MEAT COPRODUCT PROCESSING: FROM THE MUNDANE TO THE EXOTIC.

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Introduction

The first question to be asked is why bother with coproducts? After all, the core business of a meat processor is to process meat and copro production is a distraction; a loss of focus. The answers, of course, are obvious: coproducts minimize waste and add to the value which can gained from each stock unit entering the plant. With less than 60% of the carcass leaving the plant as meat, the remainder adds up to a maj disposal problem. The standard attitude has been that you might as well process it into something and at least cover the costs of disposal. T has been the historical premise around which the rendering industry has grown up.

In recent times the financial argument for putting effort into coproducts has become more compelling. With New Zealand stock numbers st or falling and processors already delivering preweighed and prepackaged cuts directly into the supermarket, coproducts provide one of the remaining avenues for increasing turnover. All the value which can be added to the meat has been added and it is the remainder of the carca from which future growth in the industry will have to come. An extreme view, and coming from a position of vested interest, but the basic tr of it has been widely acknowledged.

There is a wide range of materials, products and chemicals which can be made or isolated from a carcass once the meat has been neatly vac packed and sent to a French hypermarket. Richard Garland, of New Zealand Pharmaceuticals, told the forerunner of this conference five ye ago of the huge value which could be obtained by isolating every biochemical from an animal and selling it at biotechnology catalogue price This is still true today (and the value would be higher still if the animal were a human). But the drawback is again obvious; what about the cost? In the continuum from the mundane to the exotic, from compost (Schaub and Leonard, 1996), fertilizer and stock food to pharmaceuticals, the value rises proportionately and so, of course, does the cost. However, if the industry is to grow, it is a cost which mus faced.

In this paper I will present a general overview of the types of coproducts available from processing meat and discuss the sort of effort, and s cost, needed to recover them. In particular I will concentrate on the extraction of high value products from current low value coproduct streams, rather than the simple collection of glands and organs for dicect food use.

Most of the coproducts described here are of bovine origin. The reasons for bovine coproducts dominating the area over ovine products ar partly historical, partly due to the larger size of the carcass making processing easier and partly due to higher levels of fat and odour in ovine offals and rendered products. With current concerns about BSE (Dealler, 1993) and increasing numbers of non-traditional animals being slaughtered there must be scope for replacing bovine derived products with those from other species.

Rendered products

The traditional way of dealing with the residue of the carcass is by rendering down into high protein dried powders, such as meat and bone meals (MBM), and tallow. Concern over transmissible encephalopathies has caused a drop in the meat product market, in particular that of rendered products for food ingredients such as high protein meat meals and tallow. Harsher cooking regimes designed to destroy the transmissible agents also lower the nutritional value of the MBM and this will have a detrimental effect on the market as well. However, the clean and green disease free image of New Zealand may offset this market change in the short term.

Meat trims currently fetch $ 1-3/kg depending on quality and the added value opportunities are considerable. There is huge demand for hydrolyzed animal protein (HAP) for use as functional ingredients and flavour additives. HAP products are used as meat extenders in processed delicatessen products where they act as binding and water retention agents. They are also used as flavouring additives in human a pet foods. These products can be sold for anything between $11 - 30/kg. There has been a considerable amount of research into the enzym hydrolysis of meat trims which has shown that production costs are relatively low but the initial capital investment is high. This means that economics are better for high volumes of meat trim and meat processors have an advantage over small secondary processors.

The other major product from rendering, tallow, is facing competition from palm oil products which may have better properties for food us (Brown, 1989) and polyunsaturated vegetable oils for health reasons (Kreulen, 1976). Currently tallow sells for less than $1/kg. The value of tallow can be increased by further processing to deodorize and decolourize it and fractionation into products with defined physical propertie such as sharp melting points etc. There are a number of secondary companies in New Zealand involved in this business with the large meat processors supplying the crude raw material. There may be opportunities for the meat companies to do further processing on site.

Collagen

Collagen, a large insoluble protein, is the most abundant molecule in the carcass, after water, at around 40% of the dry weight. It is also the basis of a number of coproducts which span the range of the mundane, such as gelatin, to the exotic, such as artificial skin for burn patients

Traditionally, waste hide material is processed into gelatin by partial degradation and extraction of the collagen (Rose, 1987). This can be d a number of ways, by long soaking in basic conditions, the classical method, or faster extractions in acid, with or without the use of enzyme Bone is also used as a source of gelatin. The resulting material is widely used as a food ingredient. Specially pure, or particular molecular weight fractions are used as biochemical reagents, encapsulating materials and as adhesives. Gelatin is produced on a large scale by one specialist company in New Zealand.

However, additional value may be obtained from isolating the unmodified collagen. When hides are split the outer grain provides leather while the waste corium can be dried to give collagen. This collagen can be used as a food ingredient, like the gelatin. It can also be extruded to make fibres for use as "biomaterials" such as artificial skin, wound dressings and surgical films. Collagen type varies with the age of the animal and anatomical location. The corium of young animals is particularly useful as the collagen has low levels of crosslinking which is ideal for use in cosmetics. However, particular types of collagen, especially material with very low levels of crosslinking, can be grown by fermentation, which competes with extracted material in the high end of the market.

The unmodified collagen from demineralized bone powder has medical applications for packing holes in gums and bones and as standards in diagnostic kits.

Glycosaminoglycans

Glycosaminoglycans (GAGs) are a group of complex carbohydrate compounds which are widely distributed throughout the carcass, making up around 2% of the dry weight. A range of GAG based coproducts can be isolated from meat processing waste.

GAG	Source	Uses (price)
Hyaluronic Acid	skin eyes	moisturizer ($600/kg)
Chondroitin Sulphate	trachea nasal septa	moisturizer, healthfood ($200/kg)
Dermatan Sulphate	skin mucosa	moisturizer, anti-thrombotic ($2,000/kg)
Heparin	lungs mucosa	anti-coagulant, anti-thrombotic ($5,000/kg)

Table 1. GAG sources and uses.

Hyaluronic acid can be extracted from the corium of the skin. Eyes also contain substantial quantities of hyaluronic acid and there have been a number of studies of the economics of getting it out (at least two of them by us). The cost of collection of the raw material makes the processing of hyaluronic acid from eyes too expensive. As with many of these coproducts, the value of the top grades of the product makes processing look attractive but the value of the grade which can be achieved means that the economics are not there. The top quality hyaluronic acid, which is used as a packing material in eye surgery, is isolated from rooster combs and sells for up to $US 10,000 a gram but bovine material does not have a sufficiently high molecular weight to compete in this market. It finds its major use as a cosmetic moisturizing agent at $US 400 - 800 a kilo but this market has been overtaken by hyaluronic acid grown by bacterial fermentation (Van Brunt, 1986).

GAGs are also sold as health foods. In particular, a book has recently hit the American Best Seller lists advocating the use of the GAG chondroitin sulphate as a treatment for arthritis (Theodosakis et al. 1996). This has produced a huge upsurge of interest in the material, which can be isolated from cartilage containing waste materials. GAG enriched powders (30% GAG) can be produced from trachea by enzyme digestion, filtration and drying to sell in the region of $50-60/kg. This material is used in stock feeds and some healthfood applications. Taking it a step further to get pure (better than 90%) GAGs needs a separation by precipitation or chromatography but produces a product which will sell for $200/kg. This product is used in cosmetics as a moisturizer and to add 'feel' to creams and also in health foods. It is worth noting here that the standards of quality control for cosmetic and processed food ingredients are generally far higher than for healthfoods and natural remedies.

Heparin is another GAG which is used as a pharmaceutical to prevent blood coagulation during surgery and thrombus formation afterwards (Linhardt, 1991) and it makes an interesting case study of the difficulty of realizing the potential of a high value coproduct. As yet no GAGs other than hyaluronic acid can be produced by fermentation and the material is too complex to synthesize, so it is one of the few genuine pharmaceuticals which still is isolated from natural sources. As a coproduct of sausage manufacture with a relatively simple isolation procedure and a high value it should be good prospect to make money. Unfortunately there is a large amount of very cheap porcine heparin from China on the market and the pharmaceutical industry's demands for consistency means that they tend to stay with established suppliers. It may be possibile to exploit niche markets, such as those with religious objections to porcine products, and these are being explored by at least one New Zealand company.

Hides

Hides are the original coproduct from meat processing and a substantial and sophisticated industry has developed around maintaining hide quality from the plant and during the tanning to process. Hides consist of two layers, the outer grain, which provides the leather, and the corium which can be processed for GAGs, gelatin and collagen as discussed earlier. Recovered hair is a source of keratin which is widely used as an ingredient in hair care products.

Bone and horn

The traditional uses of bone are the MBMs and as blood and bone fertilizers. Collagen products from bone have been discussed already. Bone can also be dried and powdered for use as a calcium supplement: if ground sufficiently finely it can be added to milk products to increase calcium levels. The principle mineral component of bone, hydroxyapatite, is used as a biochemical reagent for chromatography although this is very technically demanding.

Horn is comprised of keratin rather than collagen and, contrary to popular belief, cannot be made into glue. Bovine and ovine horn can be used for carving but traditional industrial uses such as combs and buttons have been overtaken by plastics. Horn meal is used as a fertilizer in specialized situations because, in contrast to bone, it is high in sulphur and low in phosphates. It may be possible to isolate the keratin for hair care products.

Powdered horn, especially from deer, is used as an aphrodisiac food supplement in Asia along with deer velvet which is an established industry in New Zealand.

Lungs and trachea

The lungs and trachea consist of a tough flexible collagen/ GAG matrix with the trachea being supported by rings of mineralized cartilage to prevent their collapse during breathing. At present most of the trachea which is collected is used for petfood manufacture or is sold to secondary processors for the isolation of collagen and GAGs as was described earlier. However, there is some direct involvement of large meat companies in coproduct isolation from trahea in New Zealand..

Lungs and trachea also contain the trypsin inhibitor aprotinin which is sold as a biochemical reagent and potential therapeutic.

Glands

The animal's glands are the site of biosynthesis of a wide range of hormones, enzymes and other biologically active compounds which are widely used as natural remedies and health foods as well as in industry (Table 2 (Parsons, 1992)). At one time purified compounds, such as insulin from the pancreas and progesterone from ovaries, were used by the pharmaceutical industry but these have now mostly been replaced by recombinant or synthetic products, which give better quality control. There are some products, such as glucagon, that are still gland derived because they are difficult to produce as recombinant peptides. The major markets for the glands as coproducts are as whole frozen glands or freeze dried powders which are sold to secondary processors, generally overseas, as raw materials for further processing into natural remedies. New Zealand is in a good position to cater to the market, with high stock numbers, a good image and disease free status. Reliable, consistent collection of glands is the key to maintaining customers in this area.

Gland	Product	Use
Adrenal	steroids	allergy treatment
	epinephrine/norepinephrine	pharmaceutical
Hypothalmus	oxytocin	stimulate milk secretion
Ovary	estrogens	regulate female characteristics
Pancreas	proteases	leather, dairy industry
	proteases/amuylases	digestion aids
	DNase, RNase	biotechnology industry
	insulin, glucagon	pharmaceutical
Pineal	melatonin	anti-jetlag, anti-seasonal depression
Pituitary	growth hormones	stock food supplements
Testes	androgens	regulate male characteristics
Thymus	thymosin	immune regulation

Table 2. Gland products and uses (Parsons, 1992).

There is considerable scope for the large meat companies doing further processing of gland derived products but the problems are lack of technical expertise and market knowledge. The processed products are made by small specialist companies which buy in a wide range of raw materials, have a very good technical understanding of their products and are very quick to respond to market demands. They are mostly supplying small volume niche markets. However, once contact has been made with regard to supplying raw materials, and a relationship built up with the overseas company, it can make economic sense for both parties to have more processing done in New Zealand. In this way the meat processor gets quick access to both the technical skills and markets. This is probably the most straightforward route into the more sophisticated end of coproduct processing but it is difficult to start from scratch.

Also, the market is very fickle. Melatonin, from the pineal gland, was a big seller last year but the likelihood that there will be an FDA ruling making it a drug is shutting the market down. A company entering this area needs to have the confidence that there will be another similar product to sell next year and, of course, the flexibility to change its processing to make it. It may be that the larger processors will not enter the area and will always be the suppliers of just the raw materials. If this is the case it would be advantageous for the meat processing companies to form strong relationships with the secondary processors. In this way consistency of supply and quality of the raw materials would ensure the quality of the final product and both parties would gain.

Glands also contain a wide range of enzymes which are not only used as healthfoods but also have industrial and biotechnology uses. These markets are much more stable. The best example of enzyme extraction from a gland is the pancreas. This can be sold as the whole gland freeze dried and powdered as a digestion aid. Crude protein extracts containing a range of proteolytic, DNase and RNase activities are used for bating in the leather industry. Tailored mixtures of protease enzymes, generally made by specific precipitation or chromatographic processes, are used to produce hydrolysates in the dairy and flavouring industries. Here a mixture of enzyme types is desirable to get particular levels of protein cleavage without bitterness. Finally, very pure DNase is used by the biotechnology industry. This requires extensive and sophisticated chromatographic purification but the product is worth $40,000/kg. However, it takes around 12 tonnes of pancreas to make that 1 kg. The DNase process, in fact, is only economic if the protease fraction is retained and sold, despite the high value of the final product.

Bile

Bile acids are used as digestive aids, as surfactants and as starting materials for the synthesis of steroids in the pharmaceutical industry. One company in New Zealand is already a well established and major producer of bile acids for the international market.

Stomach and intestines

The intestines are traditionally used to make sausage casings. The mucosa washed out during processing is the source of heparin which was discussed earlier.

Rennet is extracted from calf stomachs and this is a well established industry in New Zealand although facing competition from recombinant products.

The intestines have a unique collagen/elastin mix which gives them the ability to stretch and contract during digestion. This is exploited in the manufacture of 'catgut' tennis racket strings, another specialized business which is established in New Zealand.

Brain

Besides the removal of the pineal and pituitary glands, which requires the removal of the brain from its case the brain can also be extracted for high value lipid fractions such as gangliosides, phospholipids, cerebrosides and ceramides (Mylek, 1993). These compounds are essential components of cell membranes and so can be found in many tissues as well as milk and blood but they are particularly abundant in nerve tissue. They are used principally in the cosmetics industry, where they are incorporated into formulations such as Elizabeth Arden's "Ceramide Eyes" in very small amounts. They also may have potential therapeutic uses, particularly gangliosides. Gangliosides consist of an oligosaccharide attached to a lipid molecule and may have a role in preventing bacterial infections. They are present in cows milk and cows milk derived infant formulae in much lower levels than in human milk and there has been considerable work done on the supplementation of infant formulae with these materials.

The processing to collect the lipid from brain involves a relatively straight forward solvent extraction of the dried tissue but the fractionation into specific compounds usually requires some form of chromatography. Brain costs around $2.50/kg and the crude oil extract can fetch $100-120/kg with a yield of approximately 8% so the economics are relatively good.

However, the problems surrounding BSE have made marketing bovine derived products extremely difficult. There are government regulated methods for sterilizing brain products in some countries but it is not clear that the high value components would survive the treatment. This is definitely an area where there is considerable scope for finding alternative sources such as ovine, goat or deer brains.

Blood

Large quantities of blood are collected and used as fertilizer or in some processed foods (Editorial, 1992). Some bovine blood is collected and fractionated into the cell fraction, for haemoglobin extraction, and the plasma which contains a wide variety of proteins and biochemicals. Specialist companies then extract materials such as albumin, cell adhesion proteins, transferrin, fibrinogen and immunoglobulins, usually by selective precipitation or affinity or ion exchange chromatography. The disease free status of New Zealand and the quality of the products produced means that our products fetch a premium in the biotechnology and diagnostic industries overseas. This is especially true for Fetal Bovine Serum (FBS) which is used as a medium for cell growth in the biotechnology industry and sells for $150-300/l. New Zealand sourced FBS is regarded as the international benchmark for quality.

Exploiting other uses for blood derived proteins and carbohydrates, such as glycoproteins for baby food supplements, will increase the amount of blood utilized.

Conclusion

Adding value to the 40% of the carcass remaining after it has been processed for meat is the logical step for growth in the meat industry. There are a large number of valuable materials which can be extracted from the processing waste and I have tried to give an overview of the major classes here.

There are, however, major barriers to realizing this added value. First, a market needs to be found for the coproduct. Currently, meat processing companies do not have the contacts in the healthfood and cosmetics markets to find new opportunities. Much of the research into coproducts in New Zealand has been done in areas which are of interest to those involved but without clear markets in mind and so much of the effort has not made it to market. One of the best means of developing new products is to respond to requests for specific materials by companies already involved in selling similar products. New Zealand's image as a clean green, disease free producer attracts potential purchasers of raw materials.

The second barrier is developing the technical expertise and culture needed to produce coproducts to the required high levels of consistency and quality. Developing new products also requires the flexibility and technical support to produce small scale samples for evaluation by the customer, which meat processors currently lack. There must be the realization that a ready made product, with a process worked out and a market for tonnes a year set up is unlikely to be handed to a processor on a plate. There needs to be a willingness to have a go. Pick up a request, make a small sample, alter it in response to the clients demands and then work up a full scale process.

The full impact of BSE on the market for bovine products has yet to fully develop and it is not clear whether concern about scrapie will fol The current fashion in cosmetic ingredients is to replace animal derived material with plant extracts wherever possible. Diversification into other species such as goats and deer may be useful for low volume products but the kill numbers will always be very low compared to sheep and cattle. Fish coproducts (the public does not generally regard fish as animals) will also become a souce of competition.

There is also increasing competition at the high end of the market, particularly in pharmaceutical grades, from recombinant products which offer better quality control. However, production by fermentation is expensive so meat derived products can compete at the lower end of the market and there are still some products which cannot be produced by fermentation.

The meat processing industry must decide whether it will continue to leave the production of high value coproducts to smaller secondary companies. The larger companies currently lack the flexibility and technical expertise to exploit small volume niche products. A possible solution may be for the large companies to produce intermediate level products, such as fractionated tallows, meat hydrolysates and simple extracts, which require processing of large volumes of raw materials, and the smaller secondary companies continue to produce the low vol products. In this case the meat industry will gain most by forming strong links with the secondary processors to ensure that the cosistency of supply and quality of the raw materials are maintained to maximize their value.
It is clear that coproducts must become an increasing source of revenue. There are many potential products but the industry needs to devel the flexibility, in terms of both marketing and technical development, to exploit them. The way has been shown by many small New Zealand companies picking up waste from the industry and the larger processors must decide whether to follow their lead, or form partnerships with them.

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