

INTRODUCTION

Blood collected at abattoirs is a potentially valuable by-product. Blood can be used in the formulation of food products, additives (emulsifiers, stabilisers, clarifiers, nutritional additives, egg albumin substitute), pharmaceuticals, fertilisers, animal feeds as well as in numerous industrial applications. The value of blood can be increased by separating the blood into plasma and haemoglobin (AKA corpuscles, serum & red albumin). For example, 10,000 litres of hygienically collected blood equals 6,000 litres of plasma and 4,000 litres of haemoglobin.

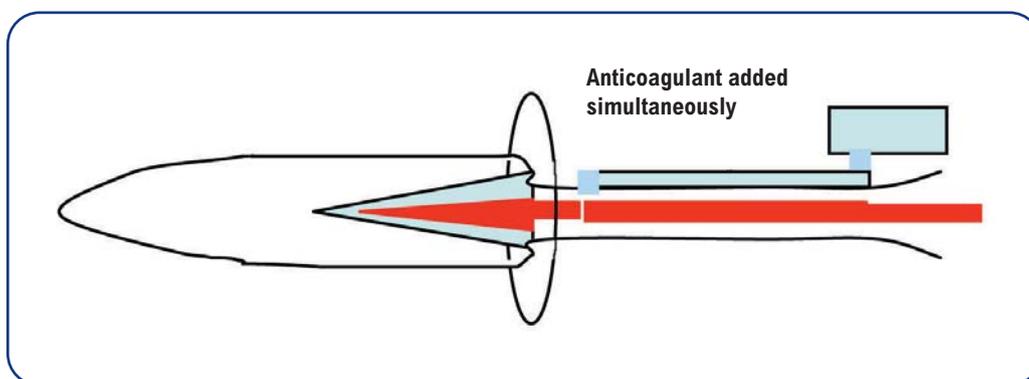
Blood is the first by-product that is obtained after slaughter, but is commonly discarded or not fully utilized because it is difficult to collect from cattle and especially sheep without contaminating it. It contains approximately 60% of the total potential protein available from by-products and is used as a source of human food, usually sausages which are fairly straight forward to make. Human usage is likely to increase as population increases and a worldwide protein deficiency increases. Even if the abattoir is not intending to harvest the blood every effort should be made to contain it. Allowing it to escape into the effluent system puts significant costs onto the water bill because of its high Biological Oxygen Demand (BOD) and suspended solids (SS).

Blood yields depend on many factors, e.g. animals size, killing speed, bleeding times and experience of the stickers. On average, 50% of an animals blood can normally be hygienically collected, the remaining percentage is retained in the capillary system throughout the body, which does reduce as the carcase is dressed through the abattoir. Bleed outs in the UK may be higher than 50% because although there is a requirement that dressing does not commence until 30seconds after the animal is stuck, this is usually longer in most British abattoirs. Knowing the bleed time and distance dictates the length of a blood trough.

Table 1 Blood yields per animal

	Yields per animal	Approx iron per 100 ml
Cattle	10–12 litres	45mg
Sheep	1.5 litres	34mg
Pigs	3 litres	42mg

Figure 1 Hollow knife for blood collection



COLLECTION TRAY AT STICKING POSITION

If an animal is to be bled care must be taken that it is properly stunned and rendered fairly immobile. Swinging and kicking animals can cause injury to the operators. Blood from healthy animals is sterile (free from microorganisms), and if the animals pass MHS inspection then it can be identified as “food for human consumption”, but it is sometimes contaminated during bleeding. To reduce this problem a hollow knife connected to a collection tube is used to direct the blood to a collection container. A flap of skin 100mm diameter should be removed prior to sticking.



Anticoagulant must be added at the collection point, at the knife blade itself (in-case of using a hollow-knife), otherwise the blood coagulates in the knife and in any pipe or pump and blocks everything. Coagulation inside equipment makes it “impossible” to clean, at least during normal production. The longer the time allowed for bleeding the higher the achieved yield. If it is to be used to make pharmaceutical products it is pumped to an agitated tank for further processing.

Where no existing collection arrangements are in place, or plans for other system proposed, you will need to install a mobile collection tray under the sticking position in order to collect blood in the abattoir.

Collection tray It is important that the collection tray is large enough to catch all the blood so as to keep the floor clean and minimise the amount of blood being washed down the drain.

It is designed to be portable so it can be moved to its point of use and then removed to allow the floor to be cleaned.



Hollow knife with tube



Blood collection in pig abattoir

STORAGE

Blood collection companies prefer daily blood collections but a minimum collection of at least once per week (old blood can have an offensive odour, and is nearly impossible or very expensive to process).

Blood collection companies have different methods of collection, according to the amount of blood being generated. The various categories of plant are listed below:

- Small plants are less than 3m³ per week
- Medium plants are greater than 3m³ but less than 10m³ per week
- Large plants are greater than 10m³ per week

Small Plants

The use of a 1000 litre Intermediate Bulk Container (IBC) is the most cost effective option. A new tank costs approximately £200 and they are also available second hand. The tank can be located on the “dirty” side of the plant and stands are available which include a “bund” to safeguard against spillage due to a faulty IBC or leaking connections.

Two collection schemes are proposed.

Either:

- The tanks will be emptied by a “milk round” tanker fitted with a hose and a vacuum pump. The exhaust from this pump will be passed through a charcoal filter to reduce odour pollution and this filter would be located at the slaughterhouse next to the IBC, or:
- The tanks would be collected full and taken to the blood processing facility. Cleaned IBC tanks would be supplied on an exchange basis. (NB Ensure fitted connections are compatible with blood collection contractor.

Medium and Large Plants

The use of bulk storage tanks emptied on a milk round basis is the most appropriate method. The tank would need to be located in a position so that articulated vehicles can gain access with minimal amounts of pipe work (10m).

For larger permanent installations you should contact your local Council to check if Planning and Building Regulation approval is required. An Environmental Impact Assessment may also be required as part of the Planning application.

Most bulk vacuum collection tankers in the industry are about 27 tonne capacity and you should discuss the size of your storage tank with your blood collection contractor.

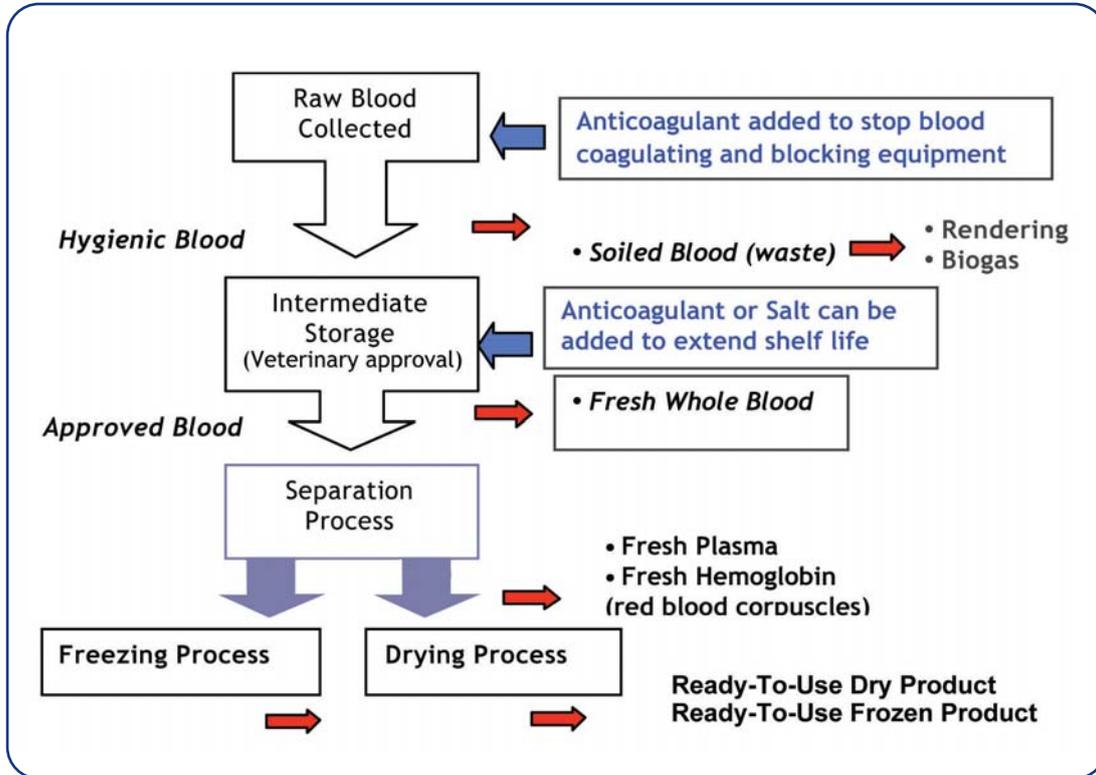
For all plant sizes it is important to talk to your blood collection contractor about tank sizes and to ensure compatible connections are fitted. It will be necessary to add preservatives to the tank, e.g. sodium metabisulphite, particularly in warm weather, and your blood collection contractor will be able to give details or supply the preservative. To reduce odour pollution the exhaust from all pumps should be passed through a charcoal filter. Again your blood collection contractor will be able to provide advice on types and suppliers.

ANIMAL BLOOD

Animal blood is either spray dried as regular whole blood or after separation into plasma and red albumin. To ensure an economically feasible drying process, all blood products are concentrated in a falling film evaporator until reaching a viscosity around 150 centipoises viscosity before drying. All slaughterhouse by-products are dried at low temperatures in order to prevent heat coagulation or Maillard reaction. Both nozzle and rotary atomization can be used in co-current flow dryers.

ANIMAL BLOOD (cont'd)

Figure 2 Processing of blood for human consumption



POSSIBLE USES

Blood plasma is the yellow liquid component of blood, in which the blood cells in whole blood would normally be suspended. It makes up about 55% of the total blood volume. Blood can be separated into haemoglobin or red blood cells and plasma by centrifugation. Serum is the cell free fraction that escapes when blood is allowed to clot. Plasma is produced when blood is collected with anticoagulant. Blood serum is blood plasma without Fibrinogen or the other clotting factors.

The red/white cells and the cell free fraction are separated by mechanical methods such as centrifugation. Plasma and haemoglobin have different characteristics and therefore different applications. Biogas generation is another possible use especially when mixed with stomach contents however blood would need some further pasteurization to enable this to happen albeit the constituents could be used.



Processing of blood for human consumption

POSSIBLE USES

Table 2 Uses of blood in the food and pharmaceutical industry

Food ingredients		
Whole Blood	Black pudding, Soup	
	Petfood	Increased water content
Blood Plasma	Sausages, black pudding, hotdogs, hamburgers, pâtés, meatballs	Replace other protein additives Increased protein content
	Meat stretcher	Improved sensoric values (taste, juice, texture and bite) 0.5 to 2% limit otherwise it can negatively impact colour and flavour
	Gelling agent	Better binding of MDM (Mechanically de-boned meat)
	Soya substitute	Soy-free labelled products (non-allergenic) GMO free additive Spray-dried plasma
Haemoglobin	Petfood (feed ingredient for piglets, fish farms, chicken or minks)	
	Biogas	
	Colouring agent	
Pharmaceuticals		
Serum	Vaccines, antibodies	Mammalian cell culture media
Plasma	Serum Albumin, Globulins	

PHARMACEUTICAL PRODUCTS

Cell culture

Cell culture involves pieces of living tissue, such as pieces of lung or kidney, being kept alive and multiplying in an artificially created environment. Cells in this situation need nutrients such as proteins, vitamins and amino acids just as a human body does, and bovine serum is an extremely rich source of these nutrients.

Uses of cell culture

Cell culture is a modern biotechnology process which has many uses in the scientific laboratory, such as virus diagnosis, cancer research, vaccine production, toxicity testing of drugs and cosmetics, transplantation research (heart, kidney) and examination of unborn children for genetic defects such as mongolism.

In vaccine production, cell culture is used to grow the virus which is then killed or made non-infectious. The vaccine can then be used to protect humans and animals against infection by that virus. Production of polio virus vaccine in cell culture has been responsible for saving many lives.

PHARMACEUTICAL PRODUCTS

(cont'd)

The serum can be derived from either adult or foetal bovine blood or from other mammalian blood.

There are two blood derived products (serum and plasma) used in pharmaceutical industries. Both plasma and serum are the light coloured liquid fractions derived after removing the red and white blood cells. Serum is the cell free fraction that escapes when blood is allowed to clot. Plasma is produced when blood is collected with anticoagulant and the red/white cells and the cell free fraction are separated by mechanical methods such as centrifugation. Plasma and serum have different characteristics and therefore different applications.

Global market data indicates that the world market for cell culture reagents, sera and media is approximately £400 million. The current market is continually changing. A number of factors have led to a trend away from bovine sera in recent years, due to TSE's etc. However the pharmaceutical industry is slow to change probably because of the amount and cost of the prerequisite number of trials required by the licensing authorities before allowing a new product on the market.

The push towards non-animal derived culture media has been driven by risk management issues associated with animal health concerns in North America and Europe and the recent volatility in Australian and New Zealand foetal blood prices. Batch variation in serum characteristics and performance has also always been a factor with animal derived material, whereas synthetic media have the potential to provide a consistent even if not optimum product. This variation in functionality can however also be seen as a potential opportunity for developing a superior product if it can be controlled in the first instance and then 'wound up' to the high levels thereafter.



The cost of changing media in the pharmaceutical industry, ensures that substantial growth is still expected in the industrial applications of sera over the next few years. Additional reports indicate that 27% of new pharmaceuticals in the development pipeline are biologicals, many of which are produced using cell culture. Production capacity in biopharmaceutical manufacturing is expected to expand by 48% over the next five years. Much of this will be for mammalian cell culture systems

Although this expansion would seem to hold promise for the meat industry it has to be understood that considerable competition is also developing in the form of specialty media designed for specific application and for dedicated cell lines. Whilst source selection (including country of origin) still occupies the front line for ensuring that biologicals are free of TSE agents, most companies now use prion removal technologies such as specialty filters which provide further protection.

FOETAL BLOOD

Foetal blood is refined into serum before being exported to pharmaceutical companies where it is the most widely used serum in the culturing of cells, tissues and organs in vitro, and is used in the manufacture of vaccines. Foetal calf serum (FCS) became a standard ingredient in cell culture media due to its superior growth characteristics for most types of cells. This well established and premium product has been exposed to major price fluctuations over the last few years and is a cautionary tale of how even the most sought after product is still subject to the vagaries of the marketplace. From a peak of £300 per litre in 2004/05 it has fallen to a low of £150 per litre in 2010.

FOETAL BLOOD

(cont'd)

The move towards non-animal derived media will probably minimize the potential for growth in this sector. Most reports predict moderate growth of only 2–3% per yr over the next few years. Other sera (newborn calf and adult bovine sera) have also found significant use for industrial cell culture applications such as vaccine production and production of specific fractions (eg. Cholesterol). Sera from goats and sheep have limited use e.g. diagnostic assays.



BLOOD TREATMENT SYSTEM

Advanced Microwave Technologies Ltd. (AMT) is a Scottish based company who are global leaders in the use of microwave based technologies for heating and conditioning liquids and gases. Microwaves are able to heat a liquid flow by delivering energy directly into the body or total volume of the liquid. This method of “Volumetric Heating” is not only very cost effective but it has many advantages over other conventional thermal heating systems which rely on energy being transferred into the liquid from a hot surface by conduction and convection.

It is particularly useful for heating difficult liquids which stick to hot surfaces and it allows microorganisms to be killed at lower retention times saving cost and preserving functionality. In the meat industry it is now being used for treating blood produced by abattoirs.

AMT has introduced a machine that can be located at a meat plant which heats and sterilizes the blood as it is produced. By doing this the proteins in the blood coagulate and allow the much of the contained water (50%) to freely drain away from the solids. The remaining sterile proteins are of a very high quality and can be used as a fertilizer, a pet food ingredient or if the blood is hygienically collected as a high quality protein for the food industry. This enables abattoirs to convert an expensive waste into potentially a very valuable income stream.

The Treatment of Blood Using Microwaves

Blood possesses certain properties and characteristics that make it difficult to treat and evaporate using conventional methods but which in fact lends it to treatment with Microwaves.

It clots very readily and forms a surface deposit which is difficult to remove from any heating surface. The treated material when cool is a suspension with a jelly like consistency and the liquid fraction is of a sufficiently low Nitrogen content that it can be disposed of to a sewer.



After processing the blood is jelly-like in consistency

BLOOD TREATMENT SYSTEM (cont'd)

The AMT system allows practically any material that can be pumped through a 50mm pipe to be heated and conditioned using microwave energy on a continuous basis.

There are many advantages in using the AMT system:

- There are no hot metal surfaces for difficult materials to stick to.
- Energy is distributed immediately and evenly throughout the total volume of the liquid.
- Energy can be introduced in varying amounts and immediately stopped making the process highly controllable.
- It is very efficient. Up to 90% of the energy used can be utilised..
- The equipment has a very small footprint reducing building costs.
- Ancillary equipment like boilers and steam pipelines can be eliminated.
- Maintenance costs are very low.
- Cooking times can be reduced enhancing the functionality of the food.
- Microorganisms are killed at lower thermal retention times due to the rapid and even heating.
- Certain chemical reactions are dramatically speeded up due to the rapid heating and the direct effect of the microwaves. (e.g. bio fuel production)

The solid fraction in theory has a significant value as a fertilizer. Overall it contains 14% Nitrogen, 2% Phosphate, 1% Potassium and high levels of sulphur and trace elements.

In summary by treating fresh blood at the abattoir the following is achieved:

- The blood is heated and sterilized. If operated at 98 degrees centigrade or above the system sterilises to a standard required by the EU animal by products legislation allowing it to be used as a fertilizer.
- The blood proteins coagulate allowing the liquid fraction to freely drain from the solids reducing volume by 50%
- The sterile liquid fraction has a low BOD (4000 if filtered through a 1 micron filter) and can be disposed of directly to the sewer.
- The remaining sterile solid proteins (50% of the total) can be used as a fertilizer or disposed as Category 3 as an ingredient for pet food.
- By using sterile blood collection techniques and storage systems the treated blood proteins can be used in the wider food industry.
- By the addition of a microwave vacuum drying system a high quality dried blood product can be produced.

References

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Some of the photos supplied by Anitec Sweden