PPI

Processing & Product Innovation

Isolated Muscle Protein (IMP) Manufacture

Over the past two decades numerous attempts have been made to produce a 'surimi-like' product from poultry or red meat. These attempts have been unsuccessful because of simple economic logic. If you can purchase a kilogram of meat feedstock for a given unit price, then process the feedstock so that its end yield is, at best, 60% of its starting weight, including capital amortisation and running costs, the end product would be expected to have cost some 70% more than the original feedstock.

If the original feedstock material is a manufacturing-grade poultry or red meat that has a ready market at reasonable value, it is unlikely that the surimied product will be able to compete at a 70% premium. This is particularly so if the end product has a higher moisture content and possibly some loss in protein functionality as a result of the processing. Australian mutton may be the unique exception to this situation.

Mutton is severely disadvantaged on the world market as much of the world's population finds the odour and flavour of mutton unacceptable and even offensive. Mutton consumption is prevalent only amongst peoples of Celtic, Gallic, Semitic and Hispanic backgrounds. However, there are social stigmas attached to the consumption of mutton in some of the countries with these ethnic backgrounds, further restricting the market for mutton.

There is a potential opportunity for low-value manufacturing mutton with limited markets to be processed to a higher value red-meat protein source without the physical attributes of mutton. Considerable work has been done to ensure the technical feasibility of the process to produce this product known as Isolated Muscle Protein (IMP). Considerable work has also been carried out to determine the economic viability of the process.

IMP technology

The IMP process is a washing process that facilitates the removal of fat and water-soluble proteins, leaving the myofibrillar component of the muscle. The IMP process essentially must remove the undesirable odour and flavour characteristics of mutton, and should also reduce fattiness, toughness and colour. The odour and flavour components are associated with the fat and water-soluble components of the meat.

The myofibrillar component of the muscle is the most valued component of the meat with respect to manufacturing properties such as water binding, emulsification capacity and gel strength on heating. This component comprises about 60% of the protein present in the muscle. Connective tissue is also insoluble giving a potential insoluble protein fraction of approximately 65% of the original protein content. Economic viability of the process depends on the ability to retain the insoluble protein and maximise the process yield.

Substantial by-product streams of fat and protein solution are produced during processing and must be recoverable to make the process viable. Potential recovery of these by-products is addressed in the Co-products brochure *'IMP By-product Utilisation'*

IMP processing

The commercial process that has been proposed is shown in Figure 1.

Comminution

Comminution opens up the meat structure to facilitate washing of the muscle cells and freeing of fat from the lean meat. The favoured method of comminution is the use of a de-sinewing machine because it breaks the fat from the lean as it removes the sinews, but retains some fibrous structure in the lean fraction. Alternatively a mincer or silent cutter could be used—with a commensurate reduction in protein functionality.

Washing

The comminuted meat is mixed with water approximating a ratio of 1:4 (meat:water). Free fat is allowed to float to the surface where it can be removed by skimming.

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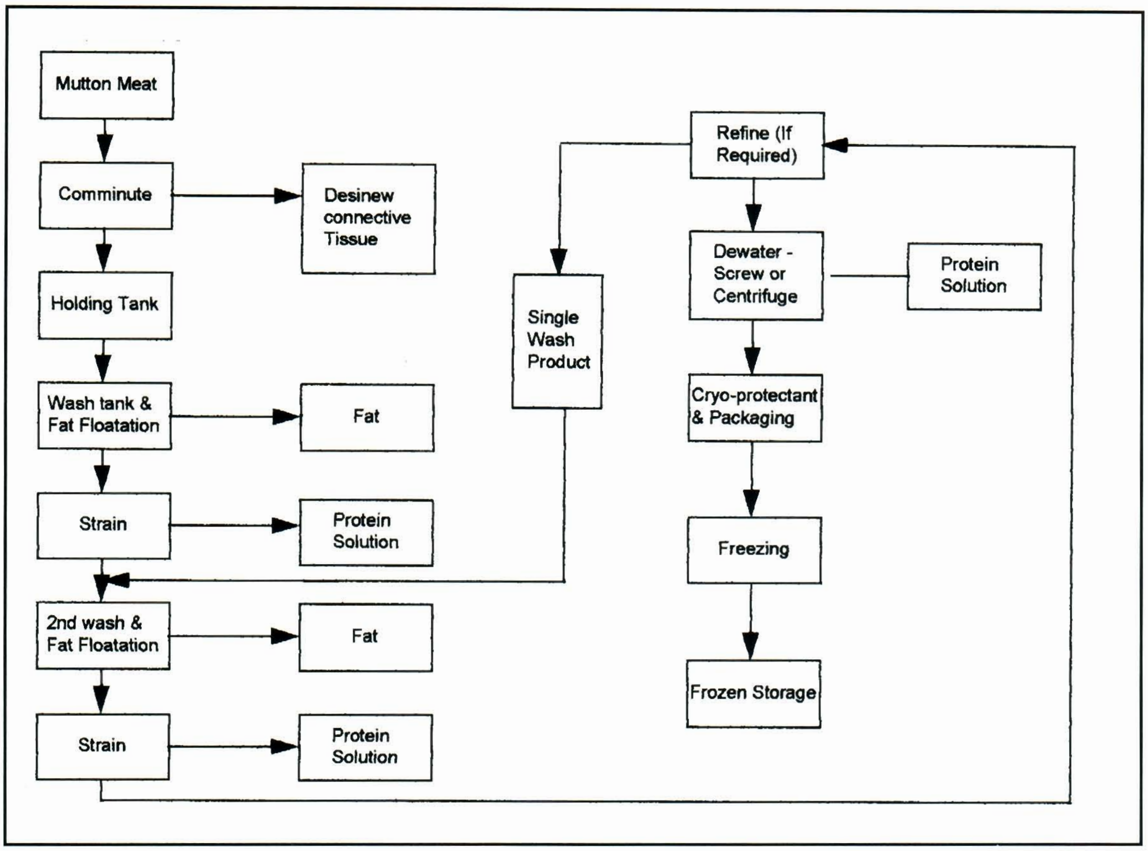
Figure 1. Flow diagram for IMP process



Fat separation is aided by use of a hydro-cyclone to free fat from the protein/CT matrix. Washing is carried out as a continuous process in a screw-driven baffled tank. Important factors in obtaining the necessary leaching of sarcoplasmic proteins, including meat pigments, are: the state of the meat (age post-slaughter), pH, salt concentration, duration of wash and severity of mechanical action. It is important to control time (flow rate) and agitation as the meat-fibre structure tends to disintegrate.

De-watering

Several alternatives have been proposed including the use of low heat and decanting, but it is known that some protein functionality will be lost when the product is heat treated; but the fat content of the final product is reduced. The preferred option is to feed the material from the wash tank through a rotary sieve to allow the free water to drain away. For fat or soluble protein removal, a further wash-drain cycle can be included if necessary. The drained product is then de-watered by either a screw dehydrator or a decanter centrifuge. Use of a decanter is required to obtain a product moisture content similar to the feedstock material. A decanter is likely to disrupt the product structure to a greater extent than a screw dehydrator but is less likely to suffer from fines loss during processing.

Handling

The solid product from the de-watering step is IMP. The IMP can be used immediately in further processing or can be frozen for later use. Freezing will be required unless the product is to be used within a day or so. Freeze/storage/thawing will result in some loss of functionality unless steps are taken to reduce the adverse effects of freezing. For stabilising of fish surimi the adding of cryo-protectants, such as the addition of 8% of a mixture of equal parts of sugar and sorbitol, is common. This may impart too much sweetness to a mutton IMP product so other cryo-protectants such as polydextrose may be more suitable.

Proposed layout

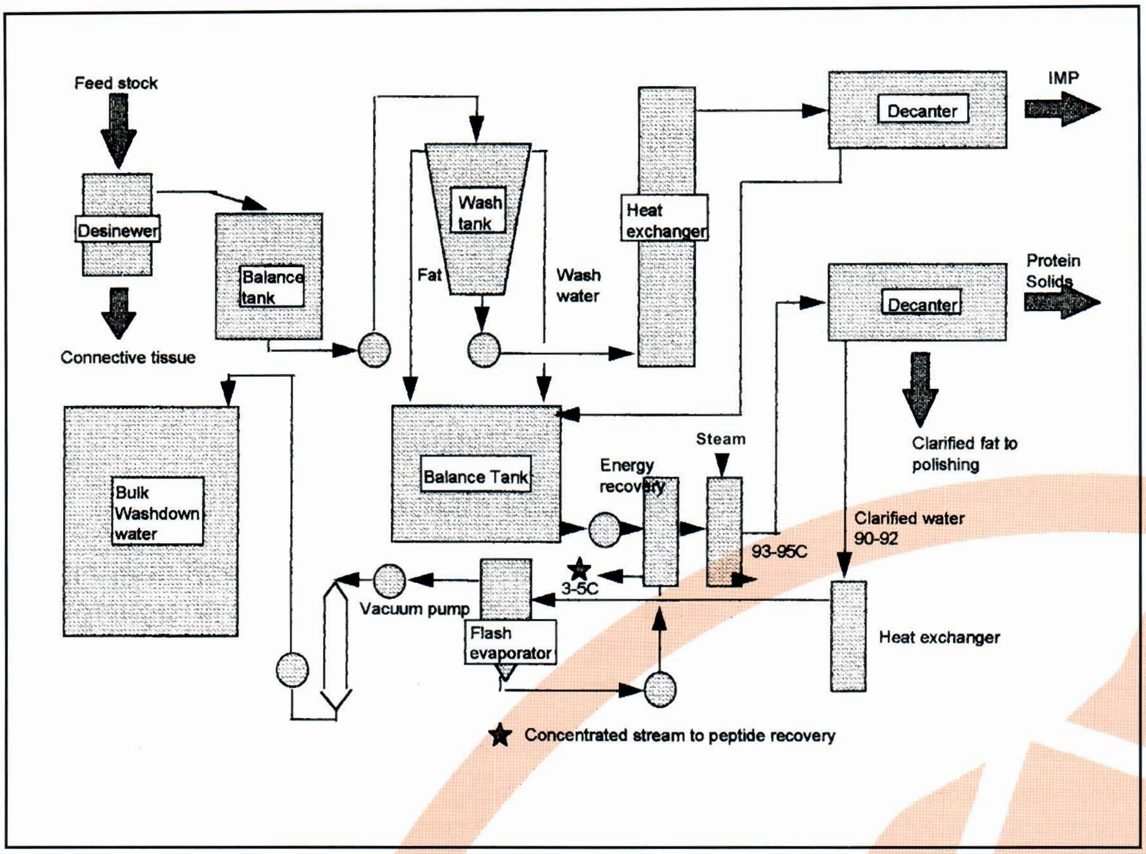
A proposed layout based on the research pilot plant has been prepared. This layout including heat recovery and fat stream recovery is shown in Figure 2.

Optimum capacity

An optimum plant size of 1.6 tonnes of IMP per hour has been identified. This has been determined on the basis of potential sheep availability within a readily transportable radius of 300 kilometres. At 1.6 tonnes of IMP per hour, the plant would require some 200 sheep per hour, based on an average yield of 13.5 kilograms of total recoverable muscle per mutton carcase (60%).

Working two shifts each of 7.5 hours the plant would produce some 24 tonnes of IMP from approximately 3000 sheep per day, processing around 700,000 sheep per annum. As a single shift operation the plant would produce some 2,800 tonnes of IMP from 350,000 sheep.

Figure 2. Schematic layout for commercial IMP process



Preliminary cost analyses for such a plant indicated that the plant should operate profitably once the growth in throughput reaches a production level exceeding 2000 tonnes per annum.

Process yields

Consistent production has been achieved from the pilot plant confirming a yield, from the lean meat fraction of the feed stock, of approximately 50% from trunk mutton on long runs (1,000–2,000 kg). Overall yield from 70CL trunk mutton was determined from the pilot plant at an average of 37%. At this yield, IMP composition averaged around 78% moisture, 4.1% fat and 18.4% protein.

Overall process yields are dependent on the performance of the de-sinewing equipment and the IMP de-watering decanter. It is known that with a commercial plant the performance in these areas could be expected to be improved with a potential 4% improvement in yield over the pilot plant.

IMP product attributes

Stable quality

IMP can be produced to exacting specifications allowing for reduced tolerances in product formulations when used as a raw material for further processing. Processing formulations generally have generous tolerances to allow for variability in the quality and functionality of meat.

Ease of use

The product can be variably formed into blocks, slabs, chips or free-flow mince. It can be pre-packed to manufacturers' requirements offering cost savings in its preparation and introduction into a formulation.

Stable price

With known projections of plant capacity, it is possible to contract-buy stock for slaughter specifically for this process. To some degree, this will insulate the product from variations in prices on the red meat market. This will allow the users of this material to more accurately predict their costs and position their products more competitively on their market.

Water-holding capacity

Provided that the functionality of the proteins is maintained throughout the process, it will have excellent water-retention properties. This will result in better yields in manufactured products containing this material. Trials conducted with IMP incorporated into emulsion-type smallgoods showed a reduced cooking loss compared to beef or pork meat.

Taste profile

As the product has virtually no taste or odour, it will readily take on any aroma or taste characteristics that the manufacturer requires. As the IMP has only about 4% fat, yields can be boosted by adding back fat from other species such as beef and pork to introduce their desirable flavour notes. At an addition level of 15–20% beef or pork fat, IMP will take on the flavour characteristics of these meats.

Taste panelling of IMP after frozen storage has indicated that the IMP loses any residual mutton flavour during storage and increases in other non-mutton flavour notes. This appeared to be independent of the packaging form used.

Low microbiological counts

Earlier studies with the low-heat centrifuge processing method have indicated a lowering of microbial numbers by more than 1 log during the process from mutton feedstock to IMP. Also, importantly, a commercial production process of this nature can be more closely monitored for microbial count than is generally possible for red meat production.

A draft quality-monitoring program has been prepared for the process including guidelines for microbiological testing and acceptable results.

Product variants

A commercial IMP plant will have the capability of producing IMP to varied specifications. As a result products can be supplied in a variety of forms from coarse fibrous textures with high levels of connective tissue through to ready-to-use emulsions.

Potential uses of IMP

Traditional meat products

IMP can be used as a major or minor ingredient in sausages, burgers, pate, sliced cooked meat and reformed meats. Expected shelf-life stability make IMP particularly attractive to ethnic and fast-food applications such as kebabs, shaslicks, nuggets and pies etc.

General products

It is believed that there are potential applications for IMP in bakery goods, beverages, baby foods, health foods, soups (both wet and dry), pasta and vegetable and fruit analogues. The product should lend itself well to continuous extrusion as a snack food.

Novel products

The unique nature of this material lends itself to inclusion into, or becoming the base for, a range of novel products. Some novel products have been investigated but have not been reported on because of their proprietary nature.

Pricing levels

Current costings would be required to confirm the various cost/price analyses conducted for IMP materials. However analyses have indicated that on large volumes of production (ie >5,000 tonnes per annum), landed prices into export markets could be on a par with, or cheaper than, the price for cheap manufacturing beef cuts.

At production volumes of 3–4,000 tonnes per annum, the indicated selling price required is about 30% above the selling price for 75CL beef trimmings.

An extensive cost analysis as part of a feasibility by Coopers and Lybrand in 1994 indicated that, at that time, a mutton purchase price of $1.00 per kilogram for feedstock would be required to achieve a profitable performance on a sale price of $3.50 per kilogram. This was based on 70CL trunk mutton with a yield from the pilot plant at an average of 37%. An expected 4% increase, on this material, to 41% from a commercial plant would be expected to be viable at a mutton price, at that time, of $1.10 per kilogram.

The performance of a cost/benefit analysis on IMP is dependent on the ability to recover the by-products produced and market them, preferably at a small profit, but at least at zero cost to the process.

Further reading

This information is a summary of information from the following projects funded by the Meat Research Corporation.

- Project M.101: Construction and trial of a pilot plant for IMP production – Modules 1–4
- Project M.483: IMP Implementation

Further detail is available from project reports from these projects which are available from Meat and Livestock Australia.

Related information is given in the following MLA Co-products brochure.

- IMP By-products Utilisation

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