final report

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Blood processing capability analysis

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1 Executive Summary

Several meat processing establishments that currently collect pharmaceutical grade blood have been identified. These establishments supply citrated whole blood, non-citrated whole blood, liquid plasma and defibrinated young cattle blood to blood processors who may extract products such as BSA and IgG or who may export plasma or serum.

In addition, one blood processing company collects inedible-grade citrated whole blood from abattoirs. The blood is separated into plasma and red cell fraction and is spray dried. The spray-dried powders are used in pet food and animal feeds.

Blood can be collected for pharmaceutical use by manual collection methods (i.e. holding a bucket under a stuck animal) with very little technology. Automated collection systems are also available. Manual collection is suitable for kills up to about 800 per day but automated systems should be considered for larger throughputs.

Collection technology does not limit the availability of blood for value-adding purposes. However, there are doubts about whether collection of pharmaceutical-grade blood from Halal slaughtered cattle is viable. In Australia, blood for pharmaceutical use is not recovered from Halal-slaughtered adult cattle. Halal slaughter methods are considered to be an impediment to collection of pharmaceutical-grade blood but it is acknowledged that the impediment can be overcome and has been in New Zealand.

The total amount of blood available from slaughtered cattle is about 120,000 tonnes per year. The capacity for recovering blood for added-value pharmaceutical use in Australia is equivalent to up to 5,000 tonnes of whole blood although it is not suggested that this amount of blood is recovered for pharmaceutical use.

Examples of the value of whole blood in terms of the products that can be derived are:

- $0.075 to $0.165 per kg for inedible whole blood used to make meat meal;
- $0.3 per kg for blood separated into plasma and red cells and dried to make powders for use in pet food and as specialty animal feed ingredients;
- $0.53 - $0.68 per kg for pharmaceutical grade blood separated into liquid plasma sold to blood processors or exporters and red cell fraction used to make blood meal;
- $1.34 per kg for pharmaceutical grade blood used to make serum and residue used to make blood meal.

These values do not take into account collection costs, processing and infra-structure costs and costs to transport blood from collection sites to processing sites. When costs are taken into account, whole blood for blood meal production has a value of about $0.022 to $0.085 per kg if processed on the collection site. Blood for serum production has a value of about $0.94 per kg. (The value of blood used to make serum is based on a report of one contract and may not be typical).

MLA has identified that there are opportunities for the production and sale of four blood derived products (BSA, IgG, haemoglobin and pro-thrombin). However, there are at least four well established companies in Australia and New Zealand that have the capability to produce these products. Any expansion of the production of these blood products would have to be in competition with the existing blood processors and may not result in the increased exploitation of value-added

blood. Similarly there are established exporters of plasma and serum and these exporters have the markets well covered. The blood processors and exporters have indicated that they can source the blood they need from the existing capacity to collect pharmaceutical grade blood in Australia and New Zealand.

There may be larger untapped markets for value-added blood products for use in pet food and animal products.

To expand the recovery of blood for value-adding purposes, MLA could:

- support the evaluation of markets for the use of value-added blood products in animal feeds.
- assist in the preparation business plans designed to evaluate the viability of producing added-value animal-feed blood products in conjunction with plasma or serum for pharmaceutical use.
- identify partnership opportunities for meat processing companies. For example, meat processors could partner with blood processors, other customers for blood or companies that may have expertise in human blood products and are looking for opportunities in animal blood processing.

2 Introduction

Meat co-products contribute about 15% of the value of products from cattle slaughtering. Blood is one of the lower value contributors to overall product value. However, blood must be recovered and processed because it is highly polluting and EPAs do not permit the unlimited discharge of blood into effluent. The most common way of handling blood is to collect it via floor drains, coagulated it by steam injection, dewater the coagulated blood and dry and mill the dewatered coagulum to produce blood meal. The main use of blood meal is as animal feed. The value of whole blood based on the sale price of blood meal is around 10 cents per kg or $1.5 per head. These values do not take into account processing costs.

MLA has identified other potential uses and markets for blood. These alternative uses could provide improved returns for blood from slaughtered cattle. In particular, a study has identified that there are opportunities for the production and sale of four blood derived products (BSA, IgG, haemoglobin and pro-thrombin). The value of cattle blood used to produce these products should be higher than the value of blood used to produce blood meal. Apart from the technology required to produce blood products, abattoirs would have to change the way that blood is collected if the blood is to be used to produce pharmaceutical grade products. The blood must be collected hygienically avoiding contamination by hair or ingesta and with no added water. In addition, for most markets pharmaceutical grade blood must be from animals that have passed post-mortem inspection.

This project is intended to find out how blood is currently collected at Australian abattoirs and how the blood is used. It is known that the majority of abattoirs collect blood in an inedible fashion and that the blood is used to make blood meal. The project will identify what, if any, other forms of blood collection are in use and how much blood may be collected by other means. The project will also identify what further processing of blood, again if any, takes place at abattoirs. The project will identify the technologies required to collect blood in order to take advantage of further processing opportunities and provide recommendations of how the industry can exploit opportunities to sell value-added blood.

The project will describe the current capability of beef processors to recover value-added blood and determine what technology or equipment is necessary to advance the capability to collect blood for further processing.

3 Objectives

The project objectives, as specified by MLA were:

1. determine current blood processing, collection and processing systems within Australia at plant level;
2. identify current value adding streams from blood products;
3. identify and collate information on technologies currently globally available / being used by the Australian industry for blood collection;
4. evaluate strengths and weakness/limitations in current blood production and processing systems;
5. identify what impediments processors perceive to face them in collecting and value adding blood – technical, labour, logistics, value chain partners etc.;
6. make recommendations, based on industry feedback as to how best to accelerate the uptake of blood processing opportunities;
7. document which companies have collected and processed blood in the past (other then for rendering) and why they no longer do so;
8. quantify the value of blood as directed to the various streams available to processors: i.e. rendering versus wholesale blood versus plasma;
9. a brief comparison of Australian with NZ in terms of blood collection capability and bioactive extraction at the processor (and preferably value adder) level.

4 Methodology

The project was conducted by visiting blood collection and processing facilities and interviewing people who are known to be involved, or have been involved with blood collection.

Contact was made with overseas suppliers of blood processing equipment.

Regulators in Australia and New Zealand were contacted to determine what establishments are licensed to collect blood and what regulation apply.

5 Results

5.1 Blood collection and processing systems

Several Australian abattoirs that currently collect cattle blood for further processing into pharmaceutical or nutraceutical products were identified. Other abattoirs have collected blood in the past but have discontinued collection were also identified.

There are at least three companies in Australia that process pharmaceutical grade blood to make BSA and other blood products. These companies also export blood plasma and serum. These companies are:

- Selborne Biological Services
- Moregate Biotech
- Bovogen Biologicals

In addition, abattoirs recover inedible grade blood for a central blood processing facility that produces added-value plasma and red cell fraction powder for animal feeds.

5.1.1 Collection of pharmaceutical grade blood

Blood is collected both manually and with semi-automatic equipment.

Manual collection has been reported by one abattoir that is currently collecting blood and two that have collected blood previously. Manual collection involves holding a 10-12 litre bucket under the stick wound. The operator follows carcases along the bleed rail while blood collects in the bucket. This method of collection is used with a thoracic stick but could probably be adapted for a Halal stick.

The blood collected in buckets may be transferred via funnels to a blood processing room either adjacent to or underneath the stick hole. The whole blood may be bottled off (this occurs in New Zealand) or may be packed as citrated on non-citrate whole blood in pails. Alternatively blood from a number of carcases may be batched in preparation for separation into plasma and red cell fraction on-site.

An alternative to holding a bucket under the stick wound and following carcases is to use a hollow bladed knife (vampire knife). An example of a vampire knife is shown in Figure 1. These knives consist of a hollow tubular handle with a detachable blade. The knife is used to stick the animal and is left in place as blood drains through the handle and reinforced plastic tube to collection buckets or direct to batching vats.

Several collectors reported that manual collection in buckets held under the stick wound is preferred to collection via vampire knives. These collectors reported that vampire knives are heavy and cumbersome and one considered that vampire knives are a safety hazard because the heavy knife may fall out of the stick wound and may then have a slashing action because it is attached to stainless steel or flexible piping. Vampire knives, if used, should be fitted with hooks or clips that attach the knife to the neck of the stuck animal and reduce the risk of the knife falling out of the wound. It was also reported that because the knife is large compared with a conventional sticking knife, it causes blood clots in the neck.

Vampire knives are used in semi-automatic collection systems. It is reported that the amount of blood recovered is lower than for manual collection. This is because it is more difficult to stick accurately with the vampire knife resulting in slower bleed rates compared with an accurate stick into the aortic arch.

The manual collection systems do not involve proprietary equipment. They can be assembled from readily available equipment and the vampire knives can be fabricated on-site. If needed, vampire knives are also available commercially from Kentmaster (http://www.kentmaster.com/product.asp?CatID=1&CtgID=30&PrdID=SBN-1)

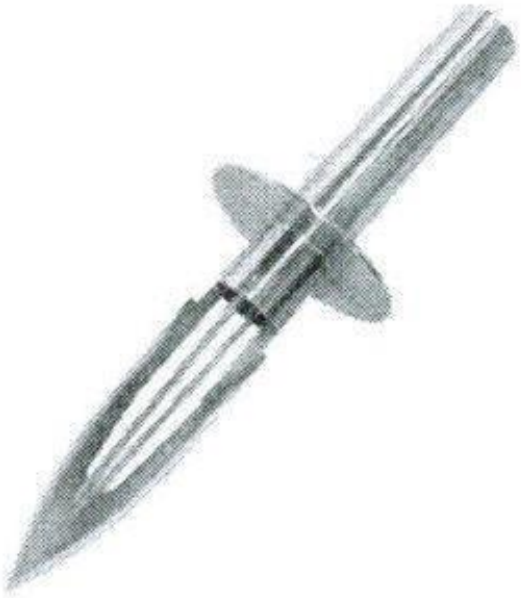

Figure 1: Kentmaster bleeding knife

Semi-automatic blood collection systems involve collection from carcases hanging on a rail or lying on a table.

The table system can apply to collection from Halal stuck calves or adult cattle. The stuck bodies are released from a V-restrainer-conveyor or knocking box on to a slatted conveyor table where they bleed into a drain. The blood collected in the drain is fed to collection vessels for processing.

A large scale semi-automatic collection system is supplied by the Swedish company Anitec. Anitec systems have been installed around the world (including Australia) to collect blood from kills of 35 to 240 cattle per hour.

In the Anitec system, vampire knives are connected by flexible hoses to collection tanks mounted on a carousel. Carcases are stuck manually with the vampire knives and the knives are left in-place while the carousel does one revolution. To insert the knife, a square of hide is cut from the dewlap with a conventional knife and the vampire knife is inserted towards the aortic arch through the

cleared flesh of the neck. Carcases are bled for the duration of one revolution of the carousel and the knife is then removed manually. As each tank on the carousel completes a revolution the blood in the collection tank is pumped to a transfer tank. The collection tank and knife are then cleaned and sterilsed automatically ready for the next carcase.

Blood from the collection tanks is accumulated in transfer tanks to create a batch. Blood is pumped from the transfer tank batch tanks. Batch tanks hold the blood from an identified number of carcases and if any carcase is condemned the batch is discarded automatically.

Approved blood is transferred from the batch tanks to an approved blood tank. It is cooled through a heat exchanger and is collected in a balance tank.

Chilled blood is centrifuged to separate the blood into plasma and red cell fraction.

Chilled plasma can be packaged for sale as liquid plasma or dried to produce plasma powder. The red cell fraction can be dried to produce red cell powder.

5.1.2 Collection of inedible blood for further processing

Citrated inedible blood can be collected for separation into plasma and red cell fraction and dried to produce plasma powder and red cell powder for pet food and animal feed.
Blood for this purpose is not rejected if it is derived from condemned bodies or is contaminated with small amount of ingesta. However, the blood has to be collected carefully to prevent contamination with water. Added water promotes haemolysis which results in discoloured plasma.

5.1.3 Plasma or serum

Pharmaceutical grade blood can be collected and supplied whole, either citrated or non-citrated, to blood processors. Alternatively the collector may separate the blood into plasma and red cell fraction by centrifugation or may defibrinate and clarify the blood to produce serum. Plasma can also be defibrinated to produce serum.

The semi-automatic collection systems such as supplied by Anitec are generally committed to centrifugal separation into plasma and red cell fraction. The manual collection systems can be associated with blood processing rooms, either adjacent to or close to the stick hole and have flexibility to produce either whole blood, plasma, defibrinated blood or serum.

If blood is separated into plasma and red cell fraction, anti-coagulant must be added as soon as possible after collection. When blood is collected through a vampire knife, sodium citrate solution is fed to the handle of the knife. If blood is collected in buckets the buckets are prepared with a dose of sodium citrate. Two major collectors have indicated that they use 8-10 gram of sodium citrate per kg of blood. There is also a recommendation that about 10 ml of 40 % sodium citrate per litre of blood is sufficient (Knipe, 1988).

Defibrinated blood is produced from non-citrated whole blood by winding strands of fibrin around a stirrer or paddle as the blood start to clot. This can be done by manual gentle stirring of the blood or by inserting collection wands or loops into buckets of blood and agitating the buckets on a rotary table. The stirrer, wand or loop is removed with fibrin attached after about 15 minutes agitation leaving behind defibrinated blood.

Serum is derived from defibrinated blood by screening the blood to remove small clots and centrifuging to remove cellular fractions.

Serum can also be derived from clotted blood but cutting the clotted blood into cubes and collecting the serum expressed from the clots. It can also be derived from plasma by addition or calcium which allows soluble fibrinogen in citrated plasma to convert to insoluble fibrin.

Serum is collected from clotted whole blood for markets such as Japan which do not permit the addition of citrate to pharmaceutical blood.

5.1.4 Issues with collection

Plasma and serum are subject to quality defects caused by haemolysis of red cells. Haemolysis is promoted by added water and it is important to avoid contamination with water during collection. It is also important to avoid other contaminants such as ingesta and hair. Blood contaminated with ingesta is not suitable for recovery for pharmaceutical use and should be discarded.

If serum is the target, the freshness of the blood at the time of defibrination by removal of fibrin strands is of primary importance. If there is a delay between collection and defibrination, clots may form before fibrin can be caught and extracted. In the case of plasma recovery, addition of citrate must occur without delay. This is done by adding sodium citrate to blood through the hollow bladed knife or by pre-loading sodium citrate into the collection buckets.

It has also been reported that pumping blood between collection tanks and batching tanks prior to separating can causes some haemolysis, particularly if pumps are allowed to cavitate.

If haemolysis occurs, plasma or serum is contaminated with haemoglobin and is discoloured. It has also been reported that plasma colour can be affected by cattle breed and season.

Blood processors have emphasised the importance of the application of quality assurance to blood collection to maintain quality by avoiding added water and other contamination. In addition, for pharmaceutical grade blood there must be a secure system to reject blood from condemned carcases.

5.1.5 Halal

There are different views about the collection of blood from cattle stuck by the Halal method. Some collectors have indicated that collection of blood is not feasible from Halal stuck animals while others indicate that collection is possible if more difficult.

The issues with collection from Halal stuck cattle are contamination from hair and possibly ingesta and the much slower rate of bleeding. Blood can be collected from Halal stuck animals using the bucket methods but collection through a vampire knife is not possible unless a thoracic stick is allowed immediately after the Halal stick. It is also helpful to insert an oesophagus plug to prevent contamination of the blood by ingesta. The slow rate of bleeding means that the collection time must be extended to achieve a reasonable yield.

Blood processors appear to avoid recovery of blood from Halal-stuck cattle in Australia. Two processors have reported that the quality of blood from Halal-stuck cattle is suspect due to the risk

of ingesta contamination and yields are low due to slow bleeding. However, pharmaceutical-grade blood is collected from Halal-stuck adult cattle in New Zealand.

5.1.6 Yields

The amount of blood collected per head is variable.

One report indicates that the amount of blood that can be collected hygienically in an open collection system (i.e. not through a hollow handled knife) in 60 seconds is as follows:

Blood weight = 7.67 + 0.007 x carcase weight (Graham and McPhail, 1974).

This equates to 9.5 litres from a 260 kg carcase.

Other research indicates that blood loss from stuck cattle is 20 grams per kg liveweight in 60 seconds. This is equivalent to about 9 kg from a 450 kg (about 260 kg carcass weight) body (Gregory et al. 1988).

Collectors have indicated that it is possible to recover up to 12 kg per body in 30 seconds but recovery of about 8- 9 kg is expected because of the typical bucket sized bucket!

The expected yield through a hollow handled knife is about 8 kg per head from individual animals. However, the average yield may be 6.5 kg per head when losses from condemnations and failure to collect from all available animals are taken into account. Chain speed also affects yields as increased chain speeds reduce the time available to collect blood.

The average target yield at manual collection establishments is about 9 litres per head from adult cattle.

It appears that careful collection in a bucket results in yields of 8 to 9 kg per head although 12 kg is possible. These yields do not include losses from condemnations. Collection in an automated system through a vampire knife may yield about 6.5 litres per head.

If plasma is produced, the expected yield is 60-65% of the whole blood (Ockerman and Hanson, 2000; Knipe, 1988, Graham and McPhail 1974). One processor has confirmed a yield of 60 % plasma from citrated whole blood. Another processor has indicated that in practice the yield of plasma from whole blood is about 55%.

The yield of serum could be 40% of whole blood according to one source (Anon., 2003). In practice a collector has indicated that 1,200 kg of serum can be collected from a kill of 600 head. This implies a yield of about 25% from whole blood.

In summary, practical yields are about 3.5 to 5 kg of plasma per head from adult cattle or 2 kg of serum per head of adult cattle.

Collection of defibrinated blood from calves and young cattle yields about 1.6 kg of defibrinated blood per head.

5.1.7 Current value adding streams

The annual cattle kill in Australia is about 7.9 million. In the ory, the total amount of available blood from adult cattle is about 120,000 tonnes. The potential yield of blood meal is about 20,000 tonnes. A survey by the Australian Renderers Association of production of rendered product in 2000/2001 reported that production of blood meal was 30,000 tonnes. This figure for blood meal includes blood meal from cattle, sheep, lambs, pigs and poultry.

The collection of valued added (pharmaceutical grade) plasma is estimated to be up to the equivalent of about 5,000 tonnes of whole blood per year. The capacity for collection of pharmaceutical grade blood is higher but a substantial proportion of hygienically collected blood is directed to other uses such as plasma powder for pet food and animal feed.

Current and recent value adding streams for pharmaceutical grade blood collected at abattoirs are:
Whole blood either citrated or not is supplied to blood processors in Australia for conversion to plasma or serum for export or for extraction of components such as BSA;
Citrated blood is separated into plasma and red cell fraction. Plasma is provided to blood processors in Australia who export plasma, derive serum from the plasma for export or extract component such as BSA.

Serum is produced from whole blood. It is frozen and exported by the collector. Serum could also be produced for supply to blood processors within Australia.

Plasma and red cell fraction are derived from citrated whole blood and the fractions are dried separately to produce powders for use in pet food and animal feed. Both hygienically collected potentially pharmaceutical grade blood and non-pharmaceutical grade blood (i.e. could include blood from condemned carcases) is used for this purpose.

Blood from collection sites that collect pharmaceutical grade blood is not all recovered hygienically. This is due to contamination, carcases condemnation or failure to collect from a body. The non-hygienically collected blood and the red cell fraction not used to produce red cell fraction powder is coagulated and added to raw material being rendered to produce meat meal or blood meal.

5.1.8 Technologies available for blood collection

Blood can be collected for pharmaceutical or edible use without much technology input. This appears to be the preferred approach by collectors and processors in Australia and New Zealand except where high kill rates and kill capacity is involved. More advanced technology is used in Europe where there has been considerable collection of edible blood in Scandinavia and Germany. Blood processors in Australia have reported that the main players in the extraction of products such as BSA and IgG are in the USA but no information on the recovery of blood in the USA has been discovered.

The technology used in Europe mainly relates to semi-automatic recovery of blood in a way in which batches or identified lots of blood are kept in correlation with carcases until the carcases pass the point of final inspection. One supplier of this technology is Anitec in Sweden (Anitec is now owned by Butina AB). Anitec has developed the following equipment:

- Anitec hollow knife®;
- RotaStick® bleeding carousel;

- RectaStore® intermediate storage;
- BallTec® plasma- and haemoglobin dryers.

The Anitec collection system requires manual input to bleed animals but the cleaning, storage, separation of plasma and red cell fraction, storage of plasma and red cell fraction and drying can be done automatically. Manual supervision of the system is involved. According to the Anitec brochure, for a cattle kill of up to 100 per hour the blood collection (bleeding) can be operated by one person. For kills of 100 to 300 per hour two people are required.

A complete Anitec blood collection system including drying of plasma and red cell fractions is in one Australian abattoir. Anitec has installed over 800 blood collection and processing systems worldwide.

Information about Anitec is available from the web site http://www.anitec.se/ Contact with Anitec should be made through parent company Butina through web site http://www.butina.eu/

G-Tech Bellmore is a New Zealand company that specialises in centrifuges for the rendering industry and other applications. Management of G Tech Bellmore has indicted that the company provides complete blood recovery systems but has not provided any details. G-Tech Bellmore can be contacted through the web site http://www.gtech-bellmor.co.nz/

Alfa-Laval, also a specialist in centrifugation, has indicted that it has centrifuges designed for blood separation. Details have not been provided. An Alfa Laval a tube centrifuge has been used by one Australian serum producer. Alfa Laval can be contacted through the web site http://www.alfalaval.com/contact-us/australia/Pages/default.aspx

5.1.9 Strengths and weakness of blood production and processing systems

The production and processing systems used for cattle blood are linked to the collection system. Table 1 summarises collection methods and the corresponding products and processing methods.

Table 1: Summary of blood collection and processing methods and corresponding products

Collection method	Products	Processing methods
Inedible collection of blood via floor drain.	Dried blood meal for general animal feed.	Whole blo od is co agulated and dewatered centrifu gally. The dewatered coagulum is dried to 5% moisture. The main d rying method is hot-air ring driers but cascading ro tary driers and steam heated contact dr iers are also used.
Inedible collectio n via bleeding into a tough feeding to a collection tank. Anti-coagulant is added.	Spray-dried plasma powder for pet food and specialty animal feed, particularly aquaculture feed and pig feed Spray-dried red cell powder for pet food and general animal feed.	Blood is collected wit h added a nti-coagulant. Blood is tr ansported t o a central processing facility where is it separated into plasma and red cell fraction by centrifugation. The fractions are spray dried.
Manual hygienic collection of blood from cattle t hat pass ante- and post-mortem inspection.	Citrated and non-citrated whole blood. Plasma in liquid or frozen f orm for pharmaceutical use. Serum may also be produced. Red cell fraction rendered with inedible material to produce meat meal or dried to produce blood meal.	Blood with anti-coagulant is collected in buckets a nd bulked in batches. Plasma an d red cell fractions are separated by centrifuge. Plasma or whole blood is provided to customers for further processing or frozen for export. Serum cou ld be produced at the abattoir but it is more common for blood proce ssors to ta ke plasma from the abattoir and then defibrinate t he plasma.
Semi-automatic hygienic collectio n of blood fro m cattle that pass a nte- and post-mortem inspection	Dried plasma powder and dried red cell fraction for use in pet food and specialty animal feeds such as pig feeds and aquaculture. Chilled liq uid plasma for pharmaceutical use. Defibrinated young cattle blood for export	Whole bloo d is co llected with vampire knives and anti-coagulant dosed into the blood. Automatic system batches blood and maintains correlation. Between blood and carcases. Plasma is chilled and sold to processors for extraction of components or is dried to plasma powder. Red cell fraction is dried. Young-cattle blood is f rom Halal stuck animals. It is collected in a trough and defibrinated. Defibrinated blood is frozen and exported.

5.1.9.1 Collection of inedible blood to produce blood meal

Strengths
- The process handles all blood in a single processing system.
- Technology is well established.
- No labour required for blood collection. Less than one full time operator required to manage the drying and bagging process.
- Markets and customers are well understood.

Weaknesses
- Value of the product (blood meal) fluctuates from $750 to $1,100 per tonne.
- Value of whole blood is very low e.g. 2 cents per litre to 8.5 cents per kg after costs, depending on blood meal price.
- Blood solids are lost to effluent in stick-water separated from heat coagulated blood.
- Contributes additional load on effluent treatment
- Use and markets for dried blood are limited to stock feed use only

5.1.9.2 Collection of inedible blood for processing by centralized processor

Strengths
- Avoids the need for investment in blood processing equipment. This is especially useful for small abattoirs
- Avoids the need for operation and maintenance of blood processing equipment.
- Removes all blood from site with little risk of escape of solids (e.g. in stick water) to effluent.
- Infra-structure is installed by the customer.
- Extra labour is not required
- Spray-dried plasma and red cell powders have expanded uses, particularly in pet food and pig feed and are priced higher than blood meal

Weaknesses
- Value of blood is low.
- Finished product quality is sensitive to added water.
- Finished product quality is affected by collection techniques.
- Delay in getting whole blood to the central processor affects quality.

5.1.9.3 Manual collection of blood to supply plasma or whole blood to processors or exporters

Strengths
- The value of blood is higher although if whole blood is supplied, the value to the abattoir may be limited.
    - (The product value of whole blood is about $0.6 per kg if plasma is produced. The product value of whole blood is about $1.65 per kg if serum is produced and $0.96 per kg after costs (see Table 3 below)).

- Yields from manual collection are higher. Yields of up to 12 kg per head have been reported. The typical yield is about 8-9 kg per head.
- Manual collection is more suited to collection from Halal slaughtered cattle.
- Some customers have indicated that they prefer plasma from manually collected blood.

Weakness
- Labour is high, typically three people to recover plasma from kill of about 600-800 per day.
- Labour could increase to 5 people per day if serum is recovered.
- Recovery can be inconsistent, depending on labour availability.
- Losses when a carcases is condemned may be high depending on the blood to carcases correlation system.

5.1.9.4 Semi-automated recovery to produce plasma and red cell products

Strengths
- Labour and collection costs are much reduced.
- Value of blood is higher due to reduced labour cost.
- Can recover and process blood from high slaughter rates and high capacity slaughter floors.
- Automated processes give greater hygiene security. Equipment is cleaned consistently and blood from condemned carcases is rejected reliably with reduced loss of excess blood.

Weaknesses
- Capital cost is high
- Yield is low, averaging 6 to 7 kg per body.
- The extensive infra-structure is less flexible e.g. is committed to plasma production and cannot readily switch to serum.

5.1.10 Impediments to collection of blood and value adding

Meat processors are generally interested in opportunities to add value to blood. Opportunities to collect blood to produce plasma or serum for sale to further processors are recognized.

Opportunities to further process plasma or serum to extract products such as BSA, IgG and pro-thrombin are generally not recognized although two meat companies (that no longer operate) have investigated this pathway.

The main impediment to value adding by hygienic collection of blood and producing whole blood, plasma or serum is lack of reliable and sustainable market opportunities. Customers are not beating at the door of abattoirs to obtain plasma and serum. When meat processors have looked for markets they have found sales opportunities difficult to identify. Sales when obtained are limited in the sense that one-off sales may be made but once the contract is completed, follow up sales are not necessarily available.

One processor who has produced serum indicated that finding suitable labour can be difficult but in this case five people were needed to collect blood and produce serum. The labour requirement is less for production of plasma.

Technical issues were not seen as impediments. There are two examples of meat processing establishments that have invested in equipment to produce plasma and red cell powder or chilled

plasma and frozen serum. These establishments maintained control over products and marketing and had to work throu gh technica l issues. However, in other cases meat pro cessors wor k in partnership with the customer and the customer pr ovides technical ex pertise inclu ding specify ing what equipment is req uired. The customer may install the equipment and provide labour for production of plasma.

Recovery of blood from Halal stuck animals is considered t o be more difficult than collection fr om conventionally stuck cat tle. Pharmaceutical-gr ade blood is not re covered from Halal stuck adult cattle in Australia and at least on e abattoir d iscontinued blood collection when a Halal kill was introduced. Blood processors have pointed out that yields from Halal-s tuck cattle a re low and t hat there is a risk of contamination. Con tamination can be limite d by oesophagus plugs and processors take blood from Halal-stuck cattle in New Zealand.

5.1.11 Recommendations to accelerate the uptake of blood processing opportunities

It is n ot clear whether th ere are additional opport unities f or blood processing. Colle ction of plasma and serum for further p rocessing is a mature business in Australia w ith at lea st three operat ors producing blood products including BSA and IgG. There is also an established trade in collection of plasma or serum for export, through intermediary traders, to further processors.

The further processors operating in Australia have indicated that they are sourcing sufficient blood in Australia and New Zealand and do not need additional collections at abattoirs.

Similarly, traders who export blood have indicated that they can source blood to meet e xport requirements. These exporters have suggested t hat there are a limited number of export customers with not much room for expansion.

There is one exa mple of an abattoir that established facilities to recover serum an d sell the serum for export. The abattoir was unable to make further sales after the initial contract was completed. There are n o clear opportunities to expand th e supply plasma or se rum to exp ort markets. T o accelerate blood proce ssing opportunities designed to supply plasma or serum it is essent ial to identify potential customers.

Opportunities to produce and sell blood products such as B SA, IgG, an d pro-thrombin appear to be even more difficult to take advantage of. The Australian co mpanies that produce blood products are obviously specialists b oth in produ ction and m arketing but are unable to expand the use of blood beyond current levels. These com panies have indicat ed t hat they ca n source all the blood t hey need and product sales are not limited by a shortage of appropriate quality blood.

A meat processing company could develop a business to produce blood products such as BSA, IgG and pro-thrombin. Such a business would be in competition with the exi sting blood processors and would not necessarily expand mark ets or sales. It may take sales from the existing processors and result in no additional use of blood.

Blood proce ssors have pointed out that marketing blood products involves going t hrough leng thy procedures, to establish customer relationsh ips and to be accepte d as an ap proved supplier. Customers may take years to vali date new s uppliers. In addition it ma y take a year bet ween supplying a sample to a potential customer and making a sale. Sales are not consistent and processors report that t hey may ho ld blood pro ducts in inv entory for years waiting to make sales.

Blood processors have pointed out that although pric es may seem high, products such as BSA are sold in a co mpetitive environment a nd production mu st be efficient and effective to be competitive and provide profit. This requires experience.

These difficulties do no t mean that it is impossibl e for meat companies to develop businesses in further processed blood but it is not clear whether a new entrant to the business could establish new sales and markets or would rely on taking sales from existing and more experienced processors.

Blood processors have indicated tha t the major production of blood products is in the USA and the USA is an i mportant market for the products. Production of blood products in Australia and New Zealand has expanded since the occurrence of BSE in the EU and the EU is an important market for Australian b lood products. It ha s a lso been suggested that India is e merging as blood proce ssor although th e target markets for Ind ian blood pr oducts have not been suggested. China is also a possible pro cessor of blood product s although blood proce ssors believe that the disease statu s in China will li mit blood product oppor tunities for pharmaceutical grade p roducts, if n ot animal feed products.

The important driver to get Australian meat companies to consider production of blood products is to identify growth markets and customers. One Aust ralian meat company has investigated production of blood products such as BSA. Management from this company co mmented that the project to extract blood products was discont inued beca use with a cattle kill of 600 head t he economies of scale were not favourable. It is claimed that sales for BSA could have been found.

The impression is that markets for pharmaceutical blood pr oducts are limited, there is competition for sales and if India and China are expanding production of blood products as su ggested, prices could be undercut.

There may be large volume markets for animal feed blood products such as plasma powder or other blood components. Plasma powder may be sold as a pet food ingredient for about $4,500 per tonne compared with about $9 50 per tonn e for blood meal. While the pet fo od market may be limit ed, at least within Australia, plasma powder and other blood products may be highly valued in animal feeds such as aq uaculture fe ed and pig feed. The value and efficacy of blood products in t hese applications has not been assesse d in this report but the market for such uses of blood products could be large.

An option for expanding opportunitie s for the use of blood is to investiga te markets for value-added blood produ cts in pet food and an imal feed. If the market opportu nities are f avourable, mea t companies could set up to collect blood hygienically but with the main objective of producing value added animal feed pro ducts. As opportunities arise, pharmaceutical grade plasma could be supplied.

MLA could support the uptake of blood processing opportunities by evaluating markets for the use of value-added blood products in animal feeds.

- MLA could support the uptake of value-added blood products by assistin g in the preparation of business plans desi gned to evaluate the viability of pr oducing ad ded-value animal feed blood products in conjunction with plasma or serum for pharmaceutical use.
- People involved in blood processing have suggested that for a meat company to successfully exploit bloo d processin g opportunit ies, the meat processo r should be in partner ship with

blood processors, other customers for blood or companies that may have expertise in human blood products and are looking for opportunities in animal blood processing. MLA could identify such partnership opportunities.

Some Australian blood processors and plasma exporters source blood from New Zealand. There may be an opportunity to increase blood processing opportunities in Australia by repatriating some of the New Zealand production. It is pointed out that New Zealand has a better clean and green image than Australia, has more knowledge and experience of blood collection and rationalization and profit squeezes in the New Zealand meat industry have made abattoir operators hungrier for opportunities such as blood processing (this is presumably code for blood plasma and serum being available more economically in New Zealand). Despite the apparent advantages for sourcing blood in New Zealand, collection at New Zealand abattoirs is limited and collections are not consistent (see comments on New Zealand below).

5.1.12 Blood collectors that have discontinued collection

Several establishments have been identified as collectors of blood but have discontinued collection. Reasons given for discontinued collection include:

- change to Halal kill;
- new customer could not be found when initial contract was completed;
- partner in blood collection transferred operations to New Zealand;
- price offered for plasma did not justify equipment and labour costs

5.1.13 Value of blood in different streams

The relative values of blood are shown in Table 3.

5.1.13.1 Blood meal value

The large majority of blood available at Australia abattoirs is collected in floor drains as inedible blood for production of blood meal for general animal feed
The value of inedible blood depends on:

- blood quality, especially added water which affects the yield of blood meal;
- the costs of processing which also is affected by added water in addition to equipment and management of the process;
- the price paid for blood.

Whole blood is 19% solids (Gorbatov, 1988). The solids content of blood as collected on the slaughter floor is undoubtedly lower and for the purpose of these estimates of value is considered to be 15%. The typical solids content of blood as collected on the slaughter floor has been reported to be 10 to 15 % (Pilkington, 1975) (Independent renderers have indicated that the solids content of blood received from abattoirs is 7 to 11% but this applies mainly to poultry blood). Pilkington also reported that there is a loss of 4% to 20% solids in the blood sick-water.

From Pilkington's figures the yield of blood meal from whole blood could be from 9% to 15%.The cost of processing blood to produce blood meal is variable. Operators have indicated that the cost of producing blood meal is about $530 per tonne of blood meal. However the cost of producing blood is difficult to assess because costs are not easy to separate from other rendering costs. The

cost of $530 per tonne is from independent renderers who have separated cost of blood processing from other rendering operations.

The value of blood meal has fluctuated between $750 and $1,100 per tonne ex. works in the last two years (Spooncer 2010). Assuming a processing cost of $530 per tonne of blood meal, Table 2 shows the value of whole blood based on yields for blood from 9 to 15 % and prices from $750 to $1,100.

Table 2: Values of blood used to produce blood meal after deduction processing costs

Blood meal yield (% of whole blood as recovered)	**Value of inedible whole blood as recovered via floor drain (cents/kg)**	
	Blood meal price $750/tonne	**Blood meal price $1,100/tonne**
10 2.2		5.7
15 3.3		8.5

If inedible blood collected on the slaughter floor (with added water) is valued at 2.2 to 8.5 cents per kg, the value of blood per head is about 44 cents to $2.3.

5.1.13.2 Recovery of inedible blood for separation into plasma and red cell fraction for spray drying

There is one operation that collects whole liquid blood from abattoirs, separates the blood into plasma and red cells and spray dries the fractions to make powders for pet food and animal feed. The price the processor pays for blood has not been disclosed. However, it is confirmed that the processor pays for blood whereas renderers who take in blood to make blood meal do not pay and may charge to cover transport costs.

Other sources have indicated that dried plasma powder for use in pet food is valued at about $ 4.5 per kg. Dried red cell powder is priced similarly to blood meal. (These prices are not confirmed for spray-dried plasma and red cell powders).

Yields have been reported by the operator but cannot be disclosed. However, based on reported yields and assuming a price of $4.5 per kg for plasma and $0.95 per kg for red cell powder equivalent to blood meal), the value of whole blood based on product value is about 30 cents per kg.

Processing costs are not known but are probably higher than the costs assigned to production of meat meal. Transport costs apply and the processing facility is a dedicated site with substantial infra-structure and corresponding staff. Also the amount of blood processed is not known.

In comparison, the product value of blood used to produce blood meal (not including processing costs) is about 7.5 cents per kg to 16.5 cents per kg.

5.1.13.3 Recovery of pharmaceutical grade plasma or serum

The value of plasma is not clear. One collector of plasma has indicted that the price of pharmaceutical-grade chilled liquid plasma is $0.8 to $1 per kg. Lower prices may also be offered. One blood processor has indicated that the price paid for serum is about 3 - 5 times greater than plasma. Assuming the price of serum is $5 per litre as reported by one abattoir producer, the price

of plasma is presumably about $1 to $1.5 per litre. Another blood processor has agreed that $1 per kg is a possible price for plasma.

Plasma yield is expected to be 60% of whole blood but some collectors report a yield of 55%. The red cell fraction is used to make blood meal or red cell powder of equivalent value to blood meal.
In this case the value of products is about $0.44 to $0.6 per kg of whole blood for plasma and about $0.08 cents per kg of whole blood for blood meal. Product value, not including costs, is about 0.52 - $0.68 per kg of whole blood or $3.4 to $5.4 per head.

Information on the value of frozen serum has been provided. This information applies to serum produced by manual removal of fibrin. It is suggested that this type of serum is more valuable than serum derived from plasma or clotted blood.

The price of serum was $5 per litre. The yield of serum from whole blood was about 25%. The remainder of the blood was used to produce blood meal.

The labour input to produce 1,200 kg of serum per day was 5 people. Capital investment was reported to be $50,000.
In this case the value of products is about $1.25 per kg of whole blood for serum and about 9 cents per kg of whole blood for blood meal.

Costs of producing serum are estimated to be about $1.4 per kg of serum and the cost of producing blood meal $530 per tonne. When costs are deducted from the sale price of products the return from 1 kg of whole blood is about 94 cents. This is equivalent to about $7.5 per head.

5.1.13.4 Summary of blood values

The amount of blood collected per head depends on collection methods and uses of blood. Table 3 summarises blood values in different applications and the value of blood per head taking into account blood collected per animal.

Table 3: Relative blood values

Use of product	Value of product ($ per kg of whole blood)	Value of product after deducting costs ($ per kg of whole blood)	Value of products per head of adult cattle ($)	Value of products per head after deducting costs ($)
Inedible blood for blood meal	0.075 – 0.165	0.022 – 0.085	1.1 – 2.4	0.33 – 1.3
Blood separated to produce plasma and red cell powder for pet food and animal feed	0.3 (the meat processor does not produce the end product and the value of blood to the meat processor is not known.)	Not known	2 - 3.6 (the meat processor does not produce the end product and the value of blood to the meat processor is not known.)	Not known
Recovery of serum	1.34 0.94 10.7			7.5
Recovery of plasma	0.52 – 0.68	Not known (variable)	3.4 – 5.4	Not known (variable)

Recovery of serum appears to be is the most profitable option for recovery of blood but the costings are based on a report of one sales contract which was not repeated.

5.1.14 Comparison of Australian and New Zealand blood collection capability

Collection of blood for further processing in New Zealand is reported to be more advanced than in Australia. The amount of blood collected in New Zealand and Australia has not been discovered with any reliability. However, the New Zealand Food Authority has advised of eleven establishments that collect blood for further processing. The list includes poultry and pig processors in addition to beef abattoirs. The list is not exhaustive and is a result of an informal survey of NZ FSA veterinary team leaders on behalf of this MLA project.

It was indicted that the eleven establishments do not collect blood consistently and collection depends on demand from the major blood processors, particularly Invitrogen.

There are two major processors of blood for pharmaceutical use in New Zealand. They are Invitrogen and Moregate Biotech. There are other processors who produce freeze-dried blood products and other blood products. The Australian company Maverick Biosciences collects plasma in New Zealand for export.

It is reported by industry sources that blood collection methods are similar to the manual methods used in Australia (i.e. manual collection in buckets) and described above. One abattoir manager has described a funnel that is used to collect blood from the stick wound of calves but this is the only reported difference between manual collection in New Zealand compared with Australia. Automated

collection techniques do not appear to be used in New Zealand. However, one New Zealand meat processor is in the process of installing a new collection facility that is claimed to be "relative sophisticated" and which may have some advanced features.

No objective evidence that supports a difference between blood collection capabilities in New Zealand compared with Australia has been obtained but the following comments have been made by blood processors:

- There is more knowledge and experience of blood collection in New Zealand. This is attributed to the long-standing involvement of Invitrogen in blood processing in New Zealand.
- There a greater perception by customers of blood products of a clean and green image in New Zealand compared with Australia.
- Restructuring and profit squeezes in the New Zealand livestock and meat industries have made the management of meat processing companies more receptive to co-product opportunities such as value-added blood recovery.
- In general, Australian abattoirs are considered to be less attuned to the application of quality assurance to co-products compared with their New Zealand counterparts (this comment is not intended to apply to all Australian meat processors).

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