Results for today; Ideas for tomorrow

Meat Technology Update

Newsletter 5/03 October 2003

Blood products

Blood collected at abattoirs has many potential uses including as: an ingredient in food for human consumption, animal feeds, petfood, neutraceutical products, pharmaceuticals and fine chemicals. Products derived from Australian cattle and sheep blood may be particularly attractive on international markets because Australia is free from BSE and many other animal diseases.

Although blood and blood products appear to have a wide variety of valuable uses, market penetration of these products is difficult; however, there is interest in exploring options for uses of blood because Australia's BSE-free status makes it well placed to supply co-products to the pharmaceutical and biotechnology industries.

This newsletter provides some general information about the relationship between blood products such as whole blood, plasma, serum, and defibrinated blood. There are opportunities to pursue investigations into production of further refined blood products in partnership with MLA. For further information on opportunities for collection of blood products and partnering with MLA, contact Stuart Quigley (details are at the end of this newsletter).

Raw blood is about 20% solids and 80% water. It consists of a yellowish fluid called plasma in which are suspended red and white blood cells, proteins (mainly albumin, globulins and fibrinogen) and platelets. It is the oxygen-transporting haemoglobin in red blood cells that gives blood its characteristic colour.

Whole blood can be separated into various fractions including: plasma, red cells, serum and defibrinated blood.

Plasma is the part of the blood remaining after the removal of the cells from unclotted blood, and accounts for about two-thirds of the total weight of whole blood. The most abundant protein in plasma is albumin. The next major protein is globulin, and a third is fibrinogen. When fresh blood is extracted from an animal, the fibrinogen is rapidly converted to fibrin. Fibrin forms a network of threads that enmeshes blood cells and other blood components into a clot. Clotted blood will shrink after a few hours and express a clear fluid. This fluid expressed from clotted blood is serum.

Clotting is initiated by release of calcium into the plasma and can be prevented by adding anti-coagulants, such as sodium citrate, which bind the calcium. Adding excess calcium will overcome the anti-coagulant and initiate a clot. If plasma is to be recovered, anti-coagulant should be added to whole blood to prevent clotting. If serum is to be recovered from whole blood or plasma with added anti-coagulant, calcium ions (e.g. calcium chloride) are added to overcome the effects of anti-coagulants and to initiate a clot.

Defibrinated blood is whole blood with fibrin removed. If whole blood is stirred while it clots, as the threads of fibrin form they will collect on the stirrer or agitator (Figure 1). The fibrin can be removed as a concentrated mass on the stirrer leaving defibrinated blood.

Figure 1. If whole blood is stirred during clotting, fibrin is released as long strands.

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The major uses for blood are in animal and human food. Blood is a good nutritional source of iron and some essential amino acids, particularly lysine, but it is deficient in isoleucine and low in methionine. Blood proteins can be added to most food products, but are more commonly used in meat products to increase the protein content and for functional benefits such as improved water-holding capacity and emulsification of fats. Blood plasma is also used as a nutritional supplement to cereal foods because of the high lysine content.

Blood yields

The amount of raw blood recoverable by slaughter livestock depends on the species, sex, live weight and method of recovery. Generally, a yield between 3–4% of the live weight can be expected. Approximate blood yields are:

- Cattle: 10–15 kg;
- Calves: 1.5–3 kg;
- Sheep: 1–3 kg;
- Lamb: 1–2 kg;
- Pigs: 3–4 kg.

The amount of blood collected from an animal depends on sticking techniques, the time available to collect the blood and electrical inputs. Further details about maximising blood collection were provided in Meat Technology Update 4/03.

Hygienic blood collection

Sticking and blood collection can be carried out using either open or closed systems.

In an open system, after sticking, blood is collected by placing a vessel directly under the stick wound. It is difficult to collect blood hygienically with this method because the blood can be contaminated from several sources including bacteria from the skin/hide, airborne bacteria and regurgitated stomach contents if the oesophagus is severed whilst sticking.

Blood that is saved for edible purposes must be collected with minimum microbial contamination. A closed bleeding system is much more hygienic than open sticking and bleeding. The stick wound area should be prepared to avoid contamination of the blood. In cattle, a portion of the hide in the area of the neck where sticking will take place, is removed with a sterilised knife to expose a clean area of tissue.

A hollow-bladed knife is then inserted into the major blood vessels coming from the heart and the blood is conveyed though tubing to a holding tank. The blood usually flows from the sticking knife into the holding container by means of gravity. Vacuum may also be used to aid bleeding but too much suction can cause the blood vessels to collapse and block the flow of blood into the knife. To keep blood from clotting, a chemical anticoagulant, such as sodium citrate is added to the blood through the knife handle. Other anti-coagulants such a ammonium oxalate, sodium chloride and sodium pyrophosphate may be used. Sodium citrate should be added at a rate of up to 3 g/L of blood, for example, 7–8 mL of a 40% solution could be added to one litre of blood; however, some countries may restrict the amount of anti-coagulant that can be added to blood for human consumption.

If blood is collected for edible use it must remain correlated with individual animals or batches of animals until the carcases are inspected and passed fit for human consumption. There are commercial systems in which blood from individual animals is held in containers mounted on a carousel. The containers on the carousel maintain correlation with individual carcases as the carcases progress down the slaughter floor. The alternative is to accumulate blood from several animals (even up to a whole days kill) and hold the accumulated blood until the corresponding carcases have been inspected. If any carcase is condemned the blood from that carcase, and any other blood with which it is mixed, loses its edible status and the entire blood collection line from the knife to the batch holding tank, must be cleaned and sanitised.

As soon as possible after collection, the blood should be chilled to 2–4°C to minimise microbial growth. If high quality plasma is required, it should be separated from the red cell fraction before chilling, as chilling can cause haemolysis (bursting) of the red blood cells.

Processing of inedible blood

Inedible blood is processed to produce a dry, stable product that is ground to an even particle size and free of contaminants such as wool, hair and paunch contents.

The blood proteins in inedible blood are steam coagulated and then about half the water is separated by mechanical means. The dewatered coagulated blood is then dried and milled. The process yields a red-black powder which is used for animal feed or fertiliser. Refer to the MLA Blood recovery brochure (1997), for further information.

Processing of edible blood

Figure 2 outlines how blood fractions are derived from whole blood.

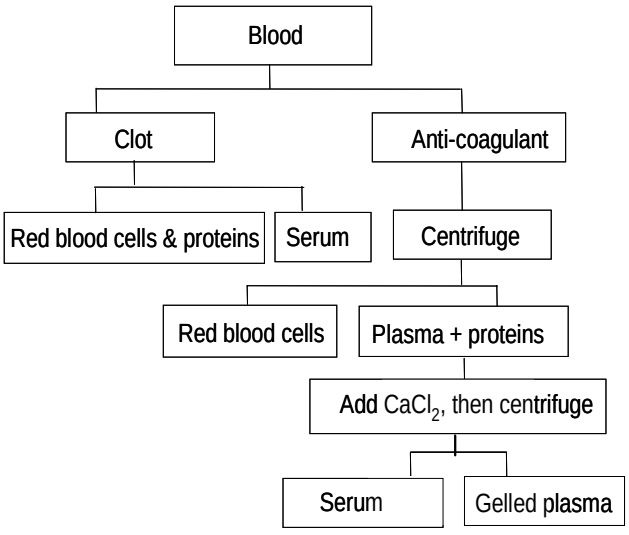

Figure 2. Blood fractions obtainable using different processing methods.

Whole blood and red cell (haemoglobin) fraction

The two methods of collecting red cells are to separate uncoagulated whole blood into plasma and red cells by centrifugation; or by allowing blood to clot and separating the red cells from the serum. The yields of red cells is about 40% of the whole blood if the fraction is separated from plasma, and about 60% if it is separated from serum.

Whole blood or the red cell fraction have limited uses. Both can be used to make blood meal for use in animal feed or fertiliser. Red cell fraction has a similar amino acid profile to whole blood but blood meal based largely on the red cell fraction is not attractive in feed use because of the very dark colour and high iron content. Red cell fraction is used in specialised feeds such as mink feed.

If blood is collected hygienically, there are some options for edible use. Small amounts are used in black pudding and blood sausages; however, the intense colour of the red cell fraction can give an undesirable dark-red colour when added to most food items at concentrations of greater than 1% so its use is limited.

There are several methods of decolourising the red cell fraction. These include bleaching with hydrogen peroxide and splitting the red-coloured haem group from the globulin protein with acidified acetone. These processes have not been widely used because of the cost and some of them, particularly bleaching, reduce the nutritional value of the blood.

Spray-dried whole blood can also be used: as an adhesive, in asphalt emulsions, in insecticides, in ceramics, and as a substitute for egg albumin when colour is not important.

Another product is red blood cell paste. Firstly, the blood with anticoagulants is centrifuged to remove the plasma. The red cell fraction is then washed with a sodium chloride solution to remove residual plasma proteins, and vacuum-evaporated to produce the red blood cell paste. The paste is sterilised by a series of heating cycles and vacuum-dried to give a yield of 25–30% of the whole blood. Red blood cell paste is the raw material for isolation of haemin and sphingomyelin and several amino acids including leucine, lysine, histidine, phenylalanine.

Blood proteins have also been used in foaming compounds for fighting fires. Mixing the blood-foaming compounds with water and air under pressure generates the foam.

Serum

Blood serum is fibrin-free plasma that is obtained after the blood has been chilled and allowed to clot. The clotted blood is cut into cubes to increase the surface area and the serum allowed to drain from the blood. The fraction that collects after 2–3 hours may be rejected because of colour, but the subsequent serum collected over 12–14 hours is a clear yellow colour. The serum is centrifuged to remove any red blood cells, deactivated by heating, sterilised by filtering, and finally stored either frozen or freeze-dried. The yield of serum from whole blood is about 40%.

The efficiency of collection of serum can be improved by centrifuging clotted blood. Clotted blood is centrifuged in batches as opposed to the continuous centrifugation that is used to separate plasma and the red cell fraction.

Serum can also be produced from plasma. After plasma is separated from red cells, calcium chloride solution is added to overcome the effects of the anticoagulant and to promote gelling (equivalent to clotting) of the plasma. The gelled plasma is centrifuged to express the serum.

Serum is used in the laboratory as a standard solution to inactivate proteolytic enzymes, in bacteriological media, for growing viruses and in the production of virus vaccines.

Plasma and proteins

Blood plasma or bovine plasma protein is obtained by centrifugation after adding an anticoagulant to prevent the blood from clotting (Figure 3). Blood plasma should be yellow or orange in colour. A darker colour is due to the release of the haemoglobin from the red cells. The red cells may burst and release haemoglobin into the plasma. This happens due to osmotic shock (i.e. dilution of the blood with water), bacterial activity and mechanical handling.

On heating, plasma forms a gel and displays similar properties to egg white. It has good foaming and leavening action and spray-dried plasma has been successfully used as an egg substitute in bakery products and other prepared foods. Blood plasma can also be incorporated into processed meat to improve water-holding capacity and fat emulsification. In Australia food products must be labelled to show they contain blood and this has been seen as a disincentive to use plasma in meat or other food products.

Bovine plasma has been used in trials in Australia to produce restructured meat products. Frozen plasma is used (as opposed to spray-dried plasma which can be more expensive to produce), along with gums and farinaceous material, to restructure beef trim into meat logs that can be later portioned into roasts or steaks.

Figure 3. Uncoagulated whole blood can be separated into two fractions (plasma and red cells) using centrifugation.

Blood plasma contains a number of different proteins that can be collected using either precipitation or ion exchange chromatography. These proteins include albumin, cell adhesion proteins, transferrin, fibrinogen and immunoglobulins.

Blood albumin and globulins are also good emulsifiers and can be used in meat sausage products to retain fat during heating. They will decrease shrinkage and increase yield.

Hygiene and cleaning

Blood collection systems should be cleaned using the following method:

1. 5 min. cold water rinse;
2. 15 min. lye (potassium or sodium hydroxide) solution;
3. 15 min. acid solution;
4. 5 min. cold water rinse.

Good quality blood should have a total plate count of less than 2000 microorganisms per mL of blood, and the counts should be stable for a few days if the blood is held at 2°C. If strict hygiene standards are not followed, the bacterial count may be as high as 250,000 organisms per mL at the point of collection, and will rapidly increase during storage.

Foetal calf blood products

Foetal calf blood is centrifuged after clotting, to produce red blood cells and serum.

In a refined form, foetal calf serum is used in scientific laboratories as a growth-promoting supplement for the nutrition of cells in culture systems. Cell culture has many uses including cancer research, vaccine production, toxicity testing of drugs and cosmetics, transplantation research (heart, kidney), and virus diagnosis.

There is considerable world demand for foetal calf serum. Australia is one of the few beef-producing countries free from serious diseases such as BSE, FMD, rinderpest and contagious bovine pleuropneumonia. This fact ensures that there is a strong market for all the foetal calf serum we produce. Australia and New Zealand produce more than 40% of the world's requirements.

Foetal blood must be collected in the 'inedible' area of the abattoir, usually in a separate room in the condemned area that is well ventilated with washing facilities available.

The most common method of collection is direct cardiac puncture, and produces good yields of high quality blood. The blood is chilled, allowed to clot, then centrifuged to obtain the pale, straw-coloured serum.

Further information

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MLA (1997). Information brochure: Blood recovery.

MLA (2001). Co-products brochures: Recovery of specific proteins and enzymes from blood, Part 1 – Aprotinin, transglutaminase, fibronectin and related proteins, Part 2 – Growth factors

MLA (2001). Project report UNSW.007: Restructured meat using bovine plasma protein.

Ockerman, H. W., Hansen, C. L. (2000) Animal By-Product Processing & Utilisation. Technomic Publishing Co., Lancaster, USA.

For more information, contact one of the Meat Industry Services staff listed below.

Food Science Australia Meat Industry Services Section

The Meat Industry Services (MIS) section of Food Science Australia is an initiative supported by Meat and Livestock Australia (MLA) and the Australian Meat Processor Corporation (AMPC) to facilitate market access for, and support world-class practices in, Australia's meat industry.

Need additional help, information or advice? *Contact one of the following:*

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