with aquaculture feed supply companies in the formulation of fishmeal to drive uptake of blood-based products.

The aquafeed industry maintains a watching brief on potential bioactive ingredients for aquafeeds which improve growth performance and animal health, such as chondroitin (see “Chondroitin sulphate: A market review” A.BIM.0041). Of particular interest are those compounds that improve the resilience of the animals to intensive farming practices, such as pre-and probiotics and antivirals, and modifiers of mineral deposition, osmoregulation and blood cell count. Blood plasma products are already used commercially to stimulate immune health in animals: immunoglobulins in equine blood plasma are used to support the immune response and improve the health of foals [28]. Currently, bioactives are added to aquafeeds at inclusion rates that vary from 10g/tonne to 5% of feeds (50kg/tonne), depending on potency. Industry needs to see evidence to substantiate bioactivity claims but may work directly with the ingredient supplier to build the necessary evidence dossier, using fish models such as barramundi [22, 23]. Therefore, there is an opportunity for Australian meat processors to consider partnering with aquaculture feed supply companies in the formulation of fishmeal to drive uptake of blood-based products.

### 3.3.3 New prospects and future directions

There may be additional opportunities for the Australian meat industry to supply new animal-derived ingredients to the aquafeed industry to reduce or replace traditional feed components in terms of both nutritional and bioactive ingredients. This report recommends that the meat industry consider some of the production outcomes that may be met by animal-derived proteins (and potentially other animal bioactives) as aquafeed ingredients in the context of [24]:

- Nutrient supplementation: Poor animal production performance that result from deficits in immune-competence, and stress and disease resistance can be addressed by provision of nutrients, particularly amino acids and/or proteins, vitamins and minerals. The nutritional requirements of the majority of commercially-produced fish are well known;
- Nucleotides: Dietary supplementation with nucleotides, also extractable from meat by-products, has demonstrated benefits in fish production, such as: enhanced feed intake; improvement in growth; increased resistance to pathogens; and increased resistance to stress; and

- Bioactive compounds: Substitution by blood-based bioactives for plant bioactive compounds, which are currently used in the industry but are often unpalatable or otherwise unsatisfactory.

The use of various materials including animal products (such as meat and bone meal, blood meal, poultry by-product meal, feather meal) have been reported as variably successful in redesigning aquafeeds [24, 25]. While this market is a substantial and growing one, for the Australian meat industry to consider aquafeed manufacturing as an end-user of animal-derived proteins as bioactive and/or nutritional ingredients, further investment in research is needed to demonstrate to industry the comparable advantage of animal proteins as aquafeed components.

### **3.4 Pet food and veterinary supplements**

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The pet market is a large, growing and stable one, especially in the US, driven by the trend to 'humanise' pets. There is strong consumer demand for pet supplements and pet nutraceuticals to maintain animal health, and for grain-free pet foods and supplements. However, there is no indication of blood-derived products as bioactive ingredients as yet in the pet supplements and pet nutraceuticals markets, and entry into these lucrative markets will be evidence-based.

#### **3.4.1 Market size**

The US market for natural and organic pet food, pet supplements (for dogs, cats, horses and other small companion animals), and natural and organic pet supplies was US\$3.2 billion in 2010, and globally is expected to rise to \$5.5 billion in 2014 [29-31]. The pet market in Japan is stable but "lavish" and is valued at A\$4 billion in 2012, including A\$2.9 billion in pet food, particularly high quality premium foods, specialised food and health supplements [32]. Expenditure on pet dietary supplements in Australia was A\$21.4 million in 2009 [33].

In the US, more than 500 ingredients are sold as animal health supplements according to the National Animal Supplement Council [34], including probiotics, nutraceuticals, vitamins, antioxidants, fatty acids, and supplements for arthritic joints. Industry observers consider the pet food and supplements industry in the US to be "recession resistant" [35, 36].

Pet food manufacturers may not all use animal-based products (BSA, haem protein, haem iron, IgG or other gammaglobulins) in premix formulations for the pet food industry but would supply these bioactive proteins in the premix in response to demand [22, 23]. Uptake by the end-user of these products would be driven by:

- Safety data, especially from trials;
- Guarantees around the source of the proteins in terms of "not creating a problem for the end-user or industry"; and
- Stability of the proteins within the (pet food) manufacturing process.

#### **3.4.2 Leading players**

Market leaders in pet food ingredients and supplements include DSM (natural vitamins and carotenoids), Martek (microbial docosahexaenoic acid (an omega-3 fatty acid) and arachidonic acid), Vitatene (natural carotenoids), Verenum (food enzymes), Ocean Nutrition Canada (fish-derived omega-3 fatty acids), and Tortuga (animal dietary supplements). Recently, Tortuga was acquired by DSM to gain entry into the animal nutrition market in Latin America and extend DSM's

nutritional range to include organic trace minerals. This purchase completes a €1.8 billion portfolio of acquisitions in nutrition for DSM [37, 38].

### 3.4.3 Drivers

The trend in the pet industry is for natural and bioactive products for preventative health. The market is underpinned by a growing population of ageing, overweight dogs, an expanding pet population, and consumer attitudes whereby owners treat their pets as companions or family members. Pet owners now place significant value on the health and wellbeing of their pets, despite the statistics which show that rates of obesity and diabetes in pets trend in concert with that of their owners [33]. Consumer concern about ingredient quality is evidenced by a US\$15 billion spike in one year sales of “natural and holistic” pet foods reached after the melamine recall<sup>8</sup> and continue to grow at 20% pa [30, 36].

In the US market, the top-selling supplement category is joint health, with a 4% growth rate and sales of US\$690 million, or 45% of total sector sales. The dental category grew almost 7% to reach \$20 million; skin and coat supplements grew 8% and accounted for 10% of sales. A recent industry survey conducted by Nestle Purina Petcare found that 40% of dog owners and 50% of cat owners expressed interest in purchasing veterinary medications, foods or supplements to address their pet’s gastrointestinal condition. Multivitamin sales continue to decline as consumers prefer more condition-specific supplements and pet food manufacturers meet this demand with added bioactive ingredients. Consequently, there are a number of bioactive ingredients for use in the pet industry that report substantiating evidence: prebiotics, probiotics, glucosamine and chondroitin, antioxidants such as vitamins C and E, zinc and other trace elements [36].

### 3.4.4 New prospects and future directions

The trend in the pet food and supplements market is resolutely in the direction of natural and organic ingredients, which is reflected by the high level of corporate investment in that direction [30, 31]. This trend is entirely consistent with the goals of the Australian meat industry to produce value-added animal-derived bioactive products for this market. High-end pet foods, such as organic, grain-free, refrigerated and raw foods are gaining retail traction in response to the demands of the “pet parent” [36].

Consistent with the trend for natural pet foods and supplements is the growing demand, particularly in the US, for grain-free pet food [41]. Advocates of grain-free and high protein diets argue these formulas are more natural for dogs and cats, giving them more energy and healthier coats while cutting back on allergic reactions. Sales of grain-free pet food at US pet stores increased 32% in 2013; grain-free accounted for about 26% of all pet food sales in 2013 while

<sup>8</sup> In 2007, Chinese wheat gluten, intentionally adulterated with melamine was imported into the US for use in pet foods. Melamine and related products cause kidney failure in cats and dogs, as well as cancer and birth defects in humans. The tainted pet food products subsequently sickened a reported 9,000 pets and killed at least 13,000. The pet food industry paid around US\$32 million in damages to pet owners. Significantly, consumer concern about pet food quality consequently stimulated a rapid 20% growth in sales of natural and holistic pet food to US\$15 billion by 2008, while other pet food segments stagnated. The melamine event has embedded natural pet foods within the competitive western pet food market.

39. Food and Drug Administration, *Melamine Pet Food Recall of 2007*. [www.fda.gov/AnimalVeterinary/SafetyHealth/RecallsWithdrawals/ucm129575.htm](http://www.fda.gov/AnimalVeterinary/SafetyHealth/RecallsWithdrawals/ucm129575.htm). 2007.

40. Schmidt, J., *Tainted pet food suit settled for \$24 million*. [http://usatoday30.usatoday.com/money/industries/2008-05-22-petfood-lawsuit-settled\\_N.htm](http://usatoday30.usatoday.com/money/industries/2008-05-22-petfood-lawsuit-settled_N.htm). 2008.

36. Phillips Brown, L. *State of the Pet Supplement Industry*. [www.nutraceuticalsworld.com/issues/2012-03/view\\_features/state-of-the-pet-supplement-industry/](http://www.nutraceuticalsworld.com/issues/2012-03/view_features/state-of-the-pet-supplement-industry/). Nutraceuticals World, 2012.

natural pet food accounted for 63% of all food sales in pet retail (supplements, treats etc). Overall, grain-free pet products in the US have reported US\$1.8 billion in sales at pet outlets in 2013, up from US\$1.36 billion in 2012 and US\$941.8 million in 2011, and currently accounting for about one-third of all new pet items introduced each month. In addition to the sales trends, grain-free pet foods attract a premium price: consumers pay roughly 45% more for grain-free products. Market observers predict that growth will continue in the US, before slowly expanding to other regions of the world, particularly Europe.

Table 3: Summary of opportunities and challenges for animal-derived bioactive blood-based proteins

Market	Segment	Industry challenge	Opportunity for Blood-based Products		Obstacle to reach the market		Volume
Food	Ingredients	None	Low	Functional ingredients	Med-High	Regulatory Consumer acceptance Cost competition	Low
	Nutraceuticals	None	Med-High	Muscle wasting in the aged market	Med-High	Regulatory Consumer acceptance	Low
Animal feed	Animal feeds	Species-to-species feeding	High	Pig, Poultry feeds	Low	Safety and efficacy data for industry	High
		Bioactives to improve growth & productivity					
	Fishmeal replacement	High	Aquafeed	Med-High	Palatability Evidence of bioactive's efficacy & growth performance	Medium-High	
Bioactives to improve growth & productivity							
	Pet foods & supplements	Consumer demand for designer food and bioactive health supplements	High	Grain-free pet food	Low	Safety and efficacy data for industry	High

Table 3 summarises the market segments in which animal based blood products may have the greatest opportunity to solve an existing need with the lowest regulatory or other hurdle to market entry and potentially at volumetric demand.

### 3.5 Commercial Landscape

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#### WHO USES PRODUCT AND WHO ARE THE KEY COMPETITORS

There are a number of global companies that provide nutritional ingredients (protein, carbohydrates, oil, and fibre), nutritional supplements (amino acids, organic acids, iron) and bioactive ingredients (probiotics, immunoglobulins) for the compounding of animal feeds (pigs, poultry and fish) and pet foods in Australia and elsewhere. There is essentially an inverse relationship between the volume of ingredient added to the feed or its refinement, and its unit price: cereals make up a large proportion of the feed and are relatively cheap; whereas bioactive supplements are added in small volumes, are refined to relatively high purity and command a higher unit price.

Nutritional ingredients are largely unrefined agricultural products such as cereals and oilseeds; some are food industry by-products e.g. milk by-products such as whey, and non-food meat by-products. These feed components can be compared directly with each other in terms of the feed nutrient profile in the context of the ideal nutritional targets of each animal. In this way, the Australian meat industry's blood proteins (e.g. BSA) can be directly compared in terms of amino acid content with other protein sources such as soybeans or whey.

In contrast, nutritional supplements may be high quality, and often reasonably pure and may be well defined: amino acids supplements, such as those produced by Evonik or Ajinomoto, are produced either *de novo* by chemical synthesis or by fermentation from simple sugars. The concentration of each amino acid in the supplement is information provided to the consumer. Nutritional supplements are added to a compounded feed largely to address the deficiencies in nutrient profile of the major ingredients: for example, addition of the amino acids lysine, threonine, and tyrosine may be needed to improve the profile of cheap protein sources such as cereals for pigs; those amino acids plus methionine for poultry; while leucine, lysine, valine, tryptophan and histidine are essential amino acids in fish feeds [42].

Bioactive ingredients, such as those identified in MLA's *Bioactives strategy*, are a less easily categorised group of feed ingredients. These additives once included antibiotics for disease prevention, but also for less directly-related growth promotion; however these are now largely banned from use in animal feeds. As a result of industry research and development, other ingredients aspire to take their place. For example, probiotic mixtures of beneficial gut microorganisms, and the prebiotic ingredients which support colonisation of the gut by these microbes, as well as immunoglobulins in various formulations as a result of fractionating, or separating, these large molecules from animal plasma or eggs. Immunoglobulin fractions may also include many other biological molecules from plasma that contribute to the beneficial effect of the bioactive ingredient: however, to the commercial end-user, the preparations are chemically undefined.

Consequently, it is difficult to identify companies that are direct competitors for the Australian meat industry's proposed purified blood products as bioactive feed ingredients. The major benchmark in animal proteins as nutritional and bioactive feed ingredients is the US-based American Protein Corporation. However, APC does not produce the purified animal proteins, but fractions derived from plasma or serum, which are further processed, spray-dried and granulated. Each of the products therefore has a differentiating characteristic to support its application but for none is there one single biological component. The animal response to APC's products can be assessed against

control feeds, but the specific blood molecule or molecules responsible for the growth promotion, feed efficiency, stress resistance or health benefit can only be conjectured.

A comparison between the bioactive feed ingredients produced from animal blood by APC and those proposed by this work is summarised in Table 4. As far as possible, the Australian meat industry's blood-based products are matched to those of APC by composition. Recent US retail price per pound of each has been converted into USD/tonne.

From this comparison, the haem meal products are the lowest value per tonne, the immunoglobulin fraction products are the highest, with the serum albumin and immunoglobulin fraction at an intermediate value.

Table 4: American Protein Corporation's blood-based products as bioactive feed ingredients.

MLA proposed comparables	APC Product	Source	Target animal	Purpose	Price	Price per tonne (Calc)
Haem	AP301/ AP301G	Bovine and /or porcine. Products are segregated according to source.	Aquaculture, swine, poultry, ruminants and companion animals	Protein and iron source	US\$76.95 for 55lbs (25 kgs)	US\$3,080
BSA and globulins	Appetein	Bovine &/or porcine.	Pigs and poultry	Bioactive Protein source	US\$172.40 for 55lbs (25 kgs)	US\$6,900
BSA and globulins	AP920	Bovine &/or porcine. Products may be segregated according to source.	Pigs, poultry and aquaculture	Bioactive Protein source	US\$173.95 for 55lbs (25 kgs)	US\$6,900
Immuno-globulins	Solutein	Bovine	Pigs	Bioactives	US\$169.95 for 22lbs (10kg)	US\$17,000
Immuno-globulins	Gammulin	Bovine	Calves	Bioactives	US\$152.10/22lbs (10kg)	US\$15,200

(Sources: APC website and product documents; Corelli Consulting resources; current US retail prices from <http://livestockconcepts.com>.)

It may not be possible to directly compare the proposed products to competitor feed ingredients on an efficacy or economic basis, until a level of bioequivalence is determined from performance studies in the target animal and a rate of inclusion is determined for the proposed ingredients. International companies with a core business in collecting, refining and marketing animal blood products in the feed sector and providing these as ingredients to the feed compounders, include Daka Denmark A/S (Denmark), Vapran SAS (France), VEOS NV (Belgium), Haripro SPA (Italy), Regal Processors Ltd (Ireland), Sanimax Inc. (Quebec), Sonac BV (the Netherlands), American Protein Corp (US), and Nutreco (the Netherlands).

### 3.5.1 Case studies

Four significant animal feed and pet food companies with global reach are profiled here: Sonac (the Netherlands), American Protein Corp (US), Nutreco, and Mars Inc. (US).

### 3.5.2 Case study 1: American Protein Corp

American Protein Corp (APC) has operations across the US, as well as internationally in Brazil and Argentina, the UK, Poland, Spain, China, and Japan [43]. APC has a business model in which the supply chain from animal to market-ready product is directly managed by the company. The collection of blood from food-grade meat animals, its fractionation and subsequent handling is undertaken within a closed processing framework. The driver behind APC's business model is likely to have been the technology for processing plasma to generate a highly digestible product for the feed industry, a technology shared with the food ingredients sister company, Proliant. The route to market is by direct sales and online distributors. The target animals for the bioactive ingredients produced are pig, poultry, fish and companion animals. The growth of the company is organic, although strategic partnerships for feedstocks (blood and dairy) have been recently established.

**APC Products**

APC produces “functional (or bioactive) proteins” which are a complex mixture of biologically active proteins that the company asserts support and maintain normal immune function [3].

While the price for each product is available online, the annual volumetric production of each was not reported by APC.

**Example of nutritional and bioactive proteins: AP301** comprises protein fractions derived from animal red blood cells, marketed by APC as high quality, highly digestible and palatable proteins as feed ingredients for aquaculture, swine, poultry, ruminants and companion animals. AP301 is a proprietary spray-dried haem meal derived from bovine and/or porcine blood [8]. However, products from each animal source may be separately marketed [11].

As a whole red blood cell product, AP301 has a higher protein content (99.5% of dry matter) than haem supplements, and about half the iron content of conventional haem. Inclusion of AP301 in feeds for pigs has been reported to result in a good feed conversion ratio and lower feed intake than haem or iron supplements, and a higher energy value than blood meal. AP301 is reported to provide a better colouration in the meat of animals fed with this supplement than with haem or iron supplement [14]. The colourant properties of AP301 recommend this ingredient for inclusion into those companion animal food products that are designed to look like red meat. Studies have shown that 2.5% granulated blood cells leads to a growth performance which is comparable to that achieved by the addition of 4% fishmeal to a pig starter diet [15]. AP301 provides high levels of essential amino acids, but particularly lysine (9.6% of crude protein) which is limited in pig and poultry cereal-based diets.

The technology used to spray-dry this product is reported by APC to provide a higher digestibility level, high processing yields and low protein variability.



AP301 (Source: American Protein Corporation)

The proprietary fractionation and purification process used by APC for AP301 is described in the patent US 749872 [14]:

- Blood is collected directly at the abattoir and held in a chilled, circulating stainless steel tank with anticoagulants such as sodium citrate;
- Whole blood is then separated (e.g. by centrifugation) into red blood cells and the plasma fractions then is stored chilled; and
- The red blood cell fractions are then spray-dried.

As a feed ingredient, AP301 contains 92% crude protein by weight, 4% moisture, and 1800-2500 ppm iron. AP301 is typically combined with other feed ingredients: processed grains, gelatinized starches, milk products, sugars (dextrose, glucose, sucrose), fats and/or oils, animal proteins, and refined, extruded soybeans at an inclusion rate of ~2-5% by weight of the base feed [14].

A recent US retail price for AP301 was US\$76.95 for 25 kilograms [11] (or US\$3,080/ tonne).



### 3.5.3 Case study 2: Sonac

Sonac BV has built its business by acquisition and is itself part of a recent acquisition by a US-based firm aiming to build a global presence in foods and feeds. Sonac has production facilities in four continents for processing animal bone, fats and blood. The route to market for Sonac products is by direct sales and an international network of distributors. The target animals for the ingredients produced are pig, poultry, aquafeeds and companion animals.

Sonac BV (Sonac) [44] is a Netherlands-based company established in the 1930s. Sonac was part of VION Ingredients, within the VION Food Group, until the division was acquired in January 2014 for €1.6 billion (US\$2.17 billion) in cash by Darling International Inc., a listed company based in Texas, USA. VION Ingredients housed animal by-product processing companies such as Rendar, Sonac, Ecoson, Rousselot, CTH and Best Hides, and generated revenues of US\$1.6 billion in 2012, with EBITDA of US\$200 million [45], a margin of 12%.

The Sonac group of companies is a dedicated processor of food, gelatin and abattoir by-products to generate ingredients for the food, pet foods, aqua feed, pharmaceuticals and fertilizer markets. For the feed industry, Sonac produces animal fats, proteins (including those from blood products), minerals and specialties with application in the pig, poultry, dairy, aquafeed and calf milk replacers (CMR) markets. Sonac has implemented process integrating software, process control equipment and quality programs including ISO 9001, ISO 14001 and HACCP<sup>9</sup>.

To service the EU market, the company has regional production plants in the Netherlands, Germany, Belgium, Poland; and subsidiaries in France, Spain, Italy and Portugal; and exports outside the EU to such countries as Japan, Russia, Thailand, Taiwan, Philippines and the US.

Sonac Australia Pty Ltd (Sonac Australia), a subsidiary of Sonac produces blood plasma and haemoglobin from food-grade meat animals. Formerly known as BAIC Protein Pty Ltd, founded in 2005 and based in Maryborough, Victoria, the company changed its name to Sonac Australia in April 2012.

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<sup>9</sup> Hazard analysis and critical control points

**Sonac Blood Products: Ovine Plasma Powder**

In September 2013, Sonac announced an expansion of its ingredient range with the launch of an ovine plasma powder. Developed specifically for the global pet food market, this new product is derived from Australian ovine sources (free-range lambs and sheep) and is EU-certified. Sonac's Australia-derived ovine plasma powder will target the international pet food market, offering a "healthy, super premium quality solution" to formulated limited ingredient wet pet foods, treats and snacks. In these pet food products, ovine plasma powder acts structurally as a binder, and is proposed to contribute taste and palatability benefits which cannot be achieved from vegetable proteins. As an ovine-derived ingredient, this plasma powder is promoted as one that avoids the allergies induced in sensitive pets from the use of bovine- or porcine-derived binders. This, coupled with the positive safety and natural perception of Australian-derived ovine ingredients, offers pet food manufacturers more variety in formulating pet food options with broader consumer appeal.

This production is a consequence of an expansion of the animal blood processing facility in January 2013 in Maryborough, Victoria, which will more than double the plant's capacity. Currently, the plant processes 9,000 tonnes of blood per year collected from abattoirs into fats, proteins and minerals, and will expand to a capacity of 20,000 tonnes a year. The expansion is estimated at A\$2.5 million, and is supported by an investment by the Victorian state government of A\$340,000 [10]

This report is not aware of any other ovine plasma feed ingredient on the market.

A recent retail price for the ovine plasma powder is A\$5000/tonne (prices provided by Sonac Australia).

### 3.5.4 Case study 3: Nutreco

Nutreco [46] is a substantial participant in the feeds sector internationally, with a driver to achieve sustainable feed ingredients and animal health. The target animals for Nutreco's compound feeds and speciality ingredients are equally animals (ruminants and non-ruminants) and aquafeeds, although Nutreco (under the Skretting brand) is committed to expanding its fish feed division. Nutreco's global footprint continues to expand by means of a program of systematic acquisitions in strategic jurisdictions. Control over the supply chain is managed by means of sustainability agreements with suppliers. Nutreco's route to market for its feed ingredients is by a network of distributors in all major geographies.

Nutreco reported revenues in 2013 of €3.87 billion (US\$5.27 billion<sup>10</sup>) of which the Animal Nutrition division accounted for €1,837.3 million (US\$2.5 billion), and the Fish Feed division accounted for €2,029.8 million (US\$2.76 billion). In term of jurisdictions, Nutreco reported that the biggest markets were that of North America (animal nutrition €644 million (US\$876 million); fish feed €144 million (US\$196 million)), Western Europe (animal nutrition €577 million (US\$784 million); fish feed €241m (US\$328 million)) and Norway, Nutreco's most important salmon feed market (fish feed €792 million (US\$1.077 billion)) [5]. The significance of Northern Europe's aquafeed to Nutreco is evidenced by the revenues generated from Norway alone, which equalled the revenues from the combined divisions in each of North America and Western Europe.

<sup>10</sup> 1 EUR = 1.36034 USD

The revenues generated by this firm are high, and the profit margin (in this case EBITDA<sup>11</sup> margin) is around 6-7%, which likely reflects the tightness of the economics within the animal and aquafeed industries.

**Nutreco: Market share**

Nutreco reports the company's global market position in animal nutrition as number two in the premix market, and a 12% share of the global market, with growth in organic sales volume in this market of 3%. Nutreco is the market leader in Canada's feed industry. Nutreco produces in excess of 2.4 million tonnes pa of compound feeds, concentrates and pre-mixes [5].

In the fish feed segment, Nutreco claims market leadership in the salmon feed market with a global share of 33%, and number three in shrimp feed: the long-term average growth rate in fish and shrimp feed is ~5% pa. Skretting is Nutreco's branded fish feed producer and in Norway has recently upgraded the production plant at Averøy to 420,000 tonnes of feed pa, which makes that plant the largest dedicated fish feed plant in the world. The plant operates at 13,000 tonnes per week at peak demand. Globally, Nutreco produces in excess of 1.9 million tonnes of fish and shrimp feed products [5].

### 3.5.5 Case study 4: Mars Inc

Mars Inc. was first established in the US as a confectionary maker in 1911 and remains privately-held, controlled by the Mars family. The corporation reported total annual sales of more than US\$33 billion in 2013, has 70,000 staff globally, and was ranked 5th in Forbes' list of America's largest private companies [47, 48].

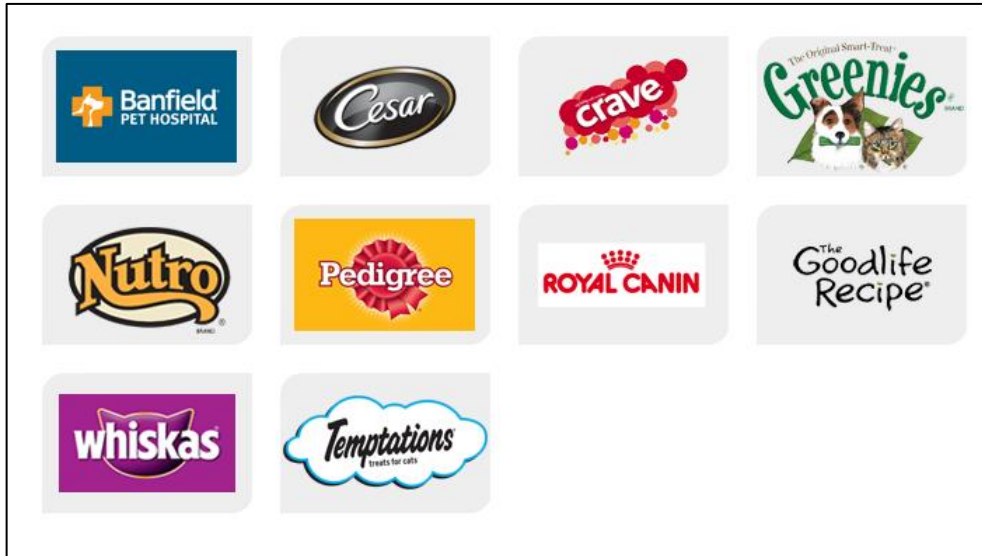
Mars Inc. operates six lines of business: chocolate; gums and confections; petcare; food; drinks; and information technology. In April 2014, Mars Inc. bought 80% of Procter & Gamble Co's pet food business for US\$2.9 billion. The acquisition increases Mars Inc.'s market share and footprint in major jurisdictions in North America and Latin America [49].

In a global pet care industry that Euromonitor International projects will reach US\$76.8 billion in sales in 2014, Mars Inc. now has the clear dominant global market share. As a result of the Procter & Gamble deal, Mars Inc.'s share of the North American dog and cat food market is expected to increase from 16% to 25% [50]. In 2012, market observers noted that Procter & Gamble's Iams brand had a turnover of ~US\$2 billion, and that pet foods businesses in Nestle, Mars and Procter & Gamble had large margins, such that for Nestle, the world's biggest food company, pet foods was the second-most profitable category behind coffee [51]. Margins for natural, organic and gourmet pet foods are up to 40%, compared with 30% for premium brands and 20% for standard brands.

<sup>11</sup> EBITDA: Earnings before tax, depreciation, and amortization; a measure of a company's financial performance in a tax year.

### Mars Petfood business

The Mars Inc. business unit Mars Petcare manufactures and markets 35 brands in total, such as Kitekat®, Banfield®, Cesar®, Nutro®, Sheba®, Chappi®, Catsan®, Frolic®, Perfect Fit® and Greenies®, and in particular 3 brands with billion-dollar revenues (Pedigree® Whiskas® and Royal Canin®) [2] (Figure 4).



Mars Petcare: some global brands (Source [7])

Mars Petcare has recently expanded into Mars Fishcare, Mars Horsecare, Petservices: Mars Fishcare is currently removing fishmeal from its product API® fish foods on a worldwide basis, "to minimize our impact on the marine food chain" [9].

## 3.6 Summary: Global perspective

Growth in the global animal feeds and pet foods markets is sustained, and sector participants are acquisitive; companies are recognising increased opportunity particularly within fish and shrimp feeds and in pet foods. The growth areas in the animal feed sector are particularly notable in the jurisdictions of Latin America, Russia, Africa and Asia, especially in the global fish and shrimp feed markets. The pet foods sector, predominantly in Western jurisdictions including Japan, is recognised as generating a higher margin on revenues than other animal feeds sectors.

The key drivers in the animal and pet feed markets are sustainability and innovation, both of which are within the capability of the Australian meat industry to respond, either directly or indirectly.

A principle driver within the animal feeds sector is sustainability: both perceived and actual. Internationally, industry participants are being publically recognised for securing food and feed raw material supplies under more equitable terms directly from the producers, especially those in developing nations. Industry is also actively researching alternatives for those raw materials which can no longer meet demand i.e. are an unsustainable source of supply such as fishmeal and fish oil, and for replacements for antibiotics for immune health and stress management.

A second key driver in the sector is innovation. Industry understands that retaining a competitive edge requires considerable investment in innovation in new bioactive and structural ingredients and in the feed formulation, and in the provision of evidence of performance or health outcomes, or processing advantages. All four of these animal feed and pet food companies make ongoing investment in product and technology research and development: APC has built a broad portfolio of research papers in the bioactivity of animal plasma as a feed ingredient; Sonac has recently released the first ovine-derived plasma product; and Nutreco invests in both bioactive ingredient development and in toolsets to model a feed formulation optimised for both nutrient content animal health and cost effectiveness. Mars Inc.'s Waltham Centre for Pet Nutrition is a UK-based research institute which has been established for over 50 years, with a track record of more than 1,800 published research papers on pet nutrition and wellbeing in dogs, cats, horses, birds and fish [52].

## 4 Strategy

### GENERATING VALUE FROM “WASTE”: HOW CAN THE MEAT INDUSTRY CONVERT BY-PRODUCT STREAMS TO VALUABLE NEW PRODUCTS

The Australian meat industry is a well-established agri-industry built around commodity products. As an agri-industry, it is not alone in envisaging revenue generated by valuable new products, particularly derived from lower value by-product feedstocks. In Australia, the dairy industry is a significant exemplar of a commodities-based agribusiness that has invested in new technologies to successfully develop value-added products. Waste management issues may have initially driven value recovery from “waste” streams and product diversification in the dairy industry, but recognition of the value uplift in wider markets by consumers now pulls change in that industry.

#### Bega Cheese: Key messages

- Feedstock:
  - Business structure for feedstock supply is a cooperative structure
  - Feedstock supply provided by farmer shareholders and supplemented by contract suppliers
  - Logistics of feedstock aggregation facilitated by co-location of refining within feedstock producing regions
- Refining:
  - Company-owned manufacturing facilities of both refining process and product packing
  - Capability in feedstock processing built by acquisition of dairy processors
  - Centralised capability around a small number of company-owned refining facilities
  - Co-located in dairy producing regions
  - Each refining facility with technical capability dedicated to a subset of the company's product portfolio
  - Significant and continued investment in infrastructure & technology at refining facilities to maintain high level of production efficiency
  - Use of well-developed technologies

## Devondale (Murray Goulburn Co-operative): Key messages

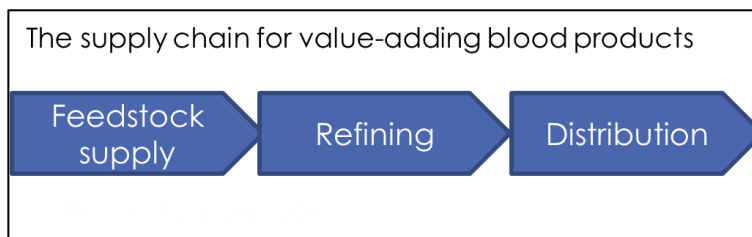
- Feedstock aggregation:
  - Co-operative business structure whereby feedstock is provided by dairy farmer-shareholders
  - Logistics of feedstock aggregation is by means of dedicated tankers.
- Refining:
  - Small number of company-owned and operated processing sites co-located with dairy production regions;
  - Centralised refining at dedicated facilities;
  - Investment in expanded capability and ongoing refining operations in key value-added areas.
- Distribution:
  - Company-owned distribution and logistics centres, including at ports to facilitate export
  - Facilities designed to hold dried, cooled or frozen product
  - Adequate capacity: from 18,000 to 130,000 tonne capacity

Animal products companies in the dairy industry have built a range of value-added products for a global market, with an eye to key growth jurisdictions. The Australian meat industry has already built pathways and networks to access global markets for its commodity products, and can potentially leverage this experience to access markets for a wider product portfolio.

#### 4.1 Building the business

A critical issue in building the business is how to structure a supply chain (see Figure 1) to underpin the blood product pipeline:

- Feedstock supply: aggregation and supply of feedstock adequate to support a commercial refining and manufacturing process;
- Refining: separation and purification capability to generate product(s) in volumes which meet demand; and
- Distribution of the product to the market.



*Figure 3: The key issues within the supply chain for value adding animal-derived by-products such as blood: the supply of feedstock in adequate volumes to meet production; refining of feedstock to the individual value-added products; and distribution of those products to the domestic and/or export markets.*

### Feedstock Supply

Other animal products companies recognise the need for security of feedstock supply: in the dairy industry, feedstock from supplier cooperatives is supplemented with feedstock from contract suppliers as needed to meet production volumes. In other market segments, alternative options are used to secure feedstock supply: in the animal blood industry, an independent refining company (e.g. APC) is supplied by exclusively contracted feedstock producers.

### Feedstock Aggregation

Feedstock aggregation in the dairy industry is simplified by the relatively small geographic footprint of the feedstock production industry in south-eastern Australia, and by the cooperative structure within the dairy industry. In contrast, the Australian meat industry may need *strategic logistics modelling* to manage feedstock aggregation over the wider national meat processing footprint to underpin the value-adding of meat by-product streams.

The timeframe for feedstock aggregation is a critical driver of the feasibility of the blood-based, value-adding business overall, while the radial distance between refiner and feedstock producer may be the critical determinant of the cost of operation. Blood is an unstable feedstock that degrades rapidly: therefore, a successful action plan for feedstock aggregation must meet short timeframes (Figure 2).

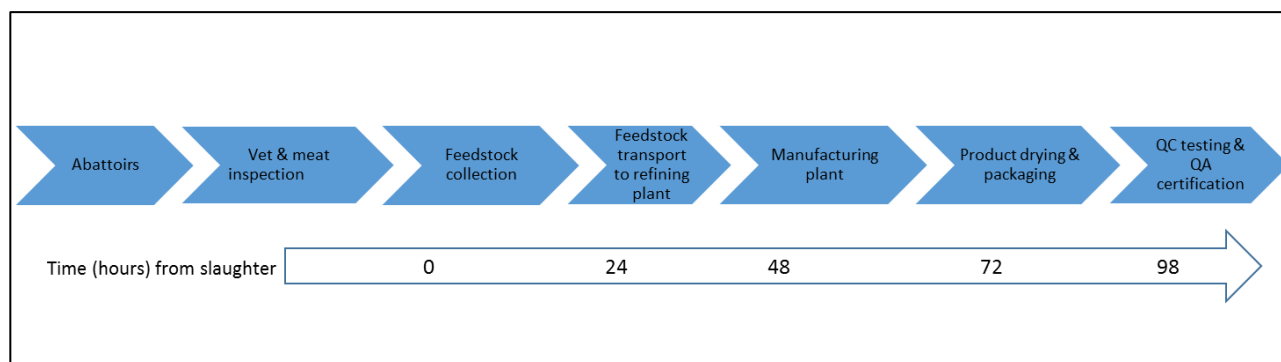


Figure 4: Time-dependent refining of blood products: Proliant's "Closed loop" Feedstock and refining supply chain for blood-derived BSA (Source: adapted from [53])

### Business/Venture Structure

There are a number of lessons to be drawn from the dairy industry in terms of a business structure to support feedstock refining to generate more value-added products.

"By moving our products up the value chain, we get a premium for every drop of milk we process"

Peter Jones  
Fonterra Australia's director of ingredients,  
Sept 2013[4]

The dairy industry aggregates feedstock around a small number of centralised company-owned or joint-venture (JV) manufacturing and packaging facilities for the value-adding of milk. Dairy has invested in in-house manufacturing and packaging infrastructure with well-developed innovative



technologies including robotics and automated processing lines, and recognises that continual investment in technologies can ensure a high level of production efficiency, and therefore maintain competitive commercial advantage.

Dairy plans for the future: some participants in the sector are building currently under-utilised manufacturing plant capacity to allow for an efficient increase in future levels of production and for flexibility in product format.

There is a tendency in the dairy industry for specialisation of manufacturing at individual manufacturing sites, which enables a company to decentralise specialised technology, equipment and know-how. This specialisation underpins dairy's capacity to generate diverse value-added products by different industry participants: in specialty cheeses, paediatric foods, infant formulas, pharmaceutical/nutraceuticals, and cosmetics (see Figure 3). For example, a new nutritional powder blending and packing facility for infant formula business was commissioned at Bega Cheese's Tatura Milk Industries, a wholly owned subsidiary, early in 2014. The facility now has capacity to blend and package up to 15,000 tonnes of canned nutritional powders plus an allowance of facility footprint for future upgrades to increase capacity and provide product format flexibility [4, 54].

<b>Ingredients</b>	<p><b>Products:</b> milk powders (full cream and skim), a range of cheese products, specialty ingredients, whey powders, lactose, anhydrous milk fats (AMF), cream, caseins and caseinates, whey and milk protein concentrates.</p>
	
<b>Retail and Food Service</b>	<p><b>Products:</b> UHT milk, daily pasteurised milk, butters, dairy spreads, cheese, lactose free dairy products, table cream.</p> <p><b>Brands:</b> Devondale, LIDDELLS, Cobram Premium Cheese Range, Kiewa Country</p>
  	
<b>MG Nutritionals</b>	<p><b>Products:</b> whey protein isolates, lactoferrin, natural milk minerals, sports proteins, meal replacer / supplements, infant nutrition.</p> <p><b>Brands:</b> Natra, Ascend, Proform</p>
  	
<b>MG Trading</b>	<p>Twenty-one stores and four fertiliser depots servicing rural communities with a range of products and services including hardware; farm needs and equipment; animal health; fodder; dairy hygiene; seed; fertiliser; farm chemicals; work and safety wear; milking machine sales and servicing; technical, and agronomy advice.</p> <p>Other subsidiaries and joint ventures:</p> <ul style="list-style-type: none"> <li>• MG China (wholly owned)</li> <li>• Danone/Murray Goulburn (yoghurt and some other fresh dairy)</li> <li>• INTERMIX Australia (blended products)</li> <li>• Australian Milk Products (dairy products to Central America)</li> <li>• Dairy Technical Services (food and milk testing services)</li> <li>• ProviCo (calf milk replacer)</li> <li>• Tasmanian Dairy Products (milk processing in north-west Tasmania)</li> </ul>
	

Figure 5: The business units within Devondale (Murray Goulburn Co-operative Co. Ltd). Source: [55]

## 4.2 Refining

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End-user requirements that products generated from the proposed meat by-products refining business would need to meet, include:

- Volumetric supply: i.e. will production meet end-user demand;
- Quality, concentration metrics: i.e. will the product meet critical quality requirements for each market;
- Reliable, sustainable supply of product; and
- Price.

Consequently, there are critical issues within the supply chain for blood-based products around refining of feedstock into various value-added products, particularly refining and separation technologies. The key technology issues are:

- Consistency/standardisation of refining technologies and processes;
- Economies of scale; and
- Quality control and management.

As feedstock producers, meat processors are well-experienced in the practices required for harvesting meat from animals and collecting the by-product materials. However, the proposed business of value-adding those meat processing by-products, in this case blood, is a new one for meat processors. Therefore, this industry has no experience in the rollout of refining technologies or the business practices associated with this production and may need to consider what approach to take at the outset to begin to deploy the necessary technology and to produce product for the market to evaluate. In that case, suggested approaches for meat processors to consider in order to achieve the necessary standardised, high quality, blood refining required by the value-adding business may include:

- Outsource blood processing to CMO/tolling<sup>12</sup>;
- JV or acquisition of established value-adder (refiner); and/or
- Add the refining technology to their current in-house operations.

In addition, a staged rollout of a mix of these approaches may be an option for meat processors to integrate value-adding into existing operations and to initiate the new venture.

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<sup>12</sup> CMO/tolling: Contract manufacturing organisations

## 5 Value uplift

This section of the report sets out to address the issue of value uplift for the blood products, BSA, IgG and haem, as bioactive ingredients in pig and poultry feeds, aquafeeds and pet foods. However, this analysis is limited by the lack of established markets, and therefore, established market prices for these products. Nonetheless, the issue of value uplift and correspondence with the extent of refining of the original feedstock will be addressed.

### 5.1 Building value chains within the meat industry

#### Product pipeline

One option to approach the introduction of new refining operations within the meat processing industry is to consider the new bioactive ingredients, BSA, IgG and haem, as a part of a staged product rollout, with those bioactives ultimately to complete the portfolio of other value-added products from bovine-derived blood (Figure 4).

Refining operations may be initiated with the manufacture of well-established first generation products such as blood meal using technically simple approaches. This means that the meat processing industry can “sharpen the sword” by establishing the new value-adding venture with the least technical or market challenge. This is followed by the second generation production of dried plasma and haemoglobin meal which adds to the processing of blood meal with an extra technical phase (using technology such as centrifugation) to separate whole red blood cells from plasma, followed by drying. First and second generation blood, dried plasma and haemoglobin meal products all have an established market in the animal feed industry (Table 5).

Lastly, the third generation products, BSA, IgG and haem, are rolled out as additions to the existing product portfolio. The fractionation and purification of these products are likely to require new infrastructure, new skillsets, and will address a new market for bioactives within the feed and pet foods industries.

- Build the underlying business to support the blood product pipeline: addition of each new product to the existing portfolio
- 1<sup>st</sup> generation product: blood meal
    - Established feed markets
  - 2<sup>nd</sup> generation product: dried plasma and haemoglobin meal
    - Established feed markets
  - 3<sup>rd</sup> generation product: BSA, haem and immunoglobulins
    - New market for bioactive ingredients in feed markets

This report has recommended that the new blood-based refining business be established using a staged approach to provide the time for development of a full scale manufacturing process from the technology and assessment of the market readiness of the product. The value of the staged approach for both operational deployment as well as product rollout are comparable: there is time allowed to develop the market readiness of the bioactive products; to prepare for commercial

release of the bioactive ingredients into their target markets, and to integrate these new value-adding technologies into the existing refining operations.

As outlined by Vitale 2006 [56], value chains are based on a sequential series of operational participants, each of which converts or further refines a feedstock into a product; that product is then taken up by the next participant in the value chain as a feedstock for further value-adding. In this way, the value chain for value-added, animal-derived products (Figure 4) begins with the animal producer, followed by the meat processor, who converts animals into commodity products (meat) and by-product streams (e.g. blood, bone, organs and other materials), and ends with the retailer, who sells the ultimate product to the consumer.

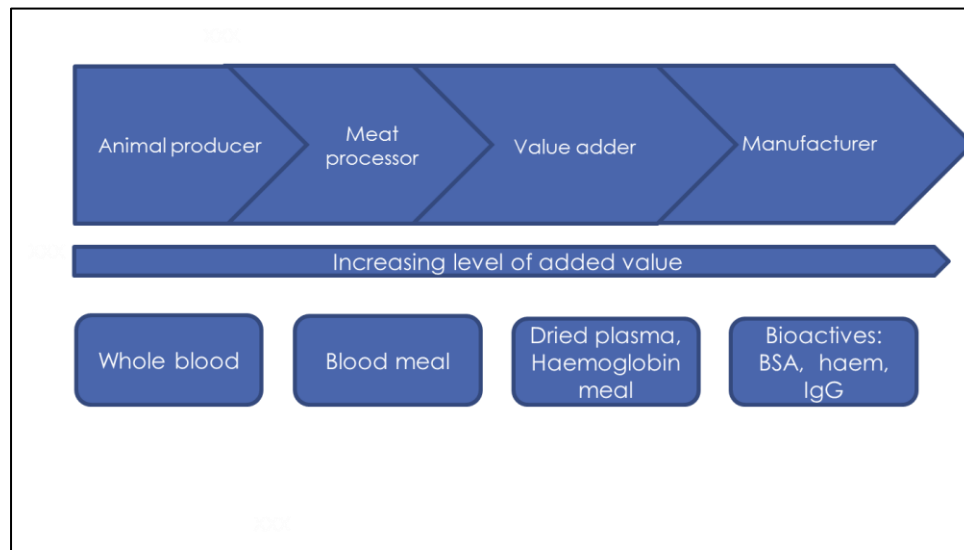


Figure 6: The value chain for blood-based products: participants and products

At the initiation of the value chain for animal-derived products, the meat processor provides feedstock to the value-adder for production of a bulk ingredient with (varying) extents of purification and fractionation. In this case, the initial feedstock is a by-product, generally of low value, which may otherwise incur a cost of disposal [56]. Inherent within the value chain is the assumption that material is altered and “improved” as it moves along the value chain, such that its value increases. The value-adder then provides the bulk ingredient to a manufacturer, who converts that material, by purification and/or reformulation processes, into a finished product. That finished product can either be sold directly to the consumer or to other customers, such as feed manufacturers, for inclusion in compounded feeds or pet health products or foods, i.e. steps of further value-adding.

Depending on the target market (bioactive or nutritional additive to animal or fish feeds, pet food additive or supplement), the technical challenge and technology investment, the cost of goods, and consequently the value uplift, some of the steps within the value chain may be undertaken by the same participant to capture more the value generated, such that the segregation between value chain components can become less distinct. That is, the meat processor may assume the operations of the value adder, and/or the manufacturer, within the refining business structure.

## 5.2 Relative value uplift

In contrast with the original assumptions of Vitale [56], the potential commercial uptake of bovine-derived BSA, IgG and haem is likely to be as bioactive components of animal, fish feeds and/or pet foods, rather than in the human nutraceutical market. However, no commercial demand has been established for these products and therefore there is no market data defined, such as retail price or volumetric uptake, to support modelling of the value uplift. The most general products comparable with the proposed blood-based products for these markets are those produced by APC and others (see Table 5). Unfortunately, these products are poor as price comparables, until the bioequivalence between the meat industry's proposed products and those of APC (in particular) is established by means of a direct correlation as feed additives in studies in target animals. Nonetheless, an indication of the relative value uplift of products derived from meat processing by-products is shown in Table 5 from existing commercial products.

Table 5: Relative value uplift of bovine-derived blood products for the feed industry

Refining technologies	Product	Value AUD/tonne	Reference	Notes
Nil	Blood	\$195	Vitale 2006	Production: 90-128mL pa (2014FY). Based on 20c/L & density of 1.025kg/L
Drying only	Blood meal	\$230	WRS	~86% protein. Inclusion rate: 5%
Separation & drying	HB meal*	\$3,000	APC, AP301/AP301G, spray dried RBC	Crude protein 99.5%, Iron: 1800-2500 ppm.
	Plasma meal	\$5,000	Sonac: bovine or ovine plasma meal	66.4% protein
Separation, fractionation & drying	Serum albumin*	\$7,390	APC: AP920 containing BSA & immunoglobulins ie Spray-dried animal plasma	78.0% crude protein. Inclusion rate: 5%-15% by weight of base feed
	Immunoglobulins*	\$16,280	APC: Gammulin, Bioactives	35-50% IgG by weight. Inclusion rate: 2.5% by weight of base feed

Source: Company websites, Stage 2 report. \* AUD = 0.93 USD

The rate of inclusion of the bioactives in compounded feed or as animal health supplements will be a major driver of the market demand for these ingredients. An understanding of the size of the market for these products and the price point will enable the modelling of the production scenario of any one refining operation. The *production scenario model* will enable optimisation of the product mix of meals and bioactive ingredients, and define the volume of feedstock required. This report anticipates that this model, together with the strategic logistics modelling recommended earlier, will assist the meat processing industry to define and initiate a successful value-adding bovine-derived blood business (Figure 7).

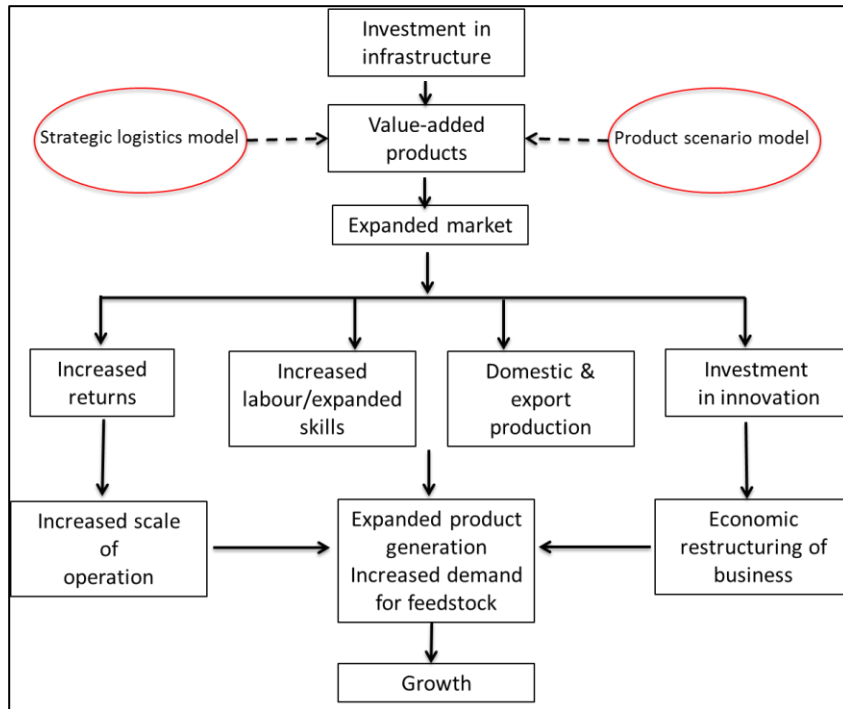


Figure 7: The economic benefits of value-adding to the Australian meat industry

## 6 Recommendations and Next Steps

This report recommends that the new blood-based refining business be established using a staged approach (Implementation Strategy) supported by an implementation team to provide the time for development of a full scale manufacturing process from proprietary technology and assessment of the market readiness of the product. The value of the staged approach for both operational deployment as well as product rollout are comparable: there is time allowed to develop the market readiness of the bioactive products; to prepare for commercial release of the bioactive ingredients into their target markets, and to integrate these new value-adding technologies into the existing refining operations. The means by which the implementation strategy is rolled out is best achieved by the strategic relationships formed by the Australian meat industry around new product development. Those strategic relationships, developed with partners who participate anywhere along the supply chain from feedstock processing to final product manufacture, may include collaborative relationships or joint ventures. These relationships bring technology, manufacturing and marketing capacity and know-how to the venture, and in this way help to manage the risk of the new venture for the meat industry.

### 6.1 Implementation Strategy

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There is potential for commercial application for blood-based bioactive ingredients such as BSA, immunoglobulins and haemoglobin in the key sectors of pig and poultry feed ingredients, in fish and shrimp feeds, and in pet foods, based on the acceptance and uptake of comparable ingredients. This is driven by market demand for bioactive ingredients to improve animal health and growth performance.

To access this market opportunity, the Australian meat industry and its partners need to establish and evidence the production of animal-derived blood-based products, with:

- Scalable manufacturing processes;
- Sustainable production from a transparent and auditable supply chain;
- Reliable product supply at appropriate volume to meet end-user needs;
- Quality and price targets;
- Innovation in feed ingredient composition, with benefits substantiated by an evidence pack in target animals; and
- Bioequivalence established for its blood products, leveraging existing published efficacy data on comparable products, such as haem and blood meals.

However, a key issue for the Australian meat industry in the commercial decision-making process is whether production of blood-based bioactive ingredients will support the high volumetric conversion of by-product streams. To date, however, a quantitative assessment of the value uplift of value-added blood-based products is limited by the lack of established demand and therefore established market prices and volumes required for these specific bioactive products. An understanding of the specific health or growth performance benefits and the rate of inclusion of the bovine-based bioactives in compounded feed or as animal health supplements will determine the market demand and price for these ingredients. In addition, the bioequivalence between the meat industry's proposed refined products and those of market leaders of similar products such as APC (in particular) may be established by means of a direct correlation as feed additives in animal studies.

Therefore, an implementation strategy for the Australian meat industry and its partners to value-add meat processing by-product streams as products for the industry animal and pet feed markets can be framed as a series of 'go/no go' stage gates, each designed to meet the following goals:

#### 6.1.1 Stage Gate 1: Define & demonstrate the product; estimate industry uptake

- *Define the Product*: Invest in further, independent, animal nutrition and industry research to define the benefits of the proposed blood products. Demonstrate that the products can be valuable bioactive ingredients in animal feeds and pet foods, by working with industry in trials of blood-based products in target animals.
- *Demonstrate the Benefits*: The benefits need to be substantiated by an evidence pack in target animals; this information will help to define the potential volumetric uptake of each blood product by industry on a *per annum* basis. These studies would ideally be carried out in collaboration with players within the animal industry, ideally animal producers and feed manufacturers, who are potential customers for the products;
- *Compare with existing feed supplements*: Leverage existing published efficacy data on comparable products such as haem and blood meals, and serum albumin. This may allow Australian meat industry and its partners to more rapidly establish bioequivalence for its blood products with existing commercial products, and therefore define the competitive advantage represented by these specific blood-based products.
- *Production targets*: Interaction with industry to define the rate and volumetric uptake of blood-based products by the animal feed and pet food industries. Understanding production targets will define the scale of feedstock supply needed to support a reliable and sustainable supply of product to market on commercial terms. In addition, an understanding of production targets will also refine the meat industry's assessment of the commercial viability of the overall venture of blood-based value adding.
- *Scalable technology*: Demonstrate that the technology to extract blood products from meat processing by-products can be scaled up. Pilot and larger scale production runs will also generate, firstly, product that can be analysed for quality, secondly, product that can be released to end-users for assessment, and thirdly, production data to refine capital and operating cost estimates. The demonstration of the process at scale may be undertaken by a manufacturing contractor (CMO - see insert) using the CSEP<sup>13</sup> technology.

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<sup>13</sup> CSEP or Chromatographic Separation is a continuous process for the separation and recovery of specific components (such as chondroitin sulphate) from a feedstock, such as cartilage.



**What value does a CMO bring?**

Toll or contract manufacturing organisations (CMOs) are able to generate proprietary products made exclusively for and on behalf of the contracting firm.

The manufacturing contract may be for small, short-term prototype runs, to full-scale high-volume production that span years. In the context of building a value-added, blood-based venture, the critical advantage to the meat processing industry of outsourcing manufacturing lies in the CMO's experience and capability to translate the research-derived manufacturing technology (CSEP) into a robust, reliable industrial process. Additional benefits to the contracting firm of using a CMO may also include:

- Compensation for lack of capacity or technical capability within the contracting firms operations, based on the CMO's manufacturing knowledge and experience;
- Streamlined time-to-market of a new product;
- Quality control, reliability and reproducibility within all phases of product manufacture;
- Control of processing and refining intellectual property;
- Efficient manufacturing costs based on the CMO's efficient operations;
- Lowered or circumvented capital investment in equipment, personnel and training required to create an effective in-house production operation, at least at the outset of manufacturing; and
- Lowered material costs, depending on the purchasing power of the CMO compared to that of the customer.

- *Product mix*: Each refining facility may be capable of generating the entire production mix possible from blood, namely blood, haemoglobin and plasma meals, as well as the higher value BSA, immunoglobulins and haem (Figure 6). At Stage Gate 1, the mix of products to be generated from each facility needs to be understood.

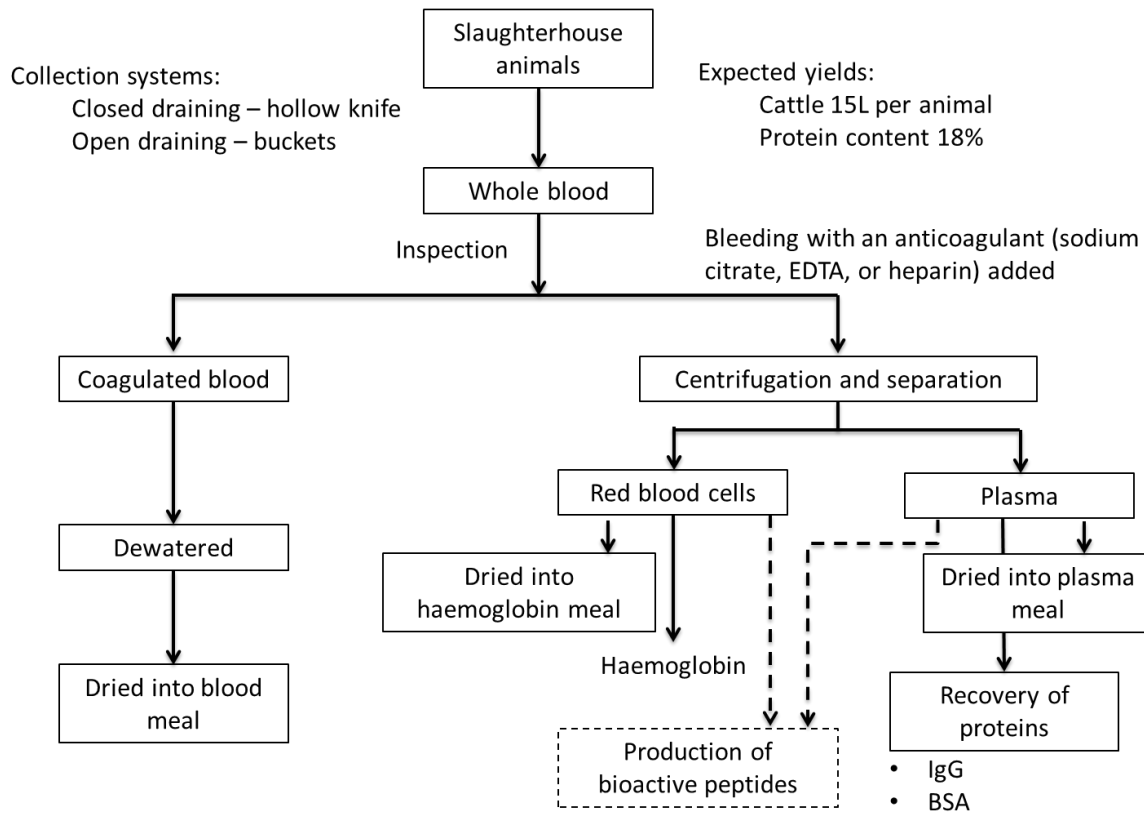


Figure 8: Whole blood processing: from collection into manufacture of usable fractions. Dotted lines indicate prospective production. Source: adapted from [57]

### 6.1.2 Stage Gate 2: Define the supply chain

- To minimise the distance the feedstock is transported, the blood value-adding industry is anticipated to be based within meat producing areas and concentrated around a small number of regional processing facilities. Based on the instability of blood as the feedstock and the geographic spread of feedstock producers, a *hub and spoke precinct model* for feedstock processing is recommended within the meat producing regions, with the refining hub at the centre of the spokes of meat processors.

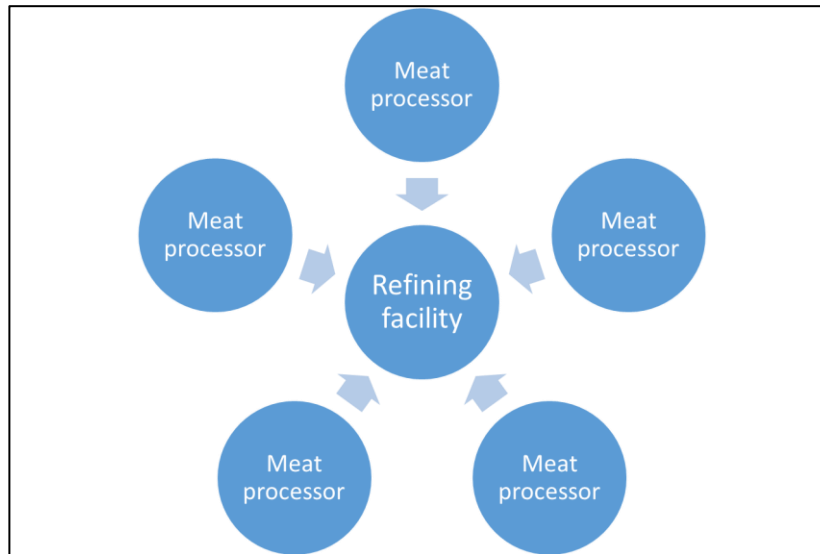


Figure 9: Hub and spoke model for the blood value-adding industry: the refining hub at the centre of the spokes of meat processors

The critical factor determining the co-location of the refining facility hub within its coterie of feedstock producers is the radial distance of the refining facility from those producers, dictated by the time required to transport the labile feedstock. The number of processors within the precinct structure is determined by the quantity of feedstock required to meet volumes of production of the value-added portfolio.

- Aggregation of feedstock needs to be achieved within suitable timeframes based on feedstock instability. The Australian meat industry and its partners may consider using *strategic logistics modelling* to manage feedstock aggregation over the wider meat processing footprint. The model is needed to predict the location of each centralised regional refining plant co-located with the meat processors, based on the hub and spoke model to meet the time constraints posed by a blood-based feedstock. Each refining plant will be located within the precinct at an optimal logistical distance from the coterie of feedstock suppliers based on the optimal time needed to aggregate an unstable feedstock. Therefore, the geography of the hub and spoke model is based on aggregation of adequate volumes of feedstock of appropriate quality: such that volumes of feedstock meet production targets at each refining centre.
- How will each refining plant be equipped? Each centralised regional refining facility may share the same set of technologies, capacity, and know-how to produce the entire value-added blood-derived product portfolio. Alternatively, as the dairy industry has done, individual refining centres may specialise in a subset of that entire portfolio, based on the volumetric demand for each product line and the availability of feedstock.
- The definition of those production volume targets needs to be modelled with input from the feed industry, for each stage of product rollout, for each product type, and for each precinct by means of *production scenario modelling*.

- A small number of distribution and warehousing centres may be needed to meet the logistical demands of export of the value-added blood-based products. These may be located at ports and/or road and rail transport interchanges.

### 6.1.3 Stage Gate 3: Define the Business structures

There are a number of options for structuring the business venture to value-added blood within the meat industry, predicated on optimising various significant business considerations such as feedstock aggregation and supply, technology deployed and relationships with end-users.

- Feedstock aggregation: A number of recommended business structures for the value-adding refining venture is suggested, based on different models of feedstock aggregation: in-house feedstock production from a single meat processor (independent model) or on feedstock production from a number of stakeholder meat processors (JV or cooperative models), with supplementary volumes provided by contract suppliers as required to meet production volume targets.
- Transparent and auditable supply chain: is anticipated to be a key attribute of the commercial arrangement with end-users [23].
- Technology: The business structure of the value-adding venture may also consider the issue of the refining and extracting technology. At the outset, the business model may therefore consider a joint venture with an appropriate manufacturer, and/or transfer of the scaled up extraction technology from a contract manufacturing organisation (CMO) into the refining business.
- End-user: In addition, the value-adding business may consider a JV based on a partnership between the meat processor(s) and an end-user, for example, a feed ingredients producer or feed compounder. The advantage of such a relationship for the feed industry partner might be to secure meals and/or bioactive additives to meet quantity, quality, delivery, and/or sustainability targets. The advantages for the meat industry partner may include highly valuable off-take agreements as well as financial and risk mitigation benefits. There are a number of financial and operational arrangements within this scenario that the meat industry may find worthwhile considering.

### 6.1.4 Stage Gate 4: Staged technology rollout

Technology rollout: The prospective blood-based products refining business may be established using a *staged approach*, which takes advantage of different manufacturing options. These options allow the meat industry to develop, in a step-wise approach: scale-up of the technology (currently at lab scale) to a commercial-ready process, assessment of the market readiness of the product and its performance and chemical documentation, and to secure and/or develop the skillsets needed to operate the refining operation, before achieving full scale commercial manufacturing. The recommended staged approach may be shaped as options, which include:

1. Outsource blood processing to a contract manufacturer (CMO or tolling) to establish the scalability of the proprietary process, and the market-readiness of the products.
2. Establish the refining facility by means of a JV with, or acquisition of, an established value-adder/refiner with the appropriate manufacturing capability.

OR

3. Establishment of a greenfield, independent refining facility co-located with the feedstock producer(s) and building in-house extraction capability based on transfer of the technology from the CMO.

## 6.2 Implementation Team

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The implementation team will support the staged implementation strategy and be responsible for:

- Strategic partnerships: Identification of strategic partners, and the development and management of relationships, on behalf of the meat processors and the value-adding venture. Strategic relationships are as essential as supply chain optimisation to overcoming the barriers and uncertainties that the meat industry may face in developing a sustainable and competitive value-adding venture. In one aspect, outsourcing in the agri-industry to build a value-adding venture (i.e. by means of a CMO) may evolve towards partnership and strategic alliance, bringing both tangible financial and strategic benefits to the venture. On the other hand, strategic relationships with end-users of the value-added products may reduce the risk of the venture by securing off-take agreements;
- Independent research: Engagement of independent, third party researchers to conduct animal studies and to compile efficacy data for the blood-based bioactives; and
- Strategic modelling: Project management of the modelling needed to assist the meat processing industry to define and initiate a successful value-adding bovine-derived blood business with input from all partners:
  - *Strategic logistics modelling* to manage feedstock aggregation over the national meat processing footprint. The model is needed to predict the location of each centralised regional refining plant co-located with the meat processors, based on the hub and spoke model to meet the time constraints posed by a blood-based feedstock.
  - *Production scenario model* to enable optimisation of the product mix of meals and bioactive ingredients from the refining operation, and define the volume of feedstock required.
  - *Financial modelling*: to support commercial decision making by the meat processing industry. A key issue for the Australian meat industry in the commercial decision-making process is whether production of blood-based bioactive ingredients will justify a high volumetric conversion of by-product streams. To date, however, a quantitative assessment of the value uplift of value-added blood-based products is limited by the lack of established demand and therefore established market prices and volumes required for these specific bioactive products. An understanding of the specific health or growth performance benefits and the rate of inclusion of the bovine-based bioactives in compounded feed or as animal health supplements will determine the market demand and price for these ingredients. In addition, the bioequivalence between the meat industry's proposed refined products and those of market leaders of similar products such as APC (in particular) may be established by means of a direct correlation as feed additives in animal studies.

In addition, evaluation of the relative opportunities for the use of blood-based products within the bulk feed market as distinct from the bioactives market needs further information on feed inclusion rates.

**BLOOD BASED PRODUCTS: STAGED IMPLEMENTATION STRATEGY**

**Target market:** pig and poultry feed ingredients, in fish and shrimp feeds, and in pet foods, driven by market demand for bioactive ingredients to improve animal health and growth performance.

**Stage Gate 1:** Define & demonstrate the product, in collaboration with end-users; confirm a scalable production technology; estimate industry uptake

**Stage Gate 2:** Define the supply chain: consider a *hub and spoke precinct model* for feedstock processing within the meat producing regions, with the refining hub at the centre of the spokes of meat processors.

**Stage Gate 3:** Define the business structures to achieve: feedstock aggregation, technology deployment and end-user alliances

**Stage Gate 4:** Staged technology rollout: scale-up of proprietary technology to a commercial-ready process, assessment of the market readiness of the product, its performance and chemical documentation, and to secure or outsource the skill sets needed to operate the refining operation, for full scale commercial manufacturing.

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