Potential Uses for the By-products of IMP Production

The Isolated Muscle Protein (IMP) process produces an insoluble protein product from deboned mutton-carcase meat. Fat, sinew and water-soluble proteins are by-products of the process representing over 50% of the original raw material.

Due to its marginal economics without utilisation of the process by-products, commercial interest in the IMP process is expected to be restrained. Opportunities have been investigated for utilisation of the three waste streams from the IMP process: connective tissue, fatty pellets and stickwater containing soluble proteins and peptides.

Connective tissue

This material represents about 17% of the original mutton-trunk raw material used to produce IMP. Approximately 350 kilograms of connective tissue is generated for every tonne of IMP produced. Analysis of the connective tissue recovered from the mechanical de-sinewing machine during the IMP process has shown that it is equivalent in protein to 80CL meat. However the connective tissue fraction has a significantly higher collagen content than the meat fraction from the mechanical de-sinewing machine and the original mutton used as feedstock to the process. Analysis of the various fractions is given in Table 1.

Table 1. Analysis of de-sinewed materials (% by weight)

Percent:	Moisture	Fat	Protein	Collagen
Mutton trunk feedstock	69.7	11.0	20.6	1.4
De-sinewed meat fraction	74.7	5.4	19.3	0.9
Connective tissue fraction	58.8	21.3	20.4	4.1

As an inedible by-product, connective tissue currently has very little commercial value: however, the material has some potential as an edible product—as an ingredient in some smallgoods products.

Connective tissue in smallgoods

Connective tissue has been successfully replaced in a number of smallgoods products. Cook loss, colour, texture and flavour are the major quality parameters for smallgoods. Products containing connective tissue at a range of replacement levels have been evaluated for these quality parameters to determine the level of replacement that is possible without affecting the product's acceptance.

In Devon and Strassburg products, connective tissue replacement has been evaluated for its suitability as a cheaper alternative to 75CL pork. Replacement of pork with connective tissue was made at a range of levels. The following effects on quality parameters were noted.

- Cook loss was shown to be unaffected at levels of replacement up to 20%.
- Colour measurements for Devon products showed that the colour progressively darkened and became more red with increasing replacement levels.
- Compression testing showed that for Devon products the Fracture Distance and Hardness of samples containing connective tissue are significantly greater than products without connective tissue. Sensory analysis for Firmness and Cohesion confirmed this.
- Compression testing for Strassburg products showed there was no statistically significant difference in Fracture Distance, Fracture Force and Hardness when connective tissue was included. This was confirmed by the sensory analysis of the texture attributes, Firmness and Cohesion. When assessing texture, product with a 20 % replacement level was found to be most similar to the control product without connective tissue.

In Lamb Kebab products, connective tissue replacement has been evaluated for its suitability as a cheaper alternative to

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mutton. Initially, total replacement was made of mutton with connective tissue—without success—as the product was noticeably stringy even when minced through a plate with an 8 millimetre diameter hole size.

Replacement of mutton with connective tissue was then made at a range of lower levels. The following effects on quality parameters were noted.

- At levels of replacement up to 50%, cook loss and shrinkage were shown to be affected only minimally.
- With increasing replacement levels, Colour Intensity, Meat Flavour and Other Flavour were not significantly affected.
- Significant differences were found in the appearance attributes of Particle Size and Greasiness. With these attributes a replacement level of 25% showed discernible (but acceptable) effects, while at 50% replacement level and above, the effect was highly significant.
- When assessing texture, product with the 25% replacement level was found to be most similar to the control product without connective tissue. Replacement with connective tissue at higher levels showed significant increases in Cohesiveness and Firmness with a significant decrease in Juiciness.

Replacement of connective tissue into these types of smallgoods at levels above 25% are not feasible because of noticeable differences. Replacement into emulsion products or minced products is more likely to be acceptable than into restructured products such as kebabs.

Fatty pellets

Fatty pellets recovered from the flotation tank contain some 50% fat, 43% moisture and 5% protein. The fat is of high quality and could become valuable to pet-food manufacturers as a replacement for tallow and/or vegetable oils.

It may also be possible to substitute edible-grade fatty pellets into smallgoods. The odour, flavour and mouth feel of mutton fat may be a limitation to this inclusion, although the effect of the fatty pellet form has not been evaluated. Assessments by the Meat Industry Research Institute of New Zealand (MIRINZ), using trained sensory panellists, showed that fat flavour intensity did not increase until mutton fat content reached 30%. Similarly consumer panelling showed that mutton-fat sausages are preferred when fat levels are within the 11% to 19% range, compared to products containing 27% mutton fat.

Stickwater proteins and peptides

The IMP process washes out most of the water-soluble components in sheep muscle. Sarcoplasmic proteins in the IMP stickwater waste stream includes glycolytic enzymes, myoglobin and haemoglobin. This waste stream will also contain carbohydrate and other soluble non-protein materials including anserine and carnosine.

Precipitation of stickwater proteins

Proteins in the stickwater stream can be recovered by simple heat treatment to precipitate them. This protein represents about 14% of the original meat feedstock for the IMP process. Large-scale batch precipitation of the IMP stickwater has been readily achieved. Precipitation commenced at approximately 50°C with maximum precipitation (in excess of 95%) occurring when held for 5 minutes at 80°C.

For commercial operations continuous precipitation would be required. A system consisting of a scraped-surface heat exchanger with automatic temperature control and 3 tube-in-tube heat exchangers for heat recovery has been trialed. From an ambient temperature of around 30°C, the pilot plant was capable of heating the stickwater to 90°C and then cooling by about 30°C. The pilot plant operated at flow rates from 6 to 13 litres per minute; and operated on stickwater in the temperature range of 87 to 96°C.

The heat-treated samples were filtered to recover the coagulated protein, and the filtrate was analysed for residual soluble-protein content. Precipitation increased with increasing temperatures as in Table 2.

Table 2. Precipitation of stickwater proteins

Set Point for Scraped Surface Heat Exchanger	Soluble Protein Concentration in Filtrate (mg/mL)	Soluble Protein Precipitated (%)
unheated	15.2	0.0
87.5°C	4.5	70.4
93.0°C	3.0	80.3
96.0°C	1.7	88.8

Recovery of stickwater proteins

Concentration of the precipitated protein has been attempted using a commercial juice-extractor press, rotary sieve and decanter. The rotary sieve showed most successful recovery but with the recovered protein having a solids content of only 6%—with some protein fines lost to the system. In commercial operation a decanter optimised for this product would be the most likely to be viable—with expected solids contents closer to 20%.

The recovered protein from a sieving system is a smooth and lumpy texture with a light brown colour.

Hydrolysates from heat-treated stickwater proteins

Samples of the stickwater proteins have been treated with enzymes to produce flavour-extract products. It has been shown that the flavours produced reflect the amino acid and peptide composition, and the non-protein components such as carbohydrates and lipids.

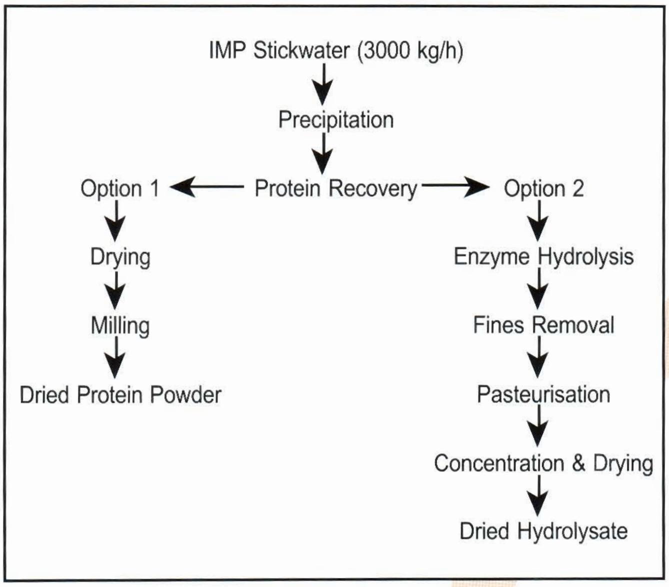
Alcalase enzyme, a bacterial protease which breaks down protein molecules, was used in conjunction with Flavourzyme enzyme. Flavourzyme contains a number of different proteolytic activities working in the neutral to slightly acidic pH range. Flavourzyme is used to degrade the proteins and peptides further, reducing the bitterness that often occurs with only moderate enzymatic hydrolysis.

The degree of hydrolysis is the percentage of the protein's peptide bonds cleaved by the enzyme and has been measured against hydrolysis time. The degree of hydrolysis increased from 5% after 1 hour to 33% after 6 hours.

Process options

Figure 1 shows the two process options suggested from the pilot studies.

Figure 1. Flow diagram for stickwater protein processing



Initial estimates of production costs for dried protein powder—based on 3000 kilograms of stickwater per hour yielding 28 kilograms of protein powder per hour—are $0.74/kg (1996 costs).

The dried protein would have significant value in the pet-food industry, particularly in North America, as a low-fat/low-ash alternative to existing ovine meat meal. Additional opportunities may exist for this product on the edible export market.

Crystallisation of Carnosine and Anserine

Carnosine and anserine are valuable dipeptides present in the heat-precipitated stickwater.

Crystallisation is a common method of recovery and purification of amino acids. Given the correct conditions of pH, temperature and concentration, both carnosine and anserine may be crystallised from a concentrated extract. The concentration of carnosine in the heat-treated stickwater ranges from 0.07 to 0.2 milligrams per millilitre depending on the type of meat processed and the amount of water added at the washing step. The stickwater would need to be concentrated between 100 and 250 times to achieve conditions where crystallisation might occur.

Energy costs for this degree of concentration and the presence of other hydrophobic peptides and amino acids are likely to make this process commercially non-viable.

Alternate procedures based on simple cation chromatography, or a two-column chromatographic technique, have been investigated and appear to be more viable.

Commercial viability of IMP

The commercial viability of the IMP process has been evaluated using a simple economic model and risk analysis simulation. Results showed that the probability of an IMP process breaking even was 83% with by-product utilisation, and 25% without by-product utilisation. Improved utilisation of all by-product streams makes the overall economics of the process less sensitive to the variations in the price of mutton and significantly improves the commercial viability of the process.

Further reading

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

- Project CS246: IMP By-products Utilisation

Further detail is available from the final project report of this project which is available from Meat and Livestock Australia.

Additional information is available from the project report for the following project.

- Project CS215: Isolation and Utilisation of Carnosine and Anserine

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

- Isolated Muscle Protein (IMP) Manufacture

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