Lamb co-products compendium

V.RMH.0007

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Glossary

Abattoir	A plant or factory where sheep are slaughtered for food, also known as a processing plant, slaughterhouse, or meatworks.
AQIS	The Australian Quarantine and Inspection Service (AQIS) is part of the Department of Agriculture, Fisheries and Forestry (DAFF). Amongst its responsibilities is providing assurance (in the form of an export certificate) that exports of food and other products are prepared in accordance with the health or quarantine requirements of the importing country.
ARA	The Australian Renderers Association (ARA) is the national membership body representing producers and traders of rendered animal products.
AUS-MEAT	A not-for-profit, joint venture company between AMPC and MLA with the principal objectives of the management of red meat trade descriptions and the AUS-MEAT National Accreditation Standards. AUS-MEAT own and operate the National Feedlot Accreditation Scheme on behalf of the Australian Feedlot Industry.
Bioactive compound	A type of chemical found in small amounts in certain foods which take actions in the body that may promote good health.
Biofuel	Most commonly ethanol and biodiesel produced from renewable biomass sources such as animal fats. It is a cleaner-burning replacement for petroleum-based fuels.
Carcase	The body of an animal after slaughter and the removal of most internal organs, skin, feet and head.
Carcase weight	The weight of an animal's carcase after slaughter. Also known as cwt or dressed weight.
Collagen	The primary protein of the connective tissue of animals and the most abundant protein in mammals
Co-product	A substance or product which is an unavoidable result from the production process of obtaining primal meat cuts. These may be edible, such as organs, or inedible, such as skin.
Crossbred	An animal produced by crossing two breeds.
CSIRO	Australia's national science agency, which works with industry, government and the research community to turn science into solutions to address Australia's greatest challenges.
Cwt	Carcase weight.
Dressed	The removal of an animal's head, feet, hide and internal organs during processing. The carcase is now ready for further processing, which will be dependent on its market destination.
Dressed weight	The weight of an animal after slaughter and the removal of most internal organs, skin, feet and head. Also called carcase weight.
Dressing percentage	The percentage of an animal's liveweight that is its carcase weight. Used to estimate a live animal's carcase weight from its liveweight: carcase weight / final liveweight x 100. Also known as DP% and dressing out percentage DO%.
Ewe	A female sheep with more than two permanent teeth.
Export market	A market that a country directs product to. For example, in Australia this might be Japan, the US or European Union.
Fancy meat	An edible co-product (carcase part) handled in a hygienic manner and packed to edible standard including organs and glands, heads, tripe, and brain.
Fat score	An assessment of the amount of fat an animal is carrying. The scores range from one (lean) to six (fat).
Fellmongery	The process of removing wool from the skin after it has been removed from the carcase and treating the skin for eventual conversion into leather.

Freeze-dry	A low temperature dehydration process that involves freezing the product and lowering pressure, thereby removing the ice by sublimation. Due to the low processing temperature, deterioration reactions are minimised, retaining a higher proportion of original nutrients.
Green offal	Offal derived from the digestive tract and the associated organs including small and large intestine, abomasum, omasum, rumen, reticulum, and colon.
Harvesting	Recovery of offals and other co-products from the carcase on the chain or from the offal table.
Heavy mutton	Sheep weighing over 24kg cwt.
Heavy export	Lambs weighing over 26kg cwt.
Heavy trade	Lambs weighing between 20–22kg cwt, also known as supermarket lamb.
Hot standard carcase weight	The weight of the carcase weighed hot, within two hours of slaughter. This is the weight generally used for over the hooks trading.
Hogget	Castrated male and female sheep with no 'ram-like' characteristics and up to two permanent teeth.
HSCW	Hot standard carcase weight.
Kill floor	Area of an abattoir where live animals are slaughtered.
Lambs	Male and female lambs with no 'ram-like' characteristics. Generally weaned, shorn, with no permanent teeth, and normally older than five months of age.
Light mutton	Sheep weighing up to 18kg cwt.
Light lambs	Lambs weighing between 22–24kg cwt.
Light export	Lambs weighing between 22–24kg cwt.
Light trade	Lambs weighing between 16–18kg cwt.
Livestock	Live animals.
MBM	Meat and bone meal – a protein-rich ingredient made from the rendering of the remaining parts of the animal carcase, including meat, bones, and other animal tissues.
MSA	Meat Standards Australia – a meat grading system designed in Australia, used to describe the eating quality of Australian beef and sheepmeat.
Meatworks	A plant or factory where cattle are slaughtered for food. Also known as a processing plant, slaughterhouse, or abattoir.
Medium mutton	Sheep weighing between 18–24kg cwt.
Medium trade	Lambs weighing between 18–20 kg cwt.
Merino	Purebred sheep for the production of fine wool.
MLA	Meat and Livestock Australia – a service provider to the Australian red meat industry whose purpose is to foster the long-term prosperity of the Australian red meat and livestock industry.
Nutraceutical	A product derived from food sources with extra health benefits in addition to the basic nutritional value found in foods.
Pelt	An undressed, untanned animal skin with wool attached.
PFIAA	Pet Food Industry Association of Australia – an industry organisation whose mission is to promote standards of excellence of the pet food industry.
Pickled pelt	Partially processed sheepskin, with wool and flesh removed, and preserved in salt and acid.
Pluck	Consists of the liver, heart, lungs, trachea and a portion of the diaphragm together as one item.

Primal cuts	Major meat cuts from the carcase of the animal, including the forequarter, loin and leg.
Processing	The process of taking a live animal, slaughtering it, and then breaking down into saleable sheepmeat.
Processor	An abattoir operator.
Producer	A sheep or cattle farmer.
Red offal	Edible offal, that does not come into contact with the digestive tract, including heart, liver, kidney, spleen, tongue, sweetbreads, pancreas.
Rendering	The process of heat treating and physical transformation of animal co-products, destroying pathogens, removing moisture, separating solids and lipids or fats/oils to produce valuable animal protein meal, or processed animal protein, and rendered animal fat/oil.
SAF	Sustainable Aviation Fuel – a biofuel used to power aircraft that has similar properties to conventional fossil derived jet fuel, but made from sustainable feedstocks such as animal tallow.
Skin	The skin removed from the carcase immediately after slaughter.
Tallow	The rendered fat ingredient made from the rendering of the remaining parts of the animal carcase, including meat, bones, and other animal tissues.
Wether	Castrated male sheep with no 'ram-like' characteristics and with more than two permanent teeth.
Woolskin	A sheepskin with the wool still attached. Can refer to the dressed, tanned sheepskin.

1 Overview

1.1 Background

Co-products comprise a significant proportion of the returns from animal processing. In 2022, the estimated export value of sheep co-products was valued at $113 million. In many cases, lamb co-products offer more opportunities for innovation and profit than commodity red meat and can provide a valuable competitive advantage for processing plants.

The weight of the co-products can account for over 50% of the sheep carcase.

In general, the highest value can be obtained by packing co-products for edible use. Pet food has the second highest value and rendering is the least valuable. However, handling and packing costs for edible offal and pet food can make recovery of these items less profitable than rendering outlets.

To maximise returns from co-products, meat processors need to identify strategies that will:

- identify the most profitable use of co-products, taking into account harvesting, processing and packing costs
- identify markets – locally and overseas – seeking lamb co-products (particularly edible offal) and establish means to maximise the recovery of these co-products
- identify the opportunity to recover higher value specialty co-products, perhaps for pharmaceutical or nutraceutical products
- develop partnerships with manufacturers seeking lamb co-products as raw materials and ingredients and maximise the value the protein and bioactive ingredients provided by these co-products.

1.2 Breakdown of products from sheep and lamb carcase

In the meat processing industry, monitoring of carcase weights and the weights of co-products harvested and sold is standard practice. However, the yield of many items remains unmonitored. Previous research within Australia (Spooncer, 1992) and internationally (Muir P.D., 2008) has explored specific co-product yields and dressing out percentages. Nonetheless, the applicability of these findings to contemporary sheep populations is debatable, given the phenotypic evolution of lambs over the past two to three decades — today's lambs are generally leaner and larger, with enhanced feed conversion efficiency. *Improving lamb lean meat yield* (Jacob R., 2018) describes Australian research programmes including the MLA Genetic Resource Flock whose purpose is to update breeding values for eating quality and lean meat yield.

In a feature article to mark 100 editions of the Ovine Observer (Department of Agriculture and Food Western Australia, 2023) it was reported that in Issue 1 in 1997 the average lamb carcase weight for Australian lambs in 1996 was 18.5kg compared to 17.6kg in 1990, while in Issue 100, September 2023, the average lamb carcase weight was 25.1kg.

For the preparation of this compendium, an independent analysis of co-product yields was conducted for MLA in February 2024. The study determined the weights and co-product yields of both Merino and non-Merino sheep across a range of liveweights. Lamb is defined as a female, castrate or entire male animal that has no permanent incisor teeth and mutton as a female or castrate male with at least one permanent incisor teeth. Details of the study can be found in Appendix 1 and the key information presented below, with further data in sections of this compendium. Heavy Merino lambs were not available for purchase and not included in the study.

1.2.1 Hot standard carcase weight (HSCW)

Hot standard carcase weight (HSCW) refers to the weight of the carcase immediately after the skin, head, feet, and internal organs have been removed. Liveweight, the weight of the animal prior to slaughter, can be categorized as either 'fresh'—directly from pasture — or 'fasted' — after a period of fasting. The liveweight used in this study is the fasted liveweight.

The cold standard carcase weight (CSCW), the weight recorded after chilling is complete, was not determined in this study. Between 15 November 2005 and 27 February 2008, *A Review of Dressing Out Percentage in New Zealand Livestock* (Muir P.D., 2008) recorded hot and cold carcase weights of 1831 slaughtered lambs and found a 2.3% loss in weight between hot and cold. With spray chilling techniques, the loss can be reduced below 1%. Spray chilling is the intermittent spraying of carcases with water to minimise carcase weight loss (shrink) during the first few hours of carcase chilling. It reduces the average carcase weight loss during overnight chilling from around 3% to 0.6% (Jacob R., 2018). Historically, losses can be as high as 5%.

The dressing percentage (DP%) or dressing out percentage, DO%, can be calculated in four ways, depending on which liveweight and carcase weight is used. *A Review of Dressing Out Percentage in New Zealand Livestock* (Muir P.D., 2008) determined the impact of the method on the estimation of DO%. This is demonstrated in Table 1 for a carcase weight of 13kg, where the estimated liveweight can range between 28.6 and 32.3kg, depending on the method.

Table 1: Effect of method of calculation on the estimation of DO%

Method of calculation	Dressing out percentage, %	Predicted liveweight for carcase of 13kg
hot carcase weight x 100 / fresh liveweight	42.2	30.8
cold carcase weight x 100 / fresh liveweight	40.3	32.3
hot carcase weight x 100 / empty liveweight	45.4	28.6
cold carcase weight x 100 / empty liveweight	43.3	30.0

Improving Lamb Lean Meat Yield (Jacob R., 2018) defined the dressing percentage (DP%) as the weight of a carcase, expressed as a percentage of the liveweight of the animal from which it was processed. The longer the fasting period, the lower the gut contents will weigh and hence the lower the liveweight and the higher the dressing percentage. Longer fasting increases dressing percentage due to greater reductions in liveweight than in carcase weight.

NSW Local Land Services provide information on factors affecting the dressing percentage in their Land factsheet LF-AP-02 (Northern Tablelands Local Land Service, 2016). Many of these factors will affect the percentage of co-products obtained from the carcase.

The fatness or soft tissue depth will influence the dressing percentage. The dressing percentage will increase by two percentage points as the fat score increases, as shown in Table 2.

Table 2: Changes in dressing percentage with fat score

Fat score	Dressing percentage
1 (GR 1–5mm)	41%
2 (GR 6–10mm)	43%
3 (GR 11–15mm)	45%
4 (GR 16–20mm)	47%
5 (GR 21mm+)	49%

The estimated dressing percentage of lambs varies according to the period of time they are off feed and water before live assessment. Table 3 outlines the increase in dressing percentage with increasing time between mustering and weighing.

Table 3: Changes in dressing percentage with hours off feed

Time off feed, hrs	Increase in dressing percentage
0–3	0
4–5	+1
6–8	+2
9–12	+2.5–3.0
13–24	+3.5–4.5

The skin weight of lambs varies according to the wool length, the amount of water held by the wool, and the tissue weight. The dressing percentage allowance for wool length is approximately 1% per 25mm of wool length change from the standard 50mm length used as a 45% dressing percentage guide.

Purebred Merino lambs at equivalent liveweights and fat scores may dress up to 2.5% less than second-cross lambs.

For the MLA 2024 study, the DP% is calculated by **hot standard carcase weight x 100 / empty liveweight**. Selecting carcases from the study with a hot carcase weight of around 13kg, the DO% calculated using this method was 44.9%, in line with that determined by (Muir P.D., 2008), 45.4%, when calculated with this method.

Combined Merino and non-Merino data comparing empty (fasted) liveweight, hot carcase weight (HCW), and DO% are shown in Table 4.

Table 4: Liveweights vs HCW and DP% by weight class, all breeds

Classification	Average liveweight, kg	Average HCW, kg	Ave DP%
All lamb	40.969	18.269	44.28
Light	33.840	14.618	43.16
Trade	43.040	18.594	43.16
Heavy	51.083	24.920	48.78
All mutton	55.725	26.923	48.05
Light	48.388	21.874	45.27
Heavy	61.840	31.130	50.36
All classes	47.212	21.930	45.87

The all-lamb DP% for Merinos was 40.23% compared with 46.98% for non-Merinos, and for all-mutton the DP% for Merinos was 45.40% compared with 51.05% for non-Merinos. That is, Merinos have a lower DP%, as noted in the Land factsheet LF-AP-02.

The DP%, in general, increases with increasing liveweight, as shown in Figure 1.

A greater correlation is found when comparing the hot carcase weight directly with the empty liveweight, shown in Figure 2.

The hot standard carcase weight can be predicted from the liveweight using the DP% or the HCW correlation from Figure 2.

Figure 1: Correlation of DO% vs liveweight for all classes and breeds

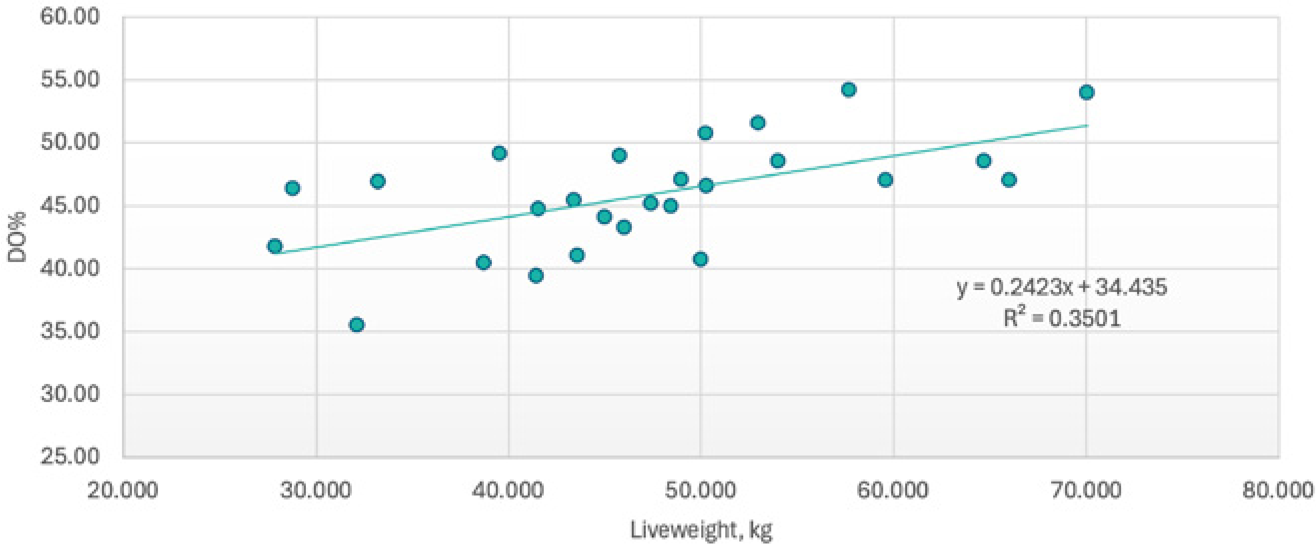
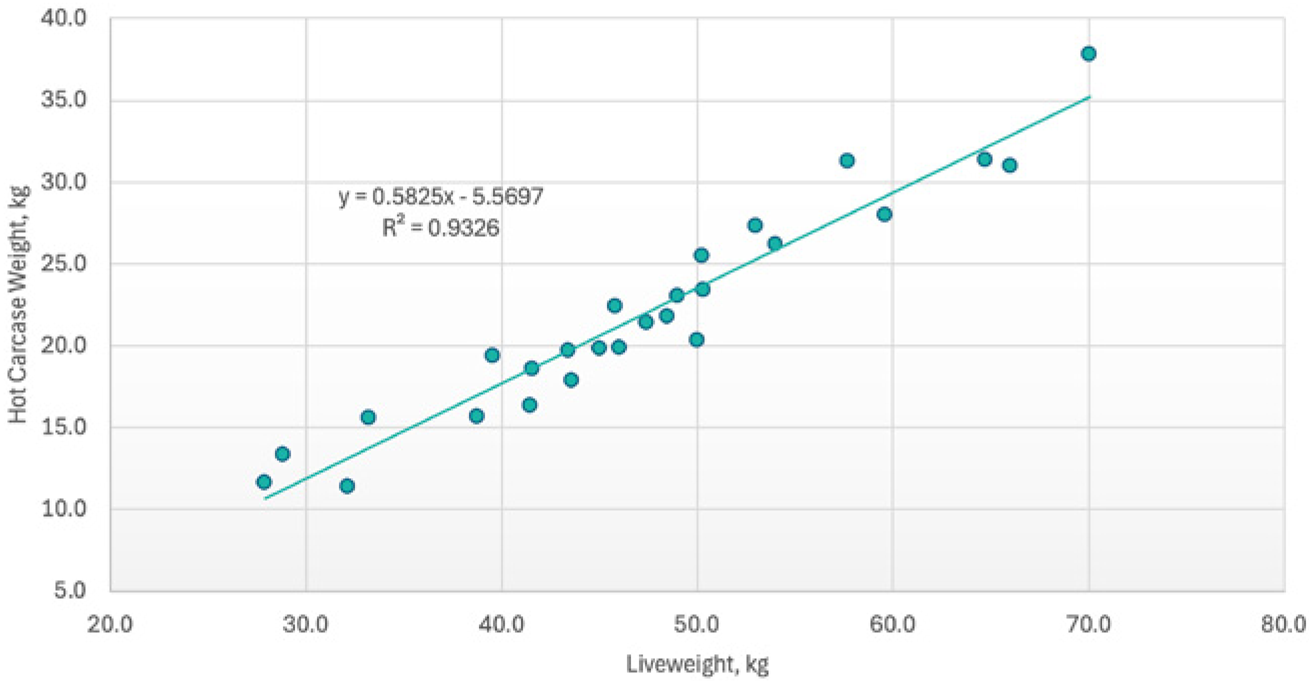


Figure 2: Liveweight vs hot standard carcase weight, all classes and breeds



1.2.2 Co-product breakdown

The difference between the liveweight and the hot standard carcase weight constitutes the weight of co-products, including the head, feet, skin, and internal organs. If the DP% for all classes and breeds averaged 45.87%, then the average percentage of co-products is 54.13% of the liveweight. The greatest contribution being the full gut contents at 46% of the co-products. The weight of the gut contents is dependent on the length of the fasting period and the digestibility of the final feed.

Examining the results for a non-Merino trade lamb with an empty liveweight of 43.3kg, and hot carcase weight of 19.4kg, we can breakdown the co-product yields as follows in Figure 3. For comparison, a heavier Merino heavy mutton with an empty liveweight of 63.4 kg, and hot carcase weight of 30.1kg, is broken down in Figure 4.

For each of the weight classes for lamb and mutton, the cumulative weight of the major co-products groupings is shown in Figure 5. In general, the co-product weight increases with the liveweight.

Figure 3: Co-products breakdown for non-Merino trade lamb

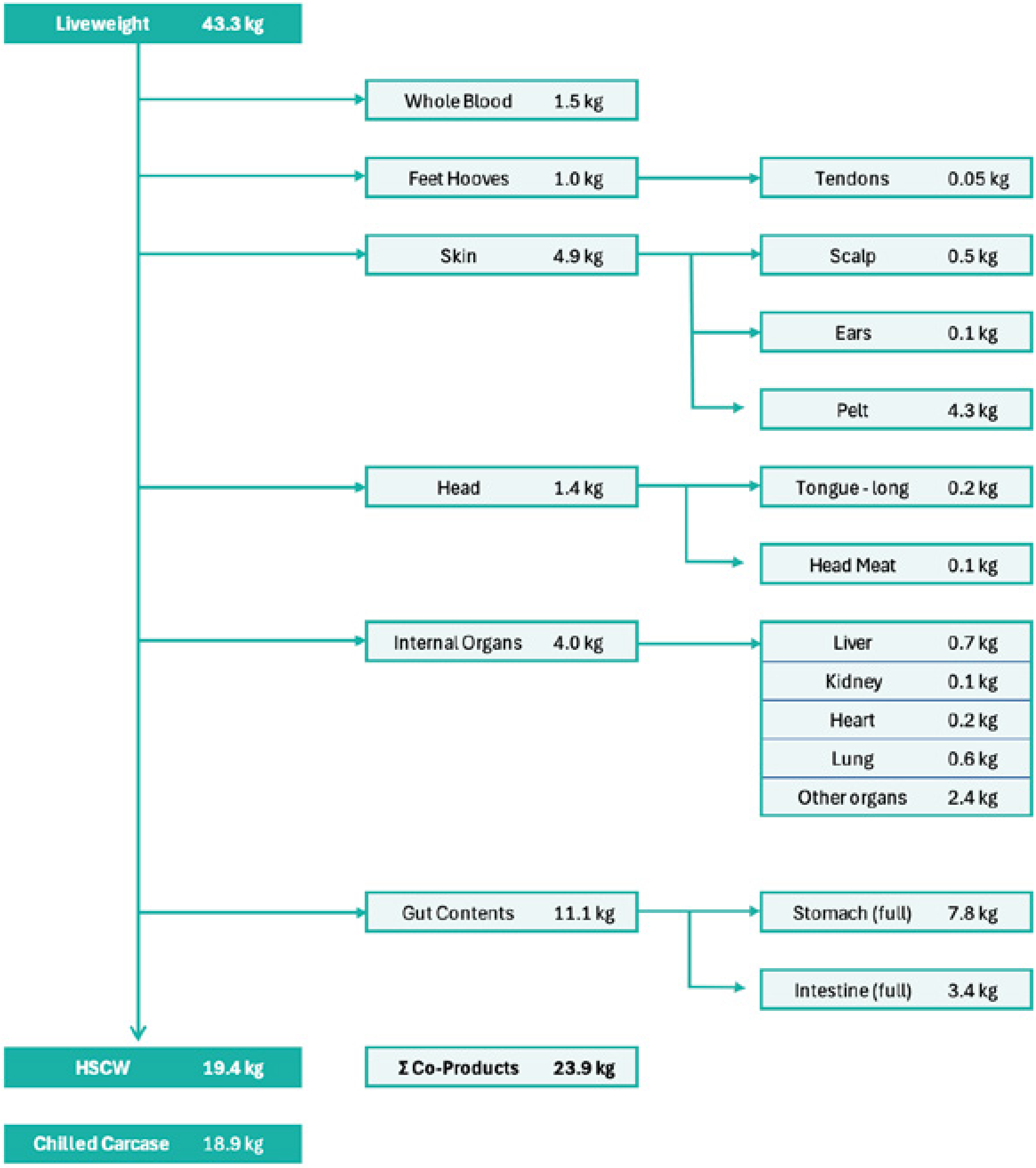
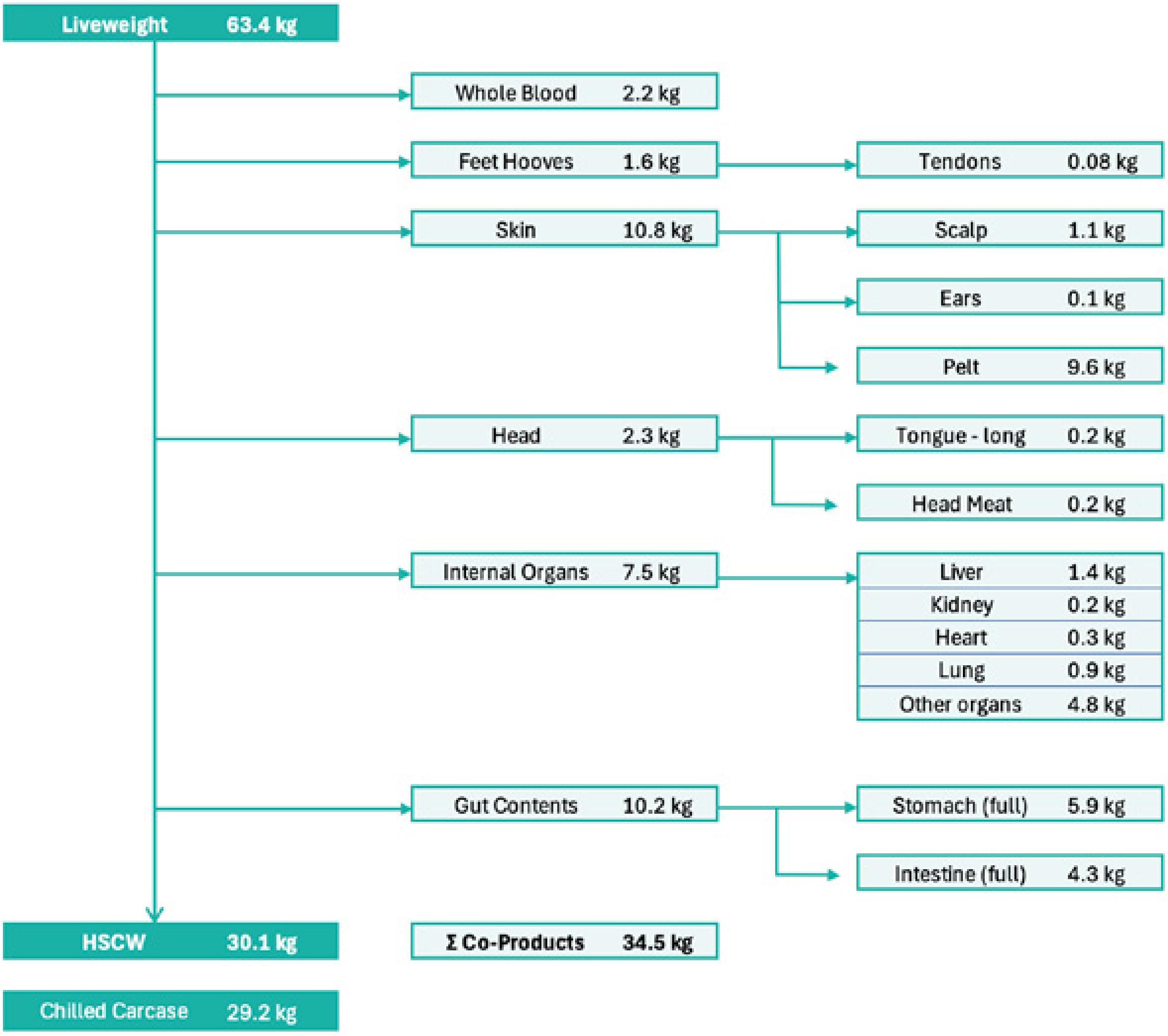


Figure 4: Co-products breakdown for Merino heavy mutton



1.3 Strategy to maximise recoveries

Where there is demand for edible offal, the greatest returns can be realised from their sale as fresh or frozen edible offal. For each item, this will depend on costs and availability of labour for harvesting, trimming and packing.

Where edible returns are not favourable, harvesting co-products as fresh or frozen ingredients for the pet food market may be less onerous and provide better and more consistent net returns.

Demand is also increasing for dried co-products, especially organs, for both the edible and pet food markets. Despite the costs of drying returns from dried offal powders for nutraceuticals are at least five times for wet organs.

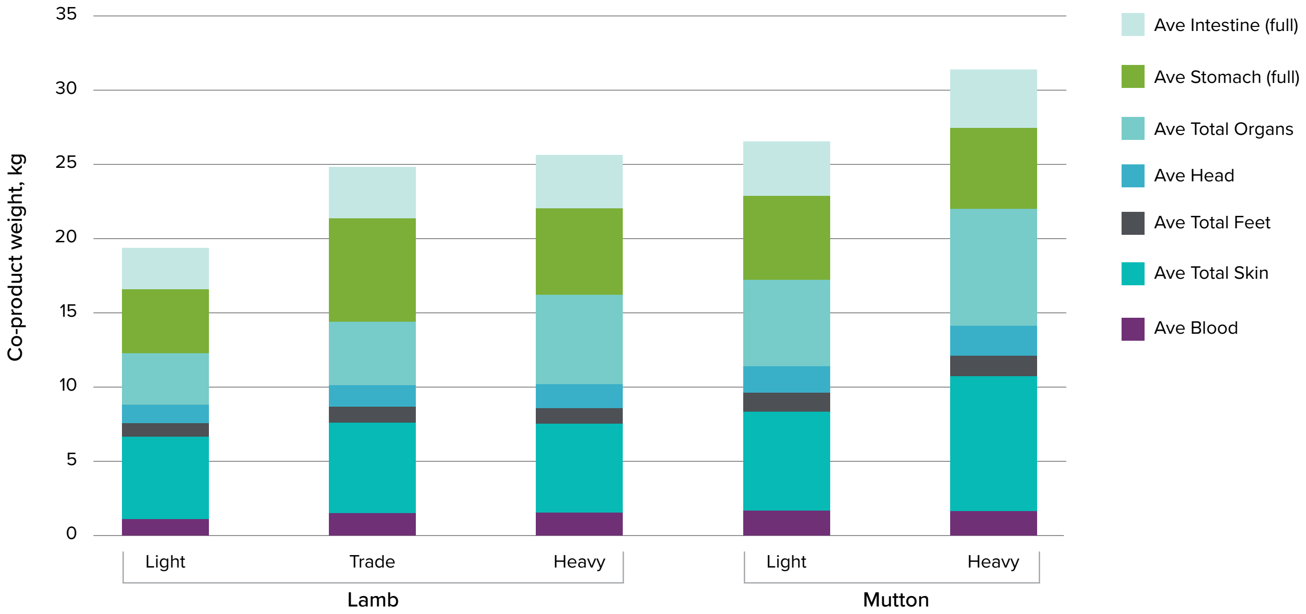
Although harvesting offals may provide a greater return, removing offals from the rendering stream may have a negative impact on the protein levels achieved and impact the value and markets for the ovine meat meals.

However, the collection of bones for use in pet food, bone extracts or degreased bone chip can provide a direct return for the bones and increase the protein content of rendered meals.

If the strategy is to produce high protein ovine meals with >65% protein, the impact of the input materials needs to be assessed against what can be achieved and returns from other streams.

In all cases customers are seeking a relationship with the processor to provide a consistent supply in terms of volume, quality and price. Opportunities exist for the co-product supplier to work with manufacturers seeking co-products to establish ongoing supply chains beneficial to both parties.

Figure 5: Cumulative co-product weights for each class



2 Edible offal

2.1 Background

Edible offal sales provide a further outlet for maximising the value returned on a carcase beyond primal meat cuts. However, not all offals have the same demand. Local offal markets are shrinking but overseas markets are growing for certain offals, especially in the Middle East and certain Asian markets.

The profitability of each offal depends on the ease of harvesting, the weight of offal recovered, the condemn rate and availability of the offal. Also to be considered is the amount of trimming required, the space and facilities for offal handling and packing, the labour available and the freezer space available. Larger items such as liver, tongues and tripe may offer the greatest returns while smaller items such as gall bladder or pancreas may be uneconomical. The possible impact offal harvesting has on the chain also needs to be considered. Offal rooms can be utilised to continue trimming and packing harvested offals without affecting the chain.

Processors need to compare the costs for harvesting, trimming and packing, against the overseas markets and which offals are in demand to determine the available returns compared with other uses or the value to rendering.

2.2 Harvest weights

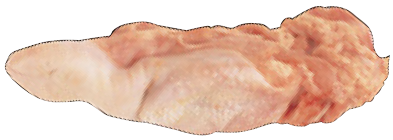
The MLA 2024 co-product yield study provides data on harvested organ weights of both Merino and non-Merino sheep across a range of liveweights. The average liveweights for each class used are shown in Table 4.

Organs have been classified as per the *Handbook of Australian Meat*'s (Aus-Meat, 2022) fancy meat item number and prepared as per the item description. For example, sheep liver item number 7030 is liver prepared with the hepatic lymph nodes incised and attached. Fat, blood vessels and connective tissue attached to the liver are removed.

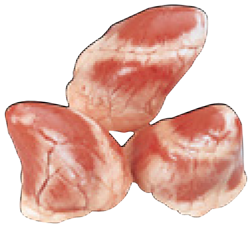
2.2.1 Commonly collected offal items

A review of the Australian Beef and Sheep meat edible offal market review (Spooncer, 2012) identified the most commonly collected sheep offal items as:

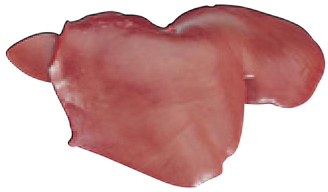
- tongue, long cut (7000) and short cut (7010)
- heart (7050)
- liver (7030)
- kidney (7040)
- tripe, scalded (7080).



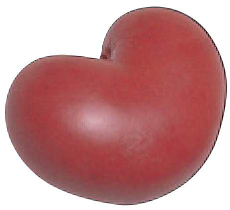
Tongue, long cut (7000)



Heart (7050)



Liver (7030)



Kidney (7040)

Tripe, scalded (7080)

Tripe was unable to be collected and processed for the yield study. Harvest weights for the other commonly collected offal items were obtained and are shown in Table 5.

In general, organ weights increase with the weight of the animal. The weight of organs from Merino sheep were heavier than non-Merino sheep, despite similar hot carcase weights. This is shown more clearly in Table 6 where the yield percentage, calculated as the organ weight divided by the hot carcase weight, are shown.

Table 5: Weights of commonly collected organs, kg

	Tongue – long cut (7000)	Tongue – short cut (7010)	Heart (7050)	Liver (7030)	Kidney (7040)
Lamb	**0.165**	**0.087**	**0.211**	**0.750**	**0.128**
Light	**0.156**	**0.079**	**0.194**	**0.641**	**0.115**
Merino	0.153	0.080	0.200	0.732	0.115
Non-Merino	0.158	0.078	0.188	0.550	0.115
Trade	**0.166**	**0.088**	**0.211**	**0.753**	**0.133**
Merino	0.170	0.093	0.217	0.822	0.140
Non-Merino	0.162	0.082	0.205	0.685	0.125
Heavy	0.182	0.102	0.243	0.963	0.147
Non-Merino	0.182	0.102	0.243	0.963	0.147
Mutton	**0.214**	**0.119**	**0.278**	**0.988**	**0.164**
Light	**0.195**	**0.116**	**0.267**	**0.856**	**0.153**
Merino	0.212	0.118	0.282	0.987	0.168
Non-Merino	0.170	0.113	0.245	0.660	0.130
Heavy	**0.229**	**0.121**	**0.287**	**1.098**	**0.173**
Merino	0.238	0.138	0.295	1.365	0.207
Non-Merino	0.220	0.103	0.278	0.830	0.140
Grand total	**0.186**	**0.100**	**0.239**	**0.851**	**0.143**

Table 6: Yield % of commonly collected organs, on hot carcase weight

	Tongue – long cut yield %	Tongue – short cut yield %	Heart yield %	Liver yield %	Kidney yield %
Lamb	**0.903%**	**0.476%**	**1.153%**	**4.107%**	**0.702%**
Light	**1.066%**	**0.542%**	**1.328%**	**4.384%**	**0.787%**
Merino	1.168%	0.609%	1.524%	5.574%	0.876%
Non-Merino	0.983%	0.486%	1.169%	3.414%	0.714%
Trade	**0.892%**	**0.471%**	**1.134%**	**4.051%**	**0.713%**
Merino	0.954%	0.524%	1.216%	4.613%	0.786%
Non-Merino	0.834%	0.422%	1.058%	3.535%	0.645%
Heavy	0.729%	0.408%	0.976%	3.866%	0.589%
Non-Merino	0.729%	0.408%	0.976%	3.866%	0.589%
Mutton	**0.794%**	**0.441%**	**1.032%**	**3.669%**	**0.609%**
Light	**0.891%**	**0.530%**	**1.221%**	**3.913%**	**0.699%**
Merino	1.000%	0.559%	1.330%	4.659%	0.795%
Non-Merino	0.742%	0.491%	1.069%	2.880%	0.567%
Heavy	**0.736%**	**0.388%**	**0.921%**	**3.526%**	**0.557%**
Merino	0.791%	0.459%	0.979%	4.531%	0.686%
Non-Merino	0.685%	0.322%	0.866%	2.583%	0.436%
Grand total	**0.846%**	**0.458%**	**1.090%**	**3.879%**	**0.654%**

For comparison, a review of offal collection (Sentance, 2011) reported the following sheep organ weights. No information was provided on the breed or carcase weight. Relevant data is reproduced in Table 7.

Table 7: Sentance 2011 Sheep offal weight data

Sheep offal	Heart 7050	Liver 7030	Kidney 7040	Spleen
Sample size, no. carcases	65	30	36	78
Average weight per carcase, kg	0.251	0.707	0.149	0.112

In 1992, the Meat Research Laboratory reported on by-product yields from sheep and cattle, (Spooncer, 1992). Sheep and lamb offals were collected and weighed on the slaughter line at two export abattoirs. Each type of offal was collected from at least 20 carcases in three categories, lambs (15–23kg), light sheep (less than 22kg) and heavy sheep (greater than 22kg). The lamb data corresponds to the trade lamb data in the 2004 survey, while the mutton data corresponds to light and heavy mutton. The proportion of Merino and non-Merino were not specified. The mean results are presented in Table 8.

Table 8: 1992 common organ weights, kg

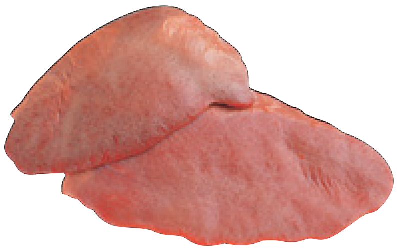
	Tongue long cut (7000)	Tongue – short cut (7010)	Heart (7050)	Liver (7030)	Kidney (7040)
Lamb	**0.152**	**0.095**	**0.157**	**0.574**	
15–23	0.152	0.095	0.157	0.574	
Mutton	**0.439**	**0.154**	**0.197**	**0.730**	**0.146**
<22	0.163	0.115	0.175	0.682	0.141
>22	0.276	0.193	0.218	0.777	0.150
Grand total	**0.591**	**0.134**	**0.183**	**0.678**	**0.146**

In most cases the organ weights from the 2024 study are heavier than the 1992 weights for similar weight classes. This could be a result of the phenotypic evolution of lambs over the past two to three decades. It should be noted however that the sample sizes in both studies are small. Sheep offal weights are known to vary according to sex, age and body condition score, and as we see from the 2024 study, Merino and non-Merino. Variations in these parameters are likely to lead to organ weight differences among small sample studies.

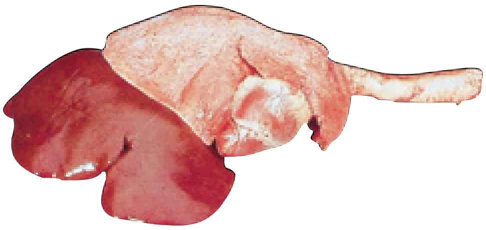
2.2.2 Other collected offal items

Weights for other edible organs defined in the Handbook of Australian Meat (Aus-Meat, 2022), but less commonly collected are presented in Table 9.

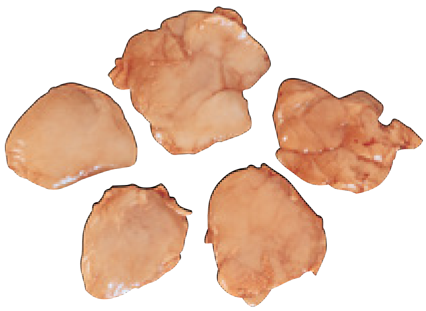
Lung (7100)



Spleen (7090)



Pluck (7140)



Thymus gland (Sweetbreads) (7060)

Table 9: Weights of less commonly collected organs

	Lung (7100)	Spleen (7090)	Pluck (7140)	Sweetbreads (7060)
Lamb	**0.568**	**0.073**	**1.620**	**0.016**
Light	**0.493**	**0.057**	**1.320**	**0.014**
Merino	0.512	0.067	1.333	0.028
Non-Merino	0.475	0.047	1.307	0.000
Trade	**0.593**	**0.074**	**1.706**	**0.019**
Merino	0.610	0.088	1.788	0.012
Non-Merino	0.577	0.060	1.623	0.027
Heavy	0.668	0.102	2.047	0.012
Non-Merino	0.668	0.102	2.047	0.012
Mutton	**0.748**	**0.108**	**2.255**	**0.009**
Light	**0.708**	**0.097**	**2.056**	**0.007**
Merino	0.737	0.098	2.230	0.012
Non-Merino	0.665	0.095	1.795	0.000
Heavy	**0.782**	**0.118**	**2.420**	**0.010**
Merino	0.850	0.127	2.752	0.020
Non-Merino	0.713	0.108	2.088	0.000
Grand total	**0.644**	**0.088**	**1.888**	**0.013**

Table 10: Weights of other organs

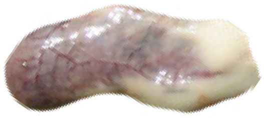
	Pancreas	Gall bladder	Oesophagus	Trachea
Lamb	**0.035**	**0.006**	**0.048**	**0.046**
Light	**0.043**	**0.005**	**0.035**	**0.041**
Merino	0.043	0.005	0.028	0.040
Non-Merino	0.043	0.005	0.042	0.042
Trade	**0.031**	**0.006**	**0.053**	**0.048**
Merino	0.038	0.007	0.057	0.042
Non-Merino	0.023	0.005	0.048	0.053
Heavy	0.025	0.007	0.065	0.055
Non-Merino	0.025	0.007	0.065	0.055
Mutton	**0.051**	**0.010**	**0.065**	**0.054**
Light	**0.052**	**0.008**	**0.072**	**0.051**
Merino	0.050	0.010	0.072	0.045
Non-Merino	0.055	0.005	0.073	0.060
Heavy	**0.050**	**0.011**	**0.058**	**0.056**
Merino	0.050	0.013	0.050	0.057
Non-Merino	0.050	0.008	0.067	0.055
Grand total	**0.042**	**0.007**	**0.055**	**0.049**

Again, we see organ weights increase with the weight of the animal. The weight of organs from Merino sheep were heavier than non-Merino sheep, despite similar hot carcase weights.

2.2.3 Other offal items

The weights of the final items harvested and weighed are presented in Table 10.

Pancreas

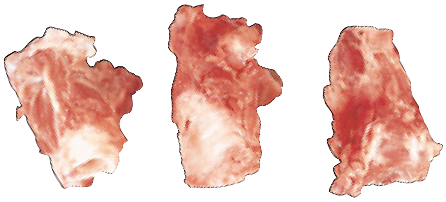


Gall bladder

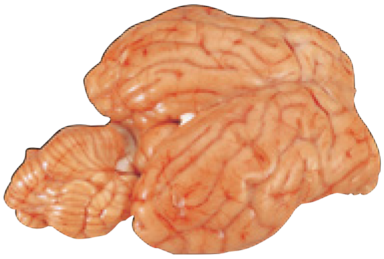
Oesophegus

Trachea

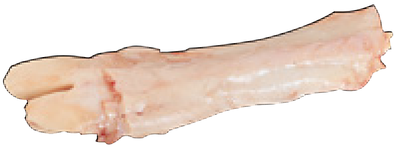
For these organs there are no clear trends and a greater variation of weights. This may reflect the difficulty in harvesting these smaller items and variations in trimming.



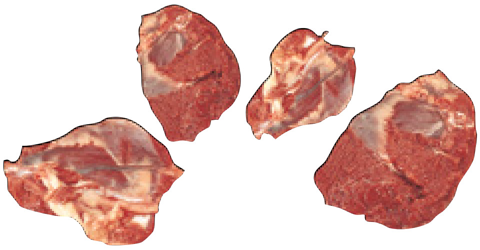
Tongue root (7025)



Brain (7070)



Tendons (7091)



Head meat (7110)

2.3 Factors affecting harvesting

In a review of the MLA co-product program with feedback obtained from industry stakeholders (Aird J, 2006), interviews indicated that errors still occur in the inspection procedure resulting in less than desired offal recovery rates. Those interviewed felt that systems used by inspectors tend to be too prescriptive. The question about the practice of quality inspection was raised when an animal has already been passed as fit for human consumption. Perhaps a risk analysis approach should be considered as it generally typifies the food industry.

A review of offal collection was conducted for MLA (Sentance, 2011) to establish benchmark data on quality and yield in edible offal collection.

All the abattoirs surveyed collected as much offal as their facilities, the availability of labour, value of the offal and AQIS condemnations allowed. If labour was short the least profitable items were dropped first. The availability of labour and the condemnation rate due to disease or other abnormality by AQIS were the main factors that affected yield.

The research team found it difficult at first to benchmark yields for two reasons:

- There was no consistent form of recording yield data between the abattoirs.
- AQIS does not record condemnations of offal unless associated with carcase condemnation.

This meant that all the abattoirs found it difficult to get accurate yield data. They largely used counts where available e.g. for runners or percentage of HSCW based on in-house studies. The latter was extremely unreliable due to large variations in offal weight between animals of different types.

To address this problem the research team developed an Excel-based management tool that was used to benchmark offal yield at the eight participating abattoirs for both beef and sheep offal over two separate weeks. This tool can be used by the industry to develop their own in-house benchmarks at each abattoir and to compare performance with other plants with a similar output.

2.4 Typical uses

Edible offal covers a range of products which have different uses in different markets. Demand for certain offal items is concentrated in particular countries. Exporters should be aware of these markets, how the offals are used in these markets and the preferred specifications of the markets.

Demand and returns will also be influenced by market access requirements and free trade agreements. Australian sheepmeat has some of the best market access globally, with most product facing less than a 5% tariff when entering export markets. Australia, however, has a modest tariff

disadvantage to New Zealand in China and is held back by disproportionately smaller quotas in the EU.

Australia's access to global markets is underpinned by strong animal health and food safety credentials, having never had a case of Foot and Mouth Disease and being host to world-leading traceability systems. This applies to co-products as well as sheepmeat.

2.5 Market volumes and values

In the aforementioned review of the MLA co-product program with feedback obtained from industry stakeholders (Aird J, 2006) it was noted that local offal markets are shrinking but overseas markets are growing. The systems used for quality assurance are generally not aligned with overseas market requirements. There is potential in the market for edible offal exports to China which is being supported by trade negotiations. An opportunity exists to re-orientate quality systems to overseas market needs.

At least one interviewee observed that some abattoirs may undervalue recovery of offals due to a lack of awareness of markets and methods of recovery.

There is growing demand for new and innovative offals which are also generally not understood. Training has not kept pace with such opportunities. Both technical understanding of appropriate requirements followed by training tools and knowledge is suggested.

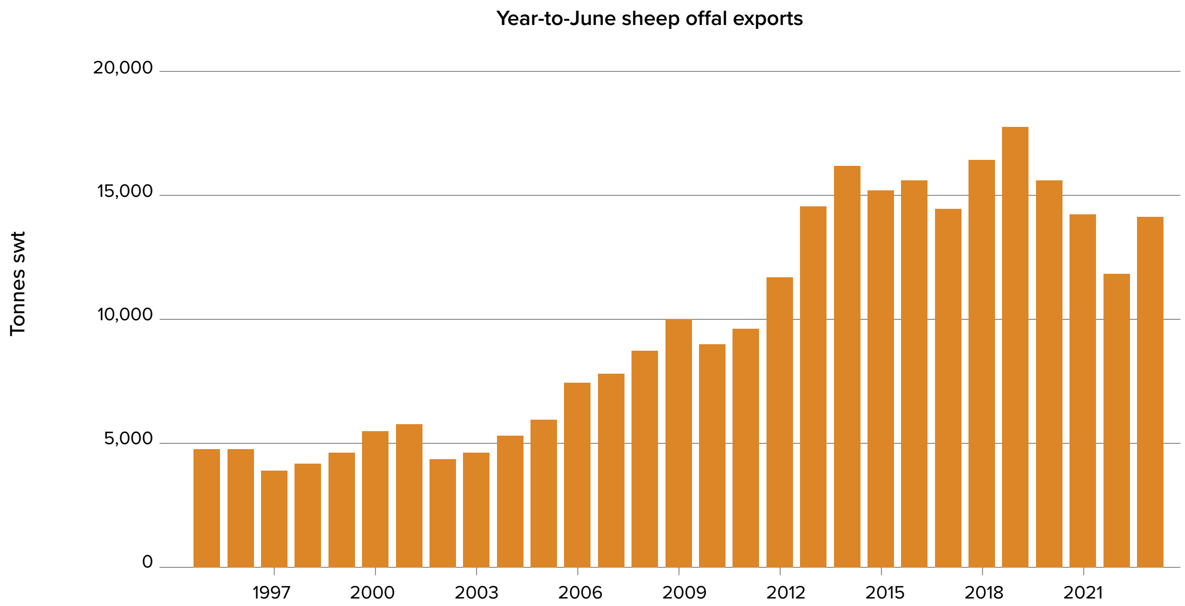
The last full year export offal data from MLA's monthly trade summary of Australian offal exports was for 12 months to June 2023. Table 11 reproduces the export volumes in tonnes shipped weight.

Table 11: Offal export tonnes by market to June 2023

Market	12-months ending June 2023	Year on year % Change
Total	**26691**	**-5**
Hong Kong	5227	-18
Saudi Arabia	7915	21
South Africa	1356	-48
Papua New Guinea	1392	22
China	1019	-13
UAE	872	14
Sri Lanka	25	-89
Vietnam	99	
Jordan	489	-12
Kuwait	427	-23
Mauritius	393	-2
Bahamas	265	
Qatar	423	-5
Singapore	335	-10
Malaysia	363	-42
Other	6091	

The report also provides a chart of the volumes since 1995, reproduced in Figure 6.

Figure 6: Annual sheep offal exports, shipped tonnes



Source: DAWR, Prepared by MLA

The MLA co-product market report for December 2023 (MLA, 2023) reported on the following sheep co-product prices, Table 12.

Table 12: Sheep co-product prices November 2023

	Average Nov data	Range	Responses	Monthly change	Annual change
Heart sheep – Halal	$2.43	$1.90	3	-2.7%	-58.4%
Heart sheep – Halal	$2.45	$1.60	4	0.7%	-57.3%
Kidneys sheep – Halal	$1.88	$1.50	4	-46.4%	-62.6%
Liver sheep – Halal	$3.00	$3.50	4	-13.5%	17.1%
Runners lamb	$3.17	$1.00	3	-48.6%	-53.6%
Runners sheep	$2.17	$1.00	3	-58.1%	-62.8%
Tripe sheep – Halal	$3.70	$2.00	3	8.8%	60.9%

Price quoted is average price reported $/kg FOB Australian port and runners as $/piece.

In 2022, Australian frozen sheep organ exports were worth US$72 million with an additional US$1 million from chilled sheep organs.

2.6 Alternative outlets

2.6.1 Nutraceuticals

Traditional eating habits have changed over time as consumers become increasingly time poor. This change has contributed to the reduction in consumption of highly nutritious meal cuts and organs that contributed to a healthy balanced diet.

Globally, as today's consumers become more health-focused and informed, we are seeing strong growth in powders, pastes, capsules, tablets, and gummies containing bioactives such as vitamins, minerals, proteins and collagen as they look to fulfil their nutrient needs through supplements rather than their diet.

Nutraceuticals are classified as substances that have physiological benefits, with the potential to provide protection against chronic diseases. Nutraceuticals may be used to improve health, delay the process of aging, prevent chronic diseases, or support the structure and function of the body.

The proteins and amino acids market is expected to grow worldwide from $9 billion in 2021 to $28.1 billion in 2030, with Asia Pacific alone growing by nearly $10 billion.

While the consumption of red meat organs is in decline, the demand for red meat organs as a source of bioactives and nutraceuticals is growing.

There is significant opportunity to increase the profit return per head via harvesting and drying sheep organs. Selling the product as a dried organ powder can generate returns per head 10 times that of selling whole frozen organs.

Dried organs currently on the market globally include liver, lung, heart, spleen, pancreas, thymus, thyroid and adrenal glands.

2.7 Available resources for maximising value

2.7.1 P.PSH.1209 - Organic freeze dry lamb liver pet treats

Organic freeze dry lamb liver pet treat (Grout, 2020) reported that the pet treat market in Australian is worth A$20 million. With pet owners buying three times as many beef treats as lamb treats, there is an overwhelming opportunity to increase the pet parent preference for buying lamb treats and to grow the market segment for red meat treats. This report presents the opportunity to develop more demand for Australian organic freeze dry raw lamb treats.

Grout concluded that there is an abundance of Australian brands with 'natural' meat treats but no brands with 'organic' meat treats because pet parents see natural as meaning the same as organic, and large brands see the cost of organic meat being price prohibitive. As the humanisation of pets occurs, this may change.

To be competitive on the local and global front, Australian prices in an emerging market (organic lamb treats) need to be comparable to the prices of natural meat treats. Organic meat processors should continue collaborating and helping organic retail brands establish themselves, to build market share. More organic products being sold in retail will benefit the organic lamb industry.

2.7.2 P.PSH.1430 - Reduction of vitamin A in lamb liver for pet food application

Liver is a highly palatable ingredient used in pet food formulations, but its inclusion level is constrained to prevent vitamin A toxicity in cats and dogs, in practice generally limited as <5–10 wt% DM (Kim et al, 2023). This project investigates whether a simple non-polar liquid extraction of vitamin A from liver might address this issue while also increasing the utility and value of liver for the red meat industry.

The potential to extract vitamin A from liver using common food grade solvents (hexane, vegetable oil and tallow) was explored at a laboratory scale. The results indicate that extraction of vitamin A is technically feasible through all of the tested solvents, with proof-of-concept experiments indicating that the vitamin A content can be reduced by 45–64% for fresh liver and 68–91% for dehydrated liver on a dry matter basis. If similar reductions are achievable at a commercial scale, this could enable cat and dog food formulations to implement quite high inclusion levels.

The ability to realise maximum inclusion rates will depend on industry users knowing the starting concentration of vitamin A in the liver and final values obtained. On-line quantitation of vitamin A is unlikely to be achievable in the near-term, therefore in practice a wide margin of error may still need to be applied to ensure pet safety. As liver becomes more frequently utilised and its variability measured, and the extracted products become optimised, the confidence in inclusions rates will improve.

2.7.3 P.PSH.0999 - Developing high-value freeze dried Australian red meat products and services

This research (Dobbrick & Buckley, 2019) formed the objective to identify three-to-five-fold value adding opportunities for the red meat industry through the application of freeze-drying technology.

Red meat products researched and reported on in previous milestones included blood, cubed beef, hides, oesophagi, bile acids and paunch. The design-led approach highlighted waste hides and the extraction of collagen as the lead opportunity.

Australian meat producers are one of the largest suppliers of salted and wet-blue hides and salted skins to the world market. Annually, Australia produces eight million cattle hides, one million calfskins and 32 million woolskins. Australia is one of the few countries with open trade in hides and skins, however farmers still regard these skins and hides as by-products and 'waste'. As a result, they are often sold for whatever amount the counterparty is willing to buy them for, where they are then transformed into leather. With the assistance of MLA and the Australian red meat industry, the technology developed by Freeze Dry Industry (FDI) offers a significant value uplift for the waste hides currently being discarded. FDI is capable of being positioned at red meat processing facilities and/or in close proximity to processors due to its energy efficiencies.

3 Rendered products

3.1 Background

The quality and composition of the raw materials used effect the quality of the finished product. Raw materials will vary at each plant, consequently the composition of meat and bone meal (MBM) will vary plant by plant. Processing temperatures and methods have the greatest effect on amino acid digestibility. Australian MBM is available in various categories, including pure beef, pure sheep, pure pig, mixed species, and may include goat and deer.

The primary focus of lamb processing is to maximise the recovery of red meat from the animal. This is expressed in 1.2.1 as the dressing percentage. Where there is demand, value, and labour available for harvesting, other co-products – especially offal – can be collected for sale. Rendering is considered a means of processing all remaining material into two saleable products, MBM and tallow. Rendering also helps to avoid the environmental impacts and costs associated with dumping this material. Despite the influence the input materials have on the output quality parameters, the proportions of these materials are not, and probably cannot be, manipulated to achieve certain product specifications.

The exception to this is in avoidance of materials that could render the product unsaleable or significantly impact its value. As an example, heads with the skin on can be tolerated but the inclusion of full, woolly pelts would result in high levels of undigested wool in the meal. Meal specifications usually have a limit on wool content. At times where the skin value is very low or zero, generally the only alternative is to dump the skins.

To maximise returns from rendered products by increasing the protein content (above 65%) permanent outlets for lower protein and higher ash components need to be secured. This could include diverting bone material to the pet food industry or, as a degreased bone chip, for the gelatine and collagen peptide industry.

Customers of meat and bone meal demand product consistency, which requires consistency of input materials. Changes in harvest and sale of organs or proportion of hard material entering the rendering plant will result in inconsistencies in meal characteristics. Consistency in particle size is also required, and especially avoidance of bone fragments in the meal. Digestibility and palatability of the meal used for feed is influenced by the freshness of the material being rendered, as well as the temperatures the material is exposed to in the process. Avoiding heat damage and over-processing is critical to maintaining digestibility. Meat meals produced at lower rendering temperatures have superior nutritional qualities.

Lamb processors do have an advantage over the beef industry as a greater proportion of the meat cuts are sold with bone in. These cuts include forequarter, leg, loin, shoulder rack, ribs, neck, foreshank etc. Value can be maximised by rendering lamb material separately, instead of as mixed species.

3.2 Rendered volumes

The production of rendered products is not closely tracked. The Australian Renderers Association (ARA) periodically surveys the production of rendered products in Australia and reports the findings in the Rendering Fact Sheet. (Australian Renders Association Inc, 2015-16). The production of pure ovine meat and bone meal for 2015–16 is reported in Table 13 below. It is expected that an additional 40–50,000 tonnes of ovine meal were included in mixed species meal production.

Table 13: Production of ovine rendered products 2015–16

Ovine meat and bone meal production	41,540 tonnes
Slaughter numbers – sheep	8,126,600 head
Slaughter numbers – lambs	23,131,200 head

3.3 Meal and tallow yields

Yields, particularly tallow yields, depend on carcase types and the materials sent to rendering. During the ARA 2015–16 survey, the production of rendered products was compared with carcase production at a number of establishments. Examples of yields per head obtained for sheep are shown in Table 14.

Table 14: Typical yields per head of slaughtered stock

Meat and bone meal	2.2–3.6kg per head
Blood meal	0.30–0.38kg per head
Tallow	3.0–5.0kg per head

Yields are impacted by the proportion of water entrained in the materials and water added, either intentionally or unintentionally, often to transport the materials. Soft materials, as would come from the viscera table, contain 20% solids and 10% fat, with the remaining 70% being moisture. Material from the boning room, which includes fat trims, and kill floor, including heads and feet, may contain 30% solids and 10% fat, with 30% moisture.

While the inclusion of bones from the boning room increases the solids content, and hence meat and bone yield, the bones also increase the resultant ash level of the meal. To meet the MBM 50% minimum protein level, additions of blood meal may be required.

By-product yields from sheep and cattle (Spooncer, 1992) determined the moisture, protein, fat and ash content of sheep offals, as presented in Table 15.

Table 15: Analyses of sheep offals – Spooncer 1992

Offal	Moisture %	Protein %	Fat %	Ash %
Head	50.6	18.1	13.4	16.5
Tongue	71.6	16.9	8.4	1.1
Root	67.5	13.4	17.5	1.8
Feet	52.3	19.4	10.2	16.9
Liver	75.2	17.4	4.6	1.0
Lung	75.1	15.8	7.6	1.8
Heart	76.5	14.8	5.6	1.1
Skirt	76.7	14.5	6.8	1.1
Kidney	77.4	16.5	3.2	1.2
Spleen	76.7	15.8	5.2	1.0
Paunch	76.9	13.2	8.7	1.0
Intestine	67.8	9.8	21.3	0.8
Runner	79.2	17.4	2.3	0.9
Caul fat	16.4	3.3	79.8	-
Kidney fat	11.9	3.0	84.6	-

Sheep bones were not included in the study. Depending on the meat and fat remaining, Table 16 may be used as a comparison for trimmed bones.

Table 16: Analysis of sheep bones

Offal	Moisture %	Protein %	Fat %	Ash %
Trimmed Bones	65	12	9	14

The study then estimated the resultant yield of tallow and meat meal from each of the component offals, as per Table 17. The ash percentage in the meal has been added for this report.

Table 17: Estimated yield of tallow and meat meal from sheep offals – Spooncer 1992

Offal	Tallow yield %	Meal yield %	Protein in meal %	Ash in meal %
Head	9.3	40.7	44.5	40.5
Tongue	6.3	21.2	79.2	5.8
Root	15.7	17.9	74.8	10.2
Feet	5.9	42.7	45.4	39.6
Liver	2.4	21.6	80.5	4.5
Lung	5.5	20.7	76.3	8.7
Heart	3.7	18.7	79.1	5.9
Skirt	5.0	18.3	79.2	5.8
Kidney	1.1	20.8	79.3	5.7
Spleen	3.2	19.7	80.2	4.8
Paunch	7.0	16.7	79.0	6.0
Intestine	2.0	12.5	78.4	6.6
Runner	-	21.5	80.9	4.1
Caul fat	79.4	3.9	84.6	-
Kidney fat	84.2	4.1	85.4	-

The tallow and meat meal yields were calculated based on 5% moisture and 10% residual fat in the meat meal. The data in the column for ash presence has been calculated such that the percentages of *protein + moisture + fat + ash = 100%*.

The yield and composition of MBM made from sheep offals will depend on the proportion and weight of the materials combined. Inclusion of high-ash materials such as heads and bones will reduce the meal protein content and increase the ash. If soft offals are harvested and diverted for sale or use in other product streams, the meal protein content may be reduced.

3.4 Rendering systems and technology

Rendering is the industrial process of heat treating and physical transformation of animal co-products, destroying pathogens, removing moisture, separating solids and lipids or fats/oils to produce valuable animal protein meal, or processed animal protein, and rendered animal fat/oil.

Many meat processors or abattoirs have an integrated rendering operation where animal co-products from the abattoir are conveyed directly to the rendering plant. Where an operation does not have an integrated rendering facility, animal co-products are transported to a service renderer, who collect and process material from various facilities. There is no substantive difference between the operations of an integrated or service renderer.

However, management of the rendering operations and performance indicators used by integrated and independent renderers can be quite different. The integrated renderer will focus on meal and tallow volumes produced against the number of carcases processed with little knowledge of the input weight of materials sent to the rendering operation. The independent renderer will weigh all materials into the operation and determine the volume of meal and tallow produced as a percentage of the input weight, taking into consideration the moisture of the input materials.

The integrated renderer will obtain energy for the operation from the main plant and return hot water for use in the abattoir. The independent renderer will need to generate steam and provide energy solely for the rendering operation and will measure this against the volume of products produced. The energy requirements for rendering are discussed further at 3.6.

3.4.1 Preparation and sorting

At the rendering facility, the collected co-products undergo sorting and preparation. This involves removing any non-renderable materials, such as contaminants and unwanted substances, to ensure the quality of the rendered products.

A grinder then reduces the raw material to a uniform size for material handling and improved heat transfer in the cooking step.

3.4.2 Rendering process

The main rendering process involves heating the raw materials to break them down into their constituent components, and then separation into fats and oils, meal solids, and water. There are two primary methods of rendering.

3.4.2.1 Dry rendering

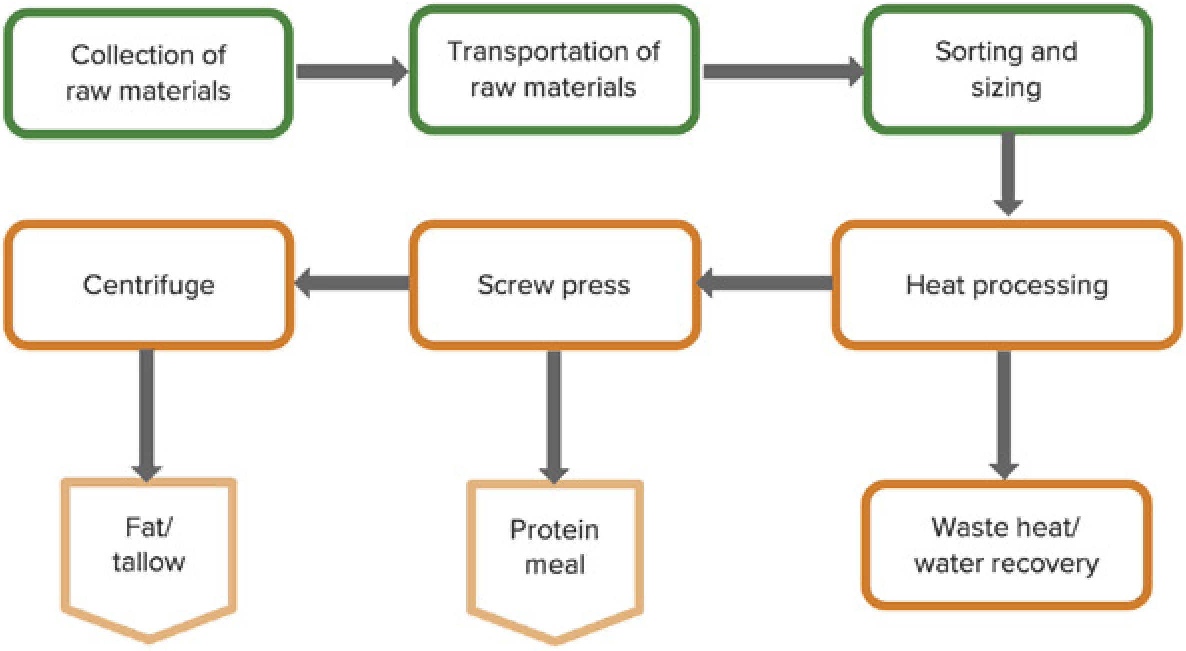
In this rendering process, the raw material is heated in a steam-jacketed vessel to around 130°C which drives off, or evaporates, the moisture from the raw material. As the water evaporates, the temperature of the material rises to a point where discharge screening separates the dry solid material from free-flowing liquid tallow.

The water driven off the raw material can be captured and utilised as a heat and hot water source in the rendering plant. This reduces the net energy required when compared with a wet rendering system.

The solid material is squeezed in a screw press to produce a dry cake of meat meal. The liquid pressed from the meal is combined with the liquid flowing from the cooker. A centrifuge further separates out any remaining water and solid material leaving clean polished tallow.

The polished fat from dry rendering systems is generally of poorer quality and the meat and bone meal have a higher fat content than wet rendering systems.

Figure 7: Dry rendering process



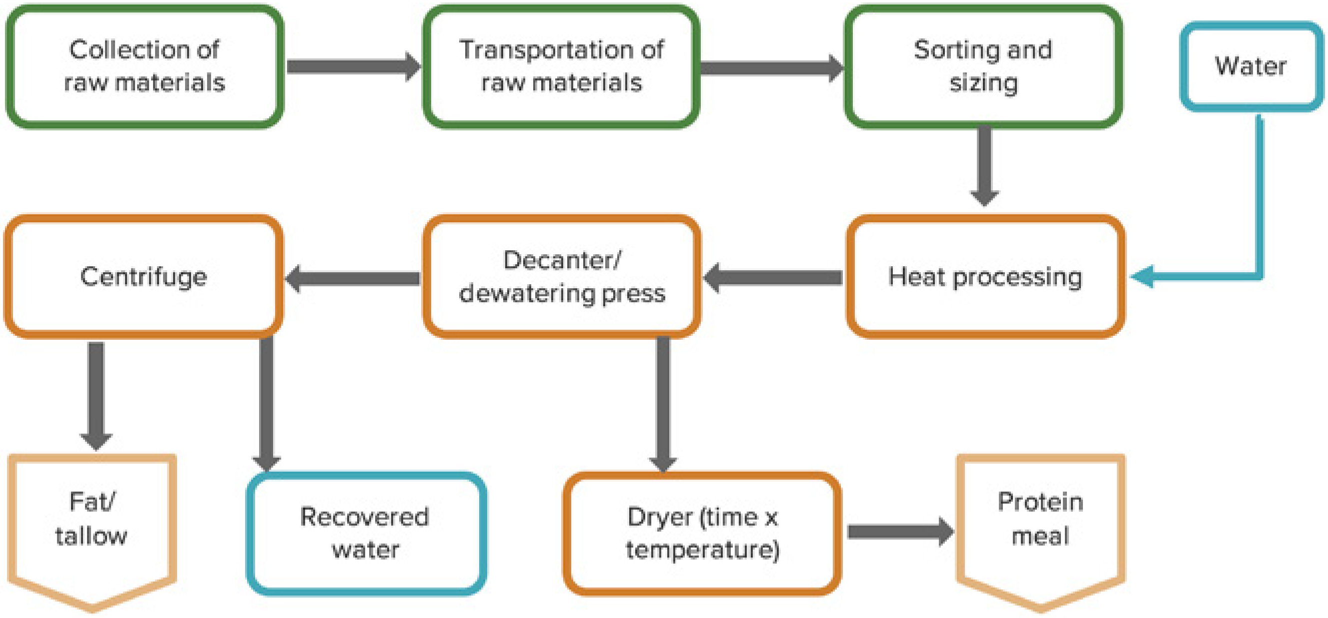
3.4.2.2 Wet rendering

In the wet rendering process, water is added, and the raw material is heated to around 90°C which ruptures the fat cells and coagulates the proteins and allows the solid materials to float in a mixture of liquid fat and water. Conventionally a rendering vessel is used to mix the input materials and heat with water. Newer plants now utilise a heated disc pre-cooker. A decanter separates the wet solids from the water/tallow solution from the render vessel. Alternatively, a twin-screw dewatering press is used. Material from the pre-cooker is fed to the screw press where free liquids percolate out in the drainer screw and then in the press, the remaining water is removed leaving a cake of around 50% moisture. The liquid from the press can be passed through a decanter to capture any remaining solids.

The separated solids are then dried in a steam heated dryer to become meat meal. The water and fat separated from the solids is reheated and separated in a centrifuge yielding a clean polished tallow. The recovered water can be reintroduced to new material to be rendered or sent to a waste heat evaporator for recovery of lost proteins.

Low-temperature rendering for competitive advantage (Rendertech Limited, 2019) describes and compares the development and options for low-temperature wet rendering.

Figure 8: Wet rendering process



3.4.2.3 Hybrid process

Hybrid processes can also be employed where initially the wet, low-temperature process is followed, and solids and liquids are separated mechanically. Instead of sending the solid fraction to a dryer, the solids are sent to a high temperature cooker to drive off the remaining water. Compared with conventional dry rendering there is less water to remove in the cooker, as this has been previously separated mechanically, and thus less steam is required to dry the solids. The resultant solids from this process have a better flowability than air dried solids.

3.4.3 Blood meal production

Blood meal is produced by continuous coagulation of whole blood at about 85–95°C followed by centrifugation to separate coagulated solids from stick water. The solids are about 60% moisture. They are usually dried to 4–8% moisture either in batch cookers, disc driers or rotary air driers.

3.5 Stick water recovery

Rendering plants attached to abattoirs generally do not measure the quantity or the quality of the outgoing waste streams individually or combined. However, several studies have been conducted by MLA to quantify the volume and characteristics of rendering waste streams. *Energy and nutrient analysis on individual waste streams* (Jensen & Batstone, 2012) reviewed MLA/AMPC environmental projects since 1990 but concluded that the focus has generally been on the downstream treatment option rather than upstream characterisation. Their analysis found that paunch wastewater and rendering stick water was identified as the most concentrated streams in terms of COD and total solids. Rendering stick water and slaughter floor wastewater contained the highest concentration of nitrogen.

Rendering plants lose potential products in waste streams. Waste streams from rendering and blood processing contain environmental pollutants which have to be removed by effluent treatment. They also contain protein, fat and other solids which represent product loss. Losses from abattoir rendering plants that use wet rendering (low-temperature rendering) systems were thought to be about $2.5 million per year. These losses add to the burden on waste treatment and the environment.

The major streams are blood stick water, wet rendering stick water, dry rendering condensate, blood dryer and meat and bone meal (MBM) dryer condensates, tallow centrifuge water and sludge discharge. These streams contain protein, fat, carbohydrate, and dissolved salts (measured as ash or conductivity). They result in various environmental problems and represent product losses, which can be recovered to some extent.

Effects of rendering/blood processing on abattoir waste and emissions (Brooks & Spooncer, 2014) determined that the volume of effluent from the wet-rendering plant was 1.87m3/tHSCW compared to an average of 1.01m3/tHSCW for four dry rendering plants analysed. The wet rendering plant discharged 17% more total nitrogen to effluent than any of the dry rendering plants. This was largely due to the fact that it discharged 1.0t TN/1,000tHSCW in the stick water from the cooker compared to an average of 0.16t/1,000tHSCW in the condensate from the cookers of the four dry rendering plants. Raw material bin drainage was a major variable contributor of TN.

In a rendering plant wastewater comes from:

- raw material bin drainage
- condensed cooker and/or dryer vapour
- cooker/tallow separator stick water.

The volume of condensate depends on the raw material composition and the amount of water added in blow lines to transfer material. It was concluded that valuable material can be, and often is, recovered from stick water by waste heat evaporation.

In a wet rendering system, waste heat can be recovered from the solids dryer, capturing the vapour driven off the solids during drying. In a dry rendering system, where a cooker is used, waste heat can be recovered from the vapour coming off the cooker. The recovered vapour is used in a vacuum evaporator to concentrate the stick water, which is then combined with the decanter or press solids for drying. This avoids the protein, fat and minerals in the stick water being lost to the wastewater and requiring further treatment.

If insufficient waste heat is available, proteins can be recovered using membrane filtration. Nano filtration with a 500 Dalton cutoff membrane is capable of recovering the fat, protein and a percentage of the salts. Reverse osmosis may be used to further purify the separated water stream for re-use. *Low-energy membrane process for concentration of stick water* (Zhou & Husson, 2018) discusses the use of membranes for stick water recovery and the use of forward osmosis, economically achieving 30 wt% concentrations at 23% of the cost of thermal evaporation.

Membrane distillation of meat industry effluent with hydrophilic polyurethane coated polytetrafluoroethylene membranes (Mostafa, et al., 2017) discusses the use of membrane distillation with hydrophobic membranes achieving 78% water recovery. Microfiltration was found to be effective in reducing the fat from the stick water prior to membrane concentration. The stick water used was analysed to have the following composition.

Table 18: Stick water parameters – Mostafa 2017

Total fat	12–21g/L
Protein	26–37g/L
Mineral from ash	7–9g/L

3.6 Cost of rendering

The cost of rendering (ProAND Associates Australia Pty Ltd, 2006) developed a model of the rendering processes and associated costs. A number of rendering operations were then surveyed to determine the costs by category which are associated with rendering. The study found that rendering costs were in the range of $130–265 per tonne of finished product. The significant variation (up to $100 per tonne) was a result of the difference in energy costs.

Subsequently, *Implementation of rendering cost model* (Spooncer, 2008) trialled the model at five rendering plants to determine if it would assist in tracking and controlling costs. The plants estimated that their average processing costs were from $68–162 per tonne of rendered product. The lower costs in the range were reported by plants with continuous wet rendering systems. The lower costs also included very low estimates of depreciation and interest. For integrated rendering operations some of the costs are shared between the rendering plant and the abattoir and are not easily allocated.

A table of the average cost components of the five plants is reproduced in Table 19. Although the absolute costs may not be relevant today, the breakdown of costs is likely to remain relevant. The average energy cost at the continuous dry rendering plants was $40–54 per tonne. At the continuous wet rendering plants, it was $14–26 per tonne.

In a private communication in 2023 the estimated rendering processing costs for an independent renderer was $200 per tonne of finished product for a plant processing 1,000 tonne of raw material per day.

Energy costs are the largest variable cost, and by far the most significant cost in the rendering operations. Of the energy costs, the cost of steam produced is the most significant and most variable, depending on cost and type of fuel used. A cooker will use 1.2–1.3kg of steam for every kilogram of water evaporated, while a disc dryer will use 1.2kg of steam for every kilogram of water evaporated.

Heat pump boilers, rather than fuel burning boilers, are now being installed by some plants to reduce energy costs.

Waste heat can be recovered and used to evaporate stick water or preheat materials entering render vessels or cookers. Minimising the water added to raw materials, for cleaning or transport for example, or mechanically removing excess water prior to cooking can reduce energy demand.

The use of anaerobic treatment lagoons is a common and effective means of treating wastewater from rendering plants and abattoirs. If the lagoons are covered, the methane generated can be captured and used as a fuel. The methane can be used in an engine to generate 40–50% of the plant electricity needs or used as a boiler fuel to raise up to 100% of the steam required.

The Energy savings calculator and energy allocation project (Colley, 2011) identified the breakdown of energy utilisation in meat processing plants with an integrated rendering plant and found that 42% of total site energy and 70% of the site steam is used in the rendering plant. Electricity use was 144–208kWh per tonne of rendered product while thermal energy was 5,051MJ per tonne of rendered product. The project also created an energy savings calculator, integrated into the energy allocation tool, that can be used to determine the impact and benefits of common energy savings projects such as recovering waste heat from water, reducing water use, etc.

The Australian Meat Processor Corporation continues a series of environmental performance reviews of the red meat processing industry. Environmental performance indicators monitored include water use, energy use, GHG emissions etc., and can be used to benchmark operations.

Table 19: Average cost component per tonne rendered product - Spooncer 2008

Cost component	Plant A Wet	Plant B Dry	Plant C Wet	Plant D Dry	Plant E Dry	Project PRCOPIC.035
Staff	21.1	22.9	24.8	17.7	31.4	32.1
R&M	26.0	29.1	24.4	25.9	46.6	48.2
Interest and depreciation	5.2	55.4	32.0	31.0	15.1	52.0
Energy	14.1	54.0	26.3	39.7	51.1	68.00
Environmental	2.0	0.5	2.4	12.6	12.7	
Total	**68.4**	**161.9**	**109.9**	**126.8**	**156.8**	**200.3**

In the 2022 environmental performance review (Ridoutt & Sikes, 2023), reporting of indicator results for the Australian beef and sheep sustainability frameworks were disaggregated for the first time.

3.7 Regulations and market access

Compliance with AS 5008 (Primary Industries Standing Committee, 2009) is the minimum standard for the operation of a rendering plant in Australia. The Australian Renderers Association Code of Practice offers manufacturers the opportunity to strengthen existing manufacturing systems to ensure product integrity and safety. The standard uses Hazard Analysis Critical Control Point (HACCP) protocols to establish and maintain hygienic rendering practices. The provisions include compliance with biological performance standards that validate the heat treatments' ability to eliminate heat-resistant biological hazards such as Bacillus anthracis and testing products for salmonella to minimise post-production contamination.

3.7.1 Certification

To gain accreditation from the ARA, rendering plants must comply with the ARA Code of Practice and Australian Standard for the Hygienic Rendering of Animal Products. Auditing is done by AUS-MEAT, an independent, internationally recognised certification body. AUS-MEAT operates under a Memorandum of Understanding (MOU) with the Australian Renderers Association (ARA) to manage the ARA accreditation program on behalf of ARA, and to provide administration and auditing services. AUS-MEAT provides industry experts to deliver training for hygienic rendering.

3.7.2 Export control

Export legislation regulates the export of animal goods. Certain goods are not prescribed under the legislation, which means there are no requirements under the export legislation that must be met to export. These are known as non-prescribed goods and can be exported without the involvement of the Department. Under the new Export Control Act 2020, animal food and pharmaceutical goods are not prescribed goods. This means they no longer require export permits. This includes meat and bone meal for animal feed and refined tallow for any use.

Non-prescribed goods (NPG) may still need to meet importing country requirements. The Department of Agriculture, Fisheries and Forestry's Manual of Importing Country requirements (Micor) (non-prescribed goods), includes advice on known importing country requirements for certain non-prescribed goods such as animal by-products.

Some importing countries may require proof that your goods were sourced, prepared and stored in establishments listed with DAFF, who has the power to issue a certificate to demonstrate compliance with importing country requirements. Animal rendering plants must be listed with DAFF. For some goods, an authorised industry body can review your ability to meet importing country requirements. For rendered products this is The Australian Renderers Association (ARA) and for pet food this is the Pet Food Industry Association of Australia (PFIAA).

3.7.3 Ruminant feed ban

Australia has an inclusive ban on the feeding to all ruminants of all meals, including meat and bone meal (MBM), derived from all vertebrates, including fish and birds. All states and territories have now adopted in their respective legislation the term 'restricted animal material' (RAM) to describe animal meals that cannot be fed to ruminants, being any meal derived from vertebrate animal origin, including fish and birds.

RAM is defined as any material taken from a vertebrate animal other than tallow, gelatin, milk products or oils. It includes rendered products, such as blood meal, meat meal, meat and bone meal, fish meal, poultry meal, eggs, feather meal, and compounded feeds made from these products.

It does not include tallow, gelatine, milk and milk products. These products are exempt from the definition of RAM and may be used in ruminant feeds.

Tallow and oils are defined as 'any product (not limiting to but including products known as tallow, yellow grease and acid oil), containing rendered fats and oils from any animal, or used cooking oil filtered or otherwise treated to remove visible particulate matter, and which complies with a specification of 2% maximum M+I (moisture plus insoluble impurities) as measured by American Oil Chemists' Society (AOCS) official methods'.

3.7.4 Indonesia market suspension

In 2018, Indonesia suspended importation of Australian rendered meat meal products used for animal feed. This was apparently due to concerns about pork material being included in rendered commodities, based on DNA testing, described as being sourced from beef and other species. Indonesia has had a long-standing ban on the import of pork-based rendered material, from all countries. The suspension was enforced from September 1, 2018, following an Indonesian audit during August.

The Australian Renderers Association (ARA) held the second In-Market Forum in Jakarta, Indonesia, in February 2024, as part of the Agricultural Trade and Market Access Cooperation (ATMAC) Program. Recently, in November 2023, the first round of audits was completed by DHGLAS officials with the view to reopening the trade of Australian-rendered products to Indonesia.

3.8 Meal safety

The Australian Standard for Hygienic Production of Animal Products (Primary Industries Standing Committee, 2009) requires that the heat treatments used in all rendering systems are validated annually by demonstrating that the heat treatment complies with a microbiological performance standard i.e. absence of Clostridium perfringens in the final product. Suitable heat treatments that can achieve this standard are not specified, allowing Australian renderers to customise their process to cater for different raw materials, the available equipment and product quality specifications.

The Australian Renderers Association provides training and accreditation of individuals on the hygienic rendering of animal products. The association provides information on hygienic rendering and production of safe products. It has been demonstrated that salmonella in raw material is reliably eliminated in the rendering process but that there may be post-processing contamination.

Scientific and regulatory authorities in Australia have identified Bacillus anthracis as a heat-resistant potential biological hazard and the ARA Code of Practice includes requirements to comply with biological performance standards that validate heat treatments as being capable of eliminating Bacillus anthracis. Heat treatments and the biosecurity of rendering processes are conditions for the export of meat meal to certain markets. The ARA has been involved with AQIS in preparing cases to justify that biological performance standards used by ARA members are equivalent to the heat treatments required by importing countries. As a result, AQIS has negotiated market access based on ARA accreditation and compliance with the Australian Standard for the Hygienic Rendering of Animal Products.

3.9 Meal and tallow quality

The quality and composition of the raw materials used will have some effect on the quality of the finished product. Raw materials will vary at each plant, consequently the composition of MBM will vary plant by plant and be influenced by whether boning room material is included. Processing temperatures and methods have the greatest effect on amino acid digestibility.

Meal is included in stockfeed as a protein source. Protein levels of standard meat and bone meal are 50% protein, although other grades, 48% and 45% may be accepted. Higher protein levels of 55–65% are often sought and command higher prices. The ash content mainly consists of calcium and phosphorous, originating from the bone component of meat and bone meal, and while a useful component supplying mineral needs in the diet, the use of high calcium in some feeds limits the inclusion of meat and bone meal. Different specifications limit the MBM 50 ash level to 36%, 32% and 28%.

Much of the variation in nutritive value of meals is due to the level and availability of essential amino acids in the protein. The use of synthetic amino acids allows the feed supplier to adjust these to desired levels. However, the higher the level of amino acids in the meal, the more the meal is worth to the feed producer. The most important of the essential amino acids found in meat and bone meal are lysine, methionine, cystine and tryptophan. Meat meal also supplies important B vitamins, particularly thiamine.

Food Science Australia (CSIRO, 2006) provides more information on meat and bone meal quality parameters and the influence of the rendering process in their meat technology information sheet.

3.9.1 Meat and bone meal

Specification

A typical analysis of meat and bone meal MBM50 is shown in Table 20.

Table 20: Typical analysis of MBM50 – source ARA

Parameter	Value
Protein	50%
Fat	12%
Moisture	8%
Fibre	3%
Ash	32%
Calcium	2.2x phosphorous level
Phosphorous	4%
Pepsin digestibility	86%
Amino acid %	
Aspartic acid	4.1
Threonine	2.2
Serine	3.1
Glutamic acid	6.7
Proline	4.4
Glycine	6.2
Valine	2.7
Methionine	0.7
Isoleucine	1.7
Leucine	3.6
Tyrosine	1.3
Phenylalanine	2.0
Lysine	2.6
Histidine	1.0
Arginine	3.9
Cystine and cysteine	0.9
Tryptophan	0.4

A typical specification for ovine 55% protein meal is shown in Table 21.

Table 21: Typical specification for Lamb MBM55

Parameter	Value
Protein	55%
Fat	15%
Moisture	6%
Ash	26%
Wool	Max 1%

The Australian Renderers Association provides information on quality control and tests for animal protein meals, including test method references.

Protein

Meat and bone meals are sold on protein content, and this can be considered the main determinant of value for the meat meal. While the majority are sold as 50% protein, meals can be sold containing other protein levels. Standard test method AOAC 990.03 Dumas.

Input materials with a high proportion of soft tissue will have a higher protein content. Materials with a higher bone content, such as boning room material will result in a lower protein content. Limiting bone is the most effective way of achieving higher protein content.

Pepsin digestibility

The digestibility of protein in meat meal is measured by treating meat meal with the enzyme pepsin under specific conditions. Crude protein that is not digested by pepsin under the conditions of the test is the undigestible portion of the protein.

Some of the protein in raw material such as the keratin in horns, hooves, hair and wool is not digestible and will contribute to undigestible protein. Other protein may become undigestible in the rendering process due to over cooking.

Fat

The fat content of meat and bone meal is the residual fat left in the product after centrifuging and pressing and usually averages 8–12%. Standard test method AOAC 920.39.

The moisture content of meat meal is controlled by the cooker end-point temperature or dryer temperature.

In general, the value of tallow is higher than the value of meat meal and it is better to extract as much fat as possible from rendered product to maximise tallow yield. Tallow extraction from rendered solids is affected by cooking temperature and press operation. Overcooked product is likely to have a high fat content.

Moisture

The moisture content in meat and bone meal is the residual water after the raw material has been dried and it usually varies between 5–8%. Moisture content of meal is critical to meal quality. Standard test method AOAC 934.01.

If the meat meal is too dry, it is very dusty and can cause handling problems. If it is too moist it can support mould growth.

The moisture content of meat meal is controlled by the cooker end-point temperature or dryer temperature.

Fibre

Fibre is the relatively insoluble carbohydrate, such as cellulose and is due to remnants of vegetable material, mainly from inadequate washing of the gut, in the rendered offal. Standard test method AOAC 962.09.

Ash

Ash is the percentage of residue (mineral matter) remaining after combustion at 600°C for two hours and reflects the ratio of bone to soft tissue in the raw material. Standard test method AOAC 942.05.

The ash content of meat meal may affect pricing, particularly for meals sold for pet food. Low-ash meat meal is more attractive for use in pet food and aquaculture diets. The ash in meat meal is mainly calcium and phosphorus derived from bone in the raw material. The percentage of ash in meat meal is directly related to the proportion of bone in the raw material. Because of this, a high protein meat meal has low-ash content.

Ash content can be adjusted by reducing the bone content of raw material or by separating the bony fraction of milled meal.

Biogenic amines

The level of biogenic amines in meat meal does not necessarily have a direct influence on the value of the product but may make a meat meal more, or less attractive to certain customers. Some customers that use meat meal in pet food and poultry rations require biogenic amines to be less than 100 or 150 mg/kg for the total of the four main amines. Biogenic amine levels are affected by the condition of the raw material. Fresh raw material (i.e. less than six hours old) usually produces meat meal with biogenic amines less than 100mg/kg.

Salmonella

Salmonella is a non-spore forming micro-organism readily destroyed by the rendering process. However post-process contamination during handling, storage and transport can still occur just as it does with any feed ingredient. ARA accredited establishments abide by a code of practice to minimise post-production contamination. Standard test method AOAC 989.13/966.08.

E. coli

E. coli is a type of non-spore forming microorganism readily destroyed by the rendering process. However post-process contamination during handling, storage and transport can still occur just as it does with any feed ingredient. ARA accredited establishments abide by a code of practice to minimise post-production contamination. Standard test method AOAC 991.14.

Clostridium perfringens

Clostridium perfringens are spore forming micro-organisms and are the microorganism used in the Australian Standard to determine the ability of the rendering process to destroy spore forming bacteria of concern. The tests are conducted on an annual basis at the plant level to validate the effectiveness of the rendering process. Standard test method AS1766.2.8

Calcium/phosphorus

The high phosphorus availability of MBM is one of its major nutritional advantages over vegetable proteins. Standard test method AOAC 935.13/965.17 15th.

3.9.2 Tallow

The Australian Renderers Association provides information on quality control and tests for fats and oils including test method references.

Titre

Titre is the solidification point of the component fatty acids in degrees Celsius. A general classification for traded fats and oils, titre is related to physical hardness. Standard test method AOCS Cc 12-59.

FFA

Free fatty acid (FFA) is the percentage of titrable acid measured with standardised sodium hydroxide solution. These acids arise from hydrolysis of fats and oils. For tallow, they are reported as oleic acid. Standard test method AOCS Ca 5a-40.

Free fatty acid is a measure of the amount of breakdown of the main component of tallow, triglyceride. High levels of free fatty acid result in yield loss when the tallow is processed to make soap or biodiesel, and may incur higher processing costs.

Breakdown of triglyceride in tallow and increases in FFA can occur in raw material before rendering and after rendering in stored tallow. Free fatty acid levels are not usually affected by the rendering process.

In raw material, FFA develops in fat due to bacterial action. Any conditions that promote bacterial growth will accelerate increases of FFA in raw material. Conversely, conditions that inhibit microbial growth will slow the rate of FFA increases.

FAC

FAC is a colour set for matching typical American fats. FAC is not a uniform or linear scale. Standard test method AOCS Cc 13a-43.

Raw colour is important in applications where the tallow is not bleached such as in pet food.

Raw colour relates to the cleanliness of the raw material. For example, fat and bone should produce tallow with FAC colours of one to seven. Tallow from washed beef gut should have FAC colour of 11A. A tallow colour of more than 21 indicates a high proportion of gut contents in the raw material.

Lovibond colour is an international, rational colour-scale based on standard red and yellow units for comparison of fats and oils colour. Lovibond AOCS "(Wesson") or BSI (U.K.) colour standards may be used. Automatic instruments may be used. Standard test method AOCS Cc 13b-45.

R&B colour is colour after refining and bleaching and is expressed in terms of red on a 5.25" (133mm) cell according to AOCS Cc8d-55.

Bleached colour is important when tallow is to be used in applications where the processing includes bleaching to produce a white product such as soap making.

The bleached colour of tallow usually relates to processing conditions. High temperatures during cooking produce fixed pigments that are more difficult to bleach out of the tallow.

IV

IV is the iodine value and may be determined by gas chromatography composition analysis or by titration methods. The IV provides the level of unsaturation. More saturated fats have lower values and are harder (higher slip melting points). Standard test method used is AOCS Cd 1d-92.

MIU

MIU is the total of results for moisture, insoluble impurities and unsaponifiable matter.

M&I

Moisture and impurities (M&I) are restricted to 2% to allow the tallow to be used free of BSE restrictions. If the M&I is >2% the tallow is a restricted animal material and cannot be fed to ruminants.

PV

Peroxide value (PV) and is a common way of assessing fat rancidity primarily caused by oxidation. Standard test method AOCS Cd 8b-90.

SV

Saponification value (SV) is an estimate of the mean molecular weight of the constituent fatty acids in a fat sample. Standard test method AOCS Cd 3-25.

Polyethylene

Polyethylene tests determine polyethylene and other plastic contaminants in fats and oils. Standard test method AOCS Ca 16-75.

3.10 Uses for rendered products

3.10.1 Meat and bone meal

Meat and bone meal (MBM) is most commonly used in pet food products, as a feed ingredient and in fertilisers. The bulk of pure ovine meal is exported to the United States, where it is used as a pet food ingredient. While the United States produces significant volumes of MBM, there is demand for single species sources (such as ovine MBM) and for product that meets European Union market access requirements for high-end pet food kibble products.

The Australian Renderers Association reported a 6.7% growth over the last five years in the Mexican pet food market, with a demand for lamb meal with 65% protein increasing consistently over the last three years. In March 2022 the Mexican Government approved imports of rendered products from Australia.

The majority of meat and bone meal is used in poultry feed, however inclusion rates are often less than 5%.

3.10.2 Tallow

In addition to its nutritional use in feeding livestock, pet food and aquaculture, higher grades of tallow may be used in numerous everyday items such as soap, glycerol, lubricants and fatty acids necessary to manufacture cosmetics, paints, plastics, organic detergents and many other industrial and consumer products.

In recent years there has been a growing demand, in Singapore and the USA, for tallow as a raw material to convert into biodiesel. Although more costly than hydrocarbon fuel, its use is driven by the sustainability and greenhouse gas reductions, compared to conventional fuels.

The use of tallow in biofuels and sustainable aviation fuel (SAF) offers several advantages. Firstly, it aligns with the principles of circular economy by valorising waste products, thus reducing the environmental impact associated with waste disposal. Secondly, these by-products are non-food resources, so their use avoids the ethical and economic issues associated with using food-based materials for fuel production.

Moreover, fuels derived from rendering by-products have the potential to be carbon neutral. The carbon released during fuel combustion could roughly equal the carbon absorbed by the animals from which the tallow was derived, primarily through their feed.

This cyclical process could significantly reduce the net carbon emissions associated with aviation, a sector currently responsible for a substantial portion of transportation-related emissions. By converting what was once considered waste into valuable fuel, this approach promises to reduce aviation's environmental footprint and contribute to a more sustainable management of biological resources. While challenges remain, the ongoing research and development in this area hold promise for making air travel more sustainable in the years to come.

The US Renewable Fuel Standard (RFS) incentivises biodiesel/renewable diesel production and use, and sets goals for production. Biomass-based diesel must show a 50% reduction in greenhouse gas emissions over petroleum diesel. The US renewable diesel production capacity is expected to increase rapidly.

The CSIRO has partnered with Boeing to analyse the availability of available feedstocks for producing SAF on the Asia Pacific region with a focus on Australia and New Zealand. The analysis covers various feedstocks including tallow and waste agricultural products. After rendering, tallow can be converted to SAF via the HEFA pathway. These feedstocks provide a near-term opportunity to supply planned plants in Perth and Gladstone. Assuming a maximised SAF yield a small-scale HEFA plant, capable of producing 50ML of SAF per year, would require 15% of Australia's projected tallow production in 2025. A large-scale plant producing 300ML of SAF per year would require 86–90% of Australia's projected tallow production in 2025. The Sustainable Aviation Fuel Roadmap (CSIRO, 2023) provides further detailed information.

According to reports from Petroleum Australia, aviation experts from the University of South Australia (UniSA) will collaborate with their Chinese counterparts over the next two years to develop a sustainable aviation biofuel industry in both countries. The partnership, announced by the Department of Foreign Affairs and Trade (DFAT), follows a $1.7 billion federal budget allocation (2024) to prioritise renewable fuels for the aviation industry over the next decade. While these renewable fuels are not yet produced in Australia, Jet Zero Australia is working with US biotechnology company LanzaJet to build a new SAF facility in north Queensland.

3.11 Volumes and returns

3.11.1 Meat and bone meal

In their pet food brochure, the ARA present Australian export numbers and markets for animal protein meals in 2022. Figure 9 shows that single species ovine meal exports totalled around 60,000 tonnes in 2022. Similar volumes may be included in mixed meal exports. MBM traditionally faces relatively low tariffs compared to other red meat products. According to the ARA, 50% of mammalian protein meals were exported in 2015–2016, with 50% used domestically.

Information is not readily available for single species ovine meals. Figure 10 shows the major markets for all animal protein meals exported in 2022. Prior to 2018, the major export market was Indonesia. The major market for ovine meals is the USA to meet the demand for single species meals.

Pricing for meat and bone meal fluctuates according to demand and comparative pricing and availability of other protein sources used in animal feeds. Meat and Livestock Australia publishes monthly pricing trends for rendered products in their co-product market reports. MLA also publishes market price statistics for Australian co-products rendered product prices. The annual average pricing for rendered products 2010–2024 is shown in Figure 11. Prices are Australian dollars per tonne ex works.

Figure 9: Animal protein meals export volumes 2022 – source: ARA

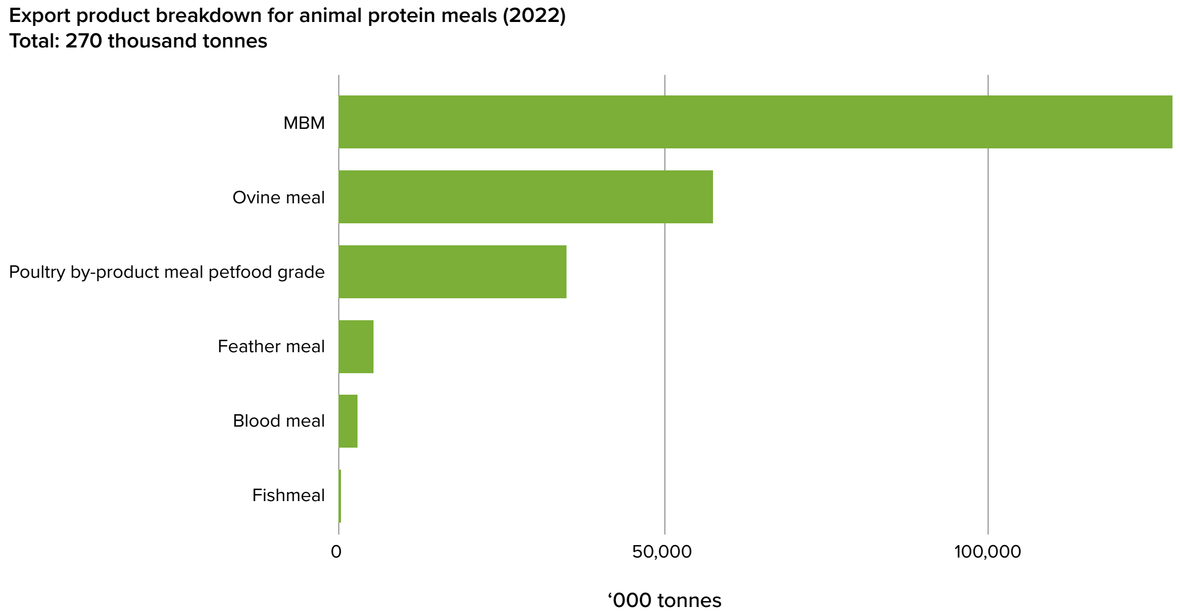


Figure 10: Major export markets for animal protein meals 2022 – source: ARA

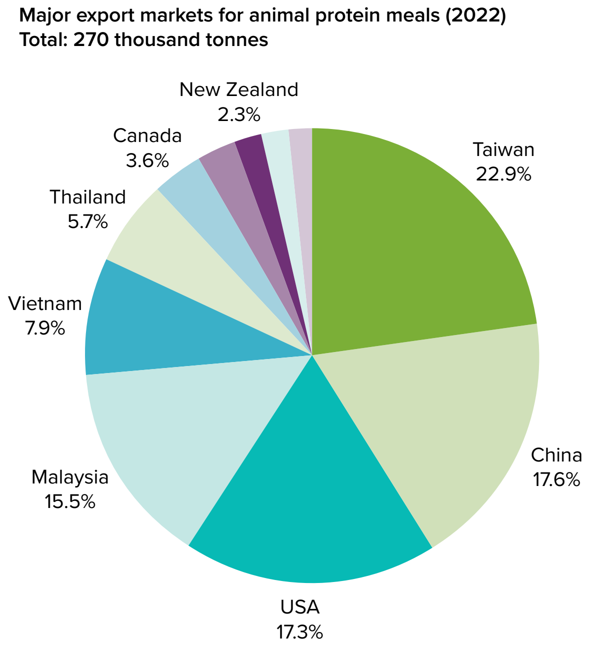
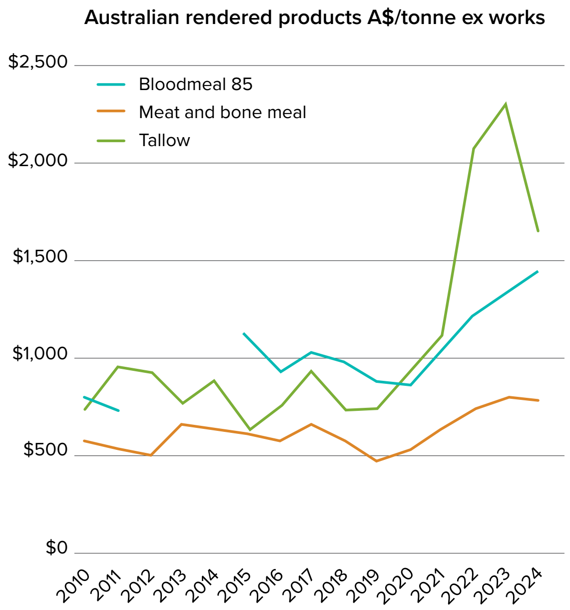


Figure 11: Annual average pricing of rendered products – source: MLA



An illustration of the comparative pricing for lamb meal is shown in Figure 12. This is for the Mexican pet food industry (Romero, 2022). This shows the additional value achievable for single species higher protein meals compared with MBM50.

Figure 12: MBM pricing to Mexico pet food – source: Romero 2022

Product	Product FOB USD/ton	Landed cost USD/ton
US Beef MBM50	500	670
AU Beef MBM50	560	840
AU Poultry MBM65	915	1,215
AU Lamb MBM65	1,500	1,800
NZ Lamb MBM50	1,400	1,700

3.11.2 Tallow

According to the ARA, Australia produces 550,000 tonnes of tallow per annum, of which 450,000 is exported. No break down of ovine tallow is available. Some ovine tallow is used in pet food products. The US and Singapore make up 90% of the export markets with much of it going towards biofuel production. Prices have doubled and even tripled compared to the norm in recent years. In the 2022–23 financial year, international prices peaked at $2,500 per tonne and are currently sitting above historical averages at $2,000 per tonne. Australian tallow prices follow US tallow prices with a 95% correlation.

Despite being a manufacturer and exporter of tallow, the US imports of tallow have increased from 60,000 tonnes in 2015, solely from Canada, to 330,000 tonnes in 2021 with 75,000 tonnes coming from Australia. Australian imports began in 2017.

Global initiatives, incentives and goals for SAF production as well as local production projects (see 3.10.2) may further strengthen tallow pricing.

4 Pet food

4.1 Background

According to an Australian national survey on pets in Australia (Animal Medicines Australia, 2022), Australia's pet population is 28.7 million with owners spending $17.1 billion per annum on pet food. Of that money spent, 90% is for cats and dogs. Most pet food is sourced from supermarkets and pet stores.

While "Whether my pet likes it" is the top consideration when purchasing pet food, price and value for money are the next most important considerations, followed by the quality of ingredients.

The estimated demand for meat co-products as a protein source in Australian pet food is 80,000 tonnes of fresh and frozen with an additional 60,000 tonnes per annum from dry meals. Chicken is the predominant source of meat protein, including viscera, heads, feet, frames, heart, livers and mechanically separated chicken.

Of this co-product demand, only 5,000–10,000 tonnes of lungs and livers are from lamb, while 15,000–20,000 tonnes per annum of lamb meal is included in pet products. Around 50,000 tonnes of frozen, mechanically separated lamb meat is exported from Australia to the USA for use in pet food.

As of December 2023, pricing of lamb lungs and livers was around $1,500 per tonne. Ovine bones, for mechanical deboning, were fetching $400–500 per tonne. The ovine meal price was A$1,350 per tonne, while mixed meal was $830.

4.2 Current pet food offerings

Lamb is included in pet food products where the characterising ingredient is claimed as lamb. Lamb lungs and livers are utilised in canned products, cooked rolls, trays, and treats. Frozen, mechanically separated lamb is included in extruded, moist kibble products while ovine meal is included in dry kibble and treats.

In the USA, labelling laws require that "real" lamb meat used in pet food be sourced from edible lamb parts. Mechanically separated meat from lamb bones is the favoured source to meet these requirements and drives the 50,000 tonne per annum export market from Australia for frozen, mechanically separated lamb meat. No such requirements exist in Australia where lamb protein can be sourced from offal or meals containing offal.

As most pet food is purchased from supermarkets, pet food offerings must meet a retail price point. For fresh pet food, mostly minced, this is currently around $10/kg. Meeting this price point limits the pricing for raw materials used in fresh products, to around $5/kg, and restricts the material and sourcing options.

To achieve the required shelf life in fresh products, muscle meat without bone marrow and without the inclusion of offal must be used. The microbial count of mechanically deboned meat is too high to achieve the required pet food shelf life.

Mechanically deboned meat can however be used in cooked products. The pricing for fresh is 22¢/kg, but with limited shelf life. Freezing considerably extends the shelf life, but its cost increases the price to 40c/kg.

Chilled and frozen offal is used in many pet food products. The shelf life of chilled offal is limited to two to three days and is therefore often purchased plate frozen. The offal used includes liver, lung, heart, kidney, and tripe. Offal may be purchased individually such as liver or lungs or purchased as pluck, a mixture including liver, heart, lung, trachea and diaphragm.

The offal is mixed with a percentage of muscle meat and included in cooked products. Trachea is also used in dry treats. Offal items sold as pet food may be fit for human consumption or may be downgraded from human consumption due to minor defects and blemishes. State laws prevent the use of condemned offal. Organs may be dried and ground to coarse or fine powders.

Whole blood is used in small quantities to provide colour to the product, as well as for nutritional properties.

Meat and bone meal is used extensively in dry pet food and tallow is used as a flavour coating in dry pet food. Premiums may be available for specialty meat meals used in pet food, for example exported high protein ovine meals, pure meat meals, and viscera-free meals.

Freeze dried raw organs such as lamb liver and lamb heart are sold as premium treats but not included in dry pet foods.

A survey of Australian pet food manufacturers conducted in *Dynamics of the Australian pet food industry* (van Doore F., 2004) reported that while the use of chicken and poultry by-products is favoured due to a focus on quality and consistency that these suppliers have managed to achieve. Lamb meal is very important as a key ingredient in high-value specialty products such as "Lamb and Rice" formulated diets. However, the key problem with lamb meals is the lower protein content when compared to products such as poultry meals.

4.3 Co-product harvesting

There are four possible dispositions of meat and offal at the time of post-mortem inspection. They are:

- suitable for human consumption
- not suitable for human consumption but suitable for animal food. Examples of conditions that cause meat and offal to be in this category are ecchymosis (blood splash) and bruising.
- not suitable for human consumption but suitable for animal food if subject to heat sterilisation. This category generally applies to abnormalities that are not associated with specific infectious diseases for example, unusual odours, tumours, cysts, discolouration and fatty infiltration of liver. Lungs affected by pneumonia may also be put into this category.
- condemned with no option for recovery as animal food. Condemned material is generally disposed of by rendering.

4.3.1 Fresh pet food

The pet food is sent by chute direct from the slaughter floor to one tonne bins. While fresh co-product collection is preferred by suppliers and pet food manufacturers due to ease of handling, fresh ingredients have a short shelf life that can impact the shelf life of the pet food, especially for chilled pet foods. Chilling the collected raw ingredients with cold water, ice, shell and tube heat exchangers can retard microbial spoilage and increase the shelf life.

4.3.2 Frozen pet food

Frozen pet food offals are segregated into the different offal items and may be trimmed. This requires a dedicated pet food room with facilities for trimming offal. The trimmed and sorted offals are put into tubs and frozen on racks in an air blast freezer or are loaded into cells of a plate freezer. The freezing facilities must be dedicated for handling pet food only. Naked blocks discharged from the plate freezer or removed from tubs are stacked on pallets, wrapped in stretch film and a plastic pallet bag is placed over the load.

Although the cost of handling and freezing increases the cost of the frozen co-products, this may be offset by greater shelf life, greater palatability, and greater flexibility in storage and delivery to the pet food manufacturer.

4.3.3 Harvesting

While greater value can be obtained for lamb co-products, compared with rendering, the harvesting, trimming, and packing requires additional labour on the slaughter floor and offal room. If labour is short, harvesting may be suspended allowing the co-products to flow through to rendering. Pet food manufacturers require a consistent supply of fresh materials. Supply of lamb co-products as ingredients in pet food requires a strong and committed relationship between supplier and pet food manufacturer.

4.3.4 Quality issues

Contamination of fresh and frozen offal by plastic is a major concern. The main source of contamination is from weasand clips and other clips and plugs used in slaughtering. In frozen products, an additional major contaminant are plastic fragments from the tubs in which the meat is frozen. To remove the frozen block from the tub, processors may strike the tub against a hard surface resulting in fracture of the plastic. This can lead to fragments of plastic being caught between frozen meat blocks.

The plastic used to wrap frozen blocks can also be an issue for the pet food manufacturer, especially when the plastic is difficult to remove. It also presents a handling issue for the manufacturer. Naked blocks with no plastic can stick together and become difficult to handle and thaw.

Metal contamination, particularly in frozen product, can cause damage to equipment and potential inclusion of metal in pet food. Other issues such as spoiled product through insufficient cooling or freezing have been raised by pet food manufacturers.

Pet food manufacturers are of the view that apathy exists in meat processing plants toward the quality and integrity of their product. They believe plant training relating to the importance of quality to pet food manufacturers could assist. Rancidity was raised as an issue in preparing meals for use by pet food companies.

Use of meat meal in pet food is limited by calcium and phosphorus levels. More meat meal would be used in pet food products if lower ash levels were available at acceptable prices (for example, poultry meal and soybean meals which have higher protein and lower ash).

4.4 Requirements from the pet food industry

Chicken is the major protein source in pet foods, mainly due to its lower price and the chicken industry's relationship with the pet food industry. The chicken industry was prepared to invest in chilling/freezing systems for the pet food industry as it rapidly developed in the 1980's. Poultry meals are now seen as the meal of choice for both consistency and palatability of the finished product.

For frozen materials, unpacking and disposal of packing is an issue. There is a preference for nude blocks, however these can stick together. The use of meat meal as a lubricant allows the block to be separated.

The MLA pet food survey (van Doore F., 2004) found that palatability of pet food is paramount to the success of a brand. High palatability in a pet food product is a key factor to ensure repeat sales and hence business success. Pet food palatability starts with the selection of good quality raw materials. Processing at the abattoir can involve operations such as rendering, freezing or chilling. These processes must be undertaken to ensure that there is minimal deterioration to the quality of the material. The product must then be shipped to the pet food manufacturer in such a manner as to preserve the product's integrity and quality. The focus of the manufacturing process must be to maintain the quality and ideally the initial flavour profiles of the meat base.

The trends in pet foods are towards health, wellness, lifestyle and size specific products. Lamb ingredients are mainly used in these products.

The trend towards premium ingredients provides the lamb industry an opportunity to promote 'premium lamb', but processors will need to work with pet food manufacturers to install collection, chilling and freezing systems that minimise cost and maximise shelf life of lamb ingredients.

4.5 Pet food markets

Dry pet food manufactured in Australia includes dry kibble and treats, while wet pet food includes cans, chilled, semi-moist products, trays, and pouches. Australia manufactures 450,000 tonnes per annum of dry pet food and 220,000 tonnes per annum of wet pet food with 90% of both sold in Australia. Export markets for pet food include Japan, New Zealand, Philippines, and Taiwan.

The MLA report *Dynamics of the Australian pet food industry* (van Doore F., 2004) reported dry pet food sales in 2003 of 130,000 tonnes and 273,000 tonnes of wet pet food, suggesting significant growth in the dry pet food sector.

Dry pet food manufacturing capacity has been increasing, most significantly with the start-up of the MasterPet kibble plant in Parkes, NSW, in 2021. With the continuing decline in canned pet food there is a surplus of wet food production capacity. Some of this capacity is being converted to pouch production, for example the Mars Petcare Wodonga plant expansion to produce 290 million single-serve pet pouches for cats. Chilled pet food CAGR (compound annual growth rate) is forecast at 3.9% in the next five years.

The global pet food demand is expected to increase 30% by 2050.

Table 22: Dry pet food pricing, market share and CAGR

Segment	Wholesale pricing, $/tonne	Market share	CAGR	Example brands
Economy	<$2,500	54%	-3.3%	Chum, Lucky Dog
Mid-price	$2,500–$4,000	28%	-1.2%	Pedigree, Optimum, Supercoat
Premium	>$4,000	18%	+6.9%	My Dog, Natures Gift

The dry pet food market is divided into three price points – economy, mid-price, and premium. While currently the economy segment has the dominant share, consumers continue to shift to premium dry pet foods. The CAGR in the last five years for each category, together with segment wholesale pricing is shown in Table 22.

The consumer expectation when comparing products in economy, mid-priced and premium is generally for more or any real meat inclusion (meat that can be used for human consumption).

Premiumisation across all segments is expected to drive the growth of specialty pet food companies looking for premium or differentiated ingredients that meet pet owners' desires. Consumers are becoming increasingly willing to pay for a better eating experience for their pets. This will see growing trends in:

- health and wellness ranges, including natural, grain free, and preservative-free products
- lifecycle stage and size specific products, e.g., for puppies, seniors, small, large, individual breeds
- premium ingredients like angus beef, lamb
- value added products and forms, e.g., tray meals, meat balls, patties
- single and functional protein offerings including Australian lamb
- dried co-products.

Examples of premium products including lamb ingredients include:

- 4Legs gourmet meat ball recipe with lamb, beetroot and green beans
- SPD Prime 100 prime cut lamb treats
- SPD slow cooked lamb and blueberry – puppy
- Vitapet dry adult dog food – lamb (with lamb meal)
- Optimum adult grain free digestion with lamb and green beans
- Coctio bone broth

An MLA review V.RMH.0091 (Flynn M, 2019) concluded that the key opportunity for the Australian red meat industry is in the wet dog food market. This is due to the high global consumer interest in raw and fresh pet food. Consumers' impressions of what is described as natural ingredient also falls into raw and fresh product that red meat processors can produce through by-products and low-value cuts.

4.6 Pet food processing and processors

4.6.1 The Pet Food Industry Association of Australia

The Pet Food Industry Association of Australia (PFIAA) represents 98% of Australian pet food manufacturers and importers. Membership includes Certified Manufacturing Members, entities engaged in the manufacturing of dog and/or cat pet food with a plant located in Australia that are third party certified to meet the Australian Standard – AS5812 Manufacturing and marketing of pet food, as well as non-certified manufacturing members and marketing members. A list of members can be found at pfiaa.com.au/our-members/.

A number of pet food ingredient supply companies also source lamb co-products for pet food ingredients in the following formats:

- mechanically deboned meat
- meat and bone meal
- whole organs
- dried organs
- bone broth
- tallow.

These products are sold locally and internationally.

4.6.2 Pet food categories

The Pet Food Industry Association of Australia information for consumers (PFIAA, 2024) describes the following types of pet food.

Complete and balanced pet foods

Chilled/fresh pet food

This refers to pet foods that have undergone low levels of processing or cooking and therefore must be stored in a chilled environment to retain freshness, even when sealed. Chilled/fresh pet foods will have a much shorter shelf life compared to their shelf-stable counterparts. Examples include pet mince, dog food rolls and meat balls.

Dry food

Dry food usually refers to dry kibble that has been cooked through the process of extrusion. This involves mixing dry ingredients with water and steam to form a dough and then passing the mixture through a die plate at high temperatures to form the kibble shape. The kibble then passes through a dryer to achieve a moisture content of approximately 10% or less and is cooled and coated with oils to enhance the flavour.

Retorted pet food

This refers to pet food that has been cooked after the blend of ingredients has been sealed in its container or packaging. During this process, the food is heated to achieve sterilisation within the container. Retorted/wet pet food contains a much higher moisture content when compared to their dry counterparts. Examples include canned pet food, pouches or trays, soups, broths, purees and pastes.

Cold pressed pet food

This undergoes a similar process to extrusion of dry pet food, whereby dry ingredients are mixed with water to form a dough and then "cold pressed" to form a pellet. This method uses much lower temperatures than extrusion and does not involve the addition of steam to expand the dough.

Gently baked pet food

An alternative dry pet food cooking method to extrusion, whereby the mixture is passed through an oven along a conveyor belt, baked and cut into shapes.

Air dried

This is the process whereby fresh/raw ingredients are mixed and exposed to a current of heated air to remove water from the mixture through evaporation. Some air-dried foods are therefore able to be rehydrated with the addition of water to the feed.

Freeze dried

Freeze dried refers to pet food that is created by first freezing and then applying heat to the mixture to remove the moisture content. As with air dried pet food, some freeze-dried diets may also be rehydratable with the addition of water before feeding.

Complementary pet foods

The composition of these foods means that they are insufficient as a sole contributor to the pet's daily ration. Complementary foods are not complete. They may or may not contribute significantly to the energy content of the daily ration, but must always be fed in combination with other foods to deliver complete and balanced nutrition.

Complementary foods take a variety of roles and may be marketed as:

- products intended to be mixed with other food (mixers, toppers, supplements, etc)
- treats, snacks, rewards or chews.

Lamb MDM can be processed into a slurry for direct injection into the extruder for dry kibble manufacturing.

Muscle meat can be diced or minced for use in fresh products.

Ovine raws, including soft tissue and offals, require heat treatment >120°C by rendering, cooking, or retorting.

4.7 Pet food regulations and standards

For regulation purposes, pet food may be separated into:

- pet meat, either fresh or frozen, including pet meat that is packaged for retail sale
- manufactured or processed pet food.

4.7.1 Pet meat safety

Minimum hygiene requirements in the processing of all animals used in the production of pet meat is included in the *PISC 88 technical report – Standard for the hygienic production of pet meat*, (Primary Industries Standing Committee, 2009) which is overseen by state food authorities. However, it is not translated legislatively in every state. Furthermore, current legislations within each state and territory pertain only to fresh pet meat and pet meat products. Most state and territories do prohibit the processing of pet meat from carcases sourced from unhealthy animals.

4.7.2 Manufactured or processed pet food

While Australia currently has a voluntary standard in place for pet food that Pet Food Industry Association of Australia (PFIAA) members adhere to, there is no obligation for non-members to follow the processes and protocols to ensure pet food is safe and compliant.

Currently, the voluntary Australian Standard AS5812 (Standards Australia, 2023) covers processes to ensure the quality of food produced, nutritional requirements are met, guidance on the use of additives and what information is to be made available on the pack for consumers.

The Standard has been further strengthened to include annual third-party audits of PFIAA members and the introduction of a mandatory recall protocol for pet food quality and safety issues to align with human food recalls.

4.7.3 Labelling

Banding of raw pet meat not fit for human consumption is required in all states and territories.

Two dispositions as animal food are known as red-banded pet food and yellow-banded pet food.

Material that may be used as animal food without heat treatment is yellow-banded pet food. It must be stained with a blue dye and packed in a container that has a yellow band at least 50 mm wide around the container or package.

Material that can be used as animal food after heat sterilisation must be moved to a designated pet food room under a secure system and must be put in a container or package that is identified with a continuous red band 50mm wide.

Under Standard AS5812, pet food labelling must include:

- the words "pet food only" and an illustration of the animal species the food is intended for
- metabolisable energy, minimum percentage of crude protein and crude fat the food contains
- information about whether the product is considered a "complete and balanced diet" or is intended as a treat or complimentary food
- a feeding guide
- a 'best before', 'use by' or packaging date depending on the nature of the food
- an ingredients list in descending order (by weight)
- the name and address of the company responsible for the product.

4.8 Available resources for maximising value

The MLA has investigated opportunities to expand the use of red meat products by the pet food industry. MLA has also investigated the use of meat and bone meal in pet food. In general, rendered products used in pet food do not receive premiums. There are, however, opportunities for premiums from specialty rendered products such as high protein ovine meal and viscera free meal and bone broths or extracts.

4.8.1 High-value opportunities in pet food

Än MLA research project V.RMH.0091 (Flynn M, 2019) Investigated high-value opportunity spaces for Australian red meat industry in the pet food category.

Results show an opportunity to move from standard by-products margins of $0.09/kg to a value-added product of $3.95/kg for retail, and $7.20/kg for B2C. These results are based on modelling that would require further validation and in-market testing in a second stage investigation of value chains.

Consumer trends specifically highlight the demand for raw and fresh pet food products that consist of real ingredients and are free of preservatives and synthetics. This presents an opportunity for the red meat industry to develop new business models and value propositions for value-added by-products and low-value cuts.

An industry workshop was conducted to validate the findings with representatives from red meat processing companies.

4.8.2 Novel pet food product

MLA investigated what novel products of the red meat industry might be attractive to the pet food industry (van Doore F., 2004). The report provides data (up to 2003) on the size and growth of different sectors of the pet food market, and indicates that red meat pet food ingredients have lost market share to poultry-based ingredients.

Development of a high-palatability meat digest for coating extruded products was of most interest to pet food manufacturers. High quality meat meals and meat-based flavour systems were ranked highly.

4.8.3 Pet food nutraceuticals

MLA has identified the top five nutraceuticals of potential interest to the pet food industry (Rand J, 2006).

Typically, the inclusion of nutraceuticals is more prevalent in premium grade pet foods and veterinary prescription diets, rather than those available through supermarkets. The most significant nutraceuticals and bioactives currently used in veterinary medicine are glucosamine, chondroitin sulphate, and pentosan polysulphate (collectively known as glycosaminoglycans), the omega-3 fatty acids, carnitine, taurine, and arginine.

The highest natural sources of carnitine are skeletal muscle and heart. Skeletal muscle, thymus, heart, liver, and kidneys are all significant sources of arginine.

5 Skins and pelts

5.1 Background

Australia produces around 30 million woolskins every year, roughly 12 million sheepskins and 22 million prime lambskins. The number and proportion of each varies due to drought and the price of wool and meat. In the last five years, volumes have varied from 26 million to 34 million. Since 2008, lamb export volumes surpassed mutton exports and has become the dominant Australian sheepmeat export.

Lambskins are generally more valuable than sheepskins. This is because most are from crossbreeds of Merino and British breeds. Skins from crossbreds have more valued properties derived from the high-density wool pile (from the Merino) and a skin which produces better leather (from the British breeds).

Sheepskins are derived mainly from the culling of animals from wool producing flocks as a result of age, poor reproductive traits or inadequate wool production. Around 2.5–3 million woolskins per year were processed in Australia to wool-on products in the 1990s. There are now no major woolskin tanneries, or fellmongeries, in Australia and most Australian skins are salted and exported, mainly to China. Woolskin tanners prefer skins with stronger type wools of around 24–28 µm in diameter. Skins with finer wools go into the fellmongering industry (removal of wool from the skin), which is now practiced overseas.

5.2 Skin weights per carcase

The MLA 2024 co-product yield study provides data on skin weights of both Merino and non-Merino sheep across a range of liveweights. The average liveweights for each class are shown in Table 4.

On average, across all classes, the weight of the skin removed from the carcase represents 13% of the liveweight. For Merino the average was 15% while non-Merino it was 11%. This difference is likely due to the presence of skin folds or pleats, characteristic of Merino sheepskin, which increases the superficial skin area, and hence weight, when compared to the plain-bodied non-Merino sheep.

Average skin weights obtained for each class are shown in Figure 13 and highlight the differences between Merino and non-Merino skins.

In addition to the skin removed from the carcase, the weight of the scalp and ears was also determined. For all classes, the weight of the scalp and ears represents 11% of the combined skin and scalp weight.

Average weights for scalps and ears for each class are shown in Figure 14 highlighting the differences between Merino and non-Merino skins.

As for the skins, the weight of Merino scalps is also greater than the non-Merino in each class. A Merino scalp is approximately 50% heavier than non-Merino. Although there is a variation in ear weight there is no apparent trend between classes or breed with an average weight of 80g. Age does influence the ear weight with mutton ears being 12% heavier than lamb.

From an unpublished CSIRO trial in 2003, it was found that from a merino woolly sheepskin weighing 5–6 kg, the dewooled skin weight was 2–3kg with 2–4kg of recoverable wool, depending on wool length. Each animal produces around 1.1–1.5kg of wool-bearing waste skins, being the head, face, brisket and legs. Generally, these woolly skin pieces are not removed from the animal and proceed attached to rendering.

Figure 13: Average skin weight by class

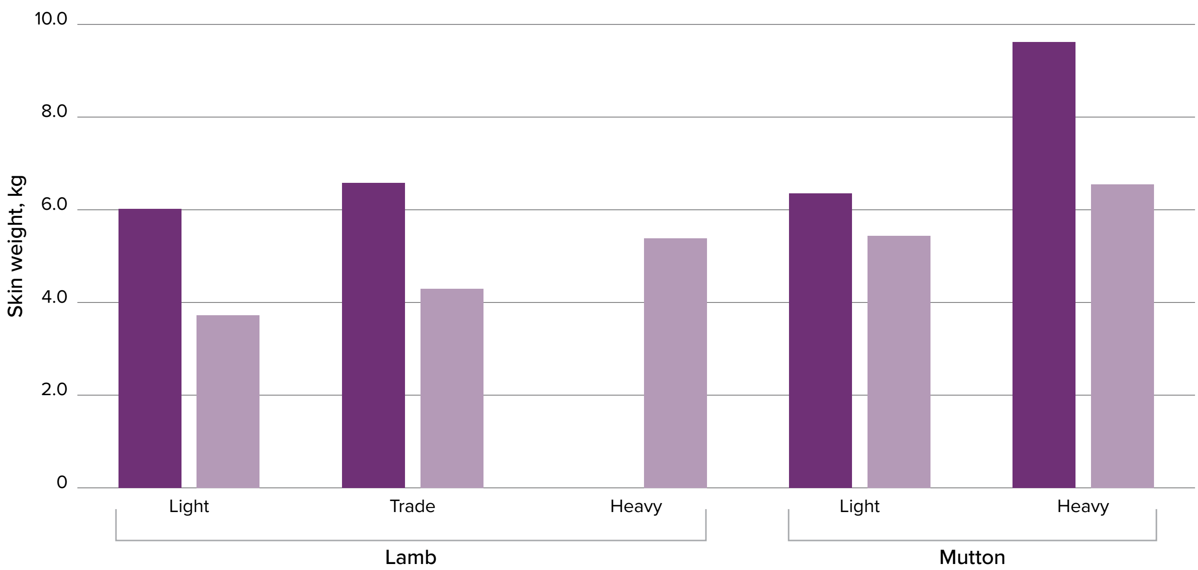
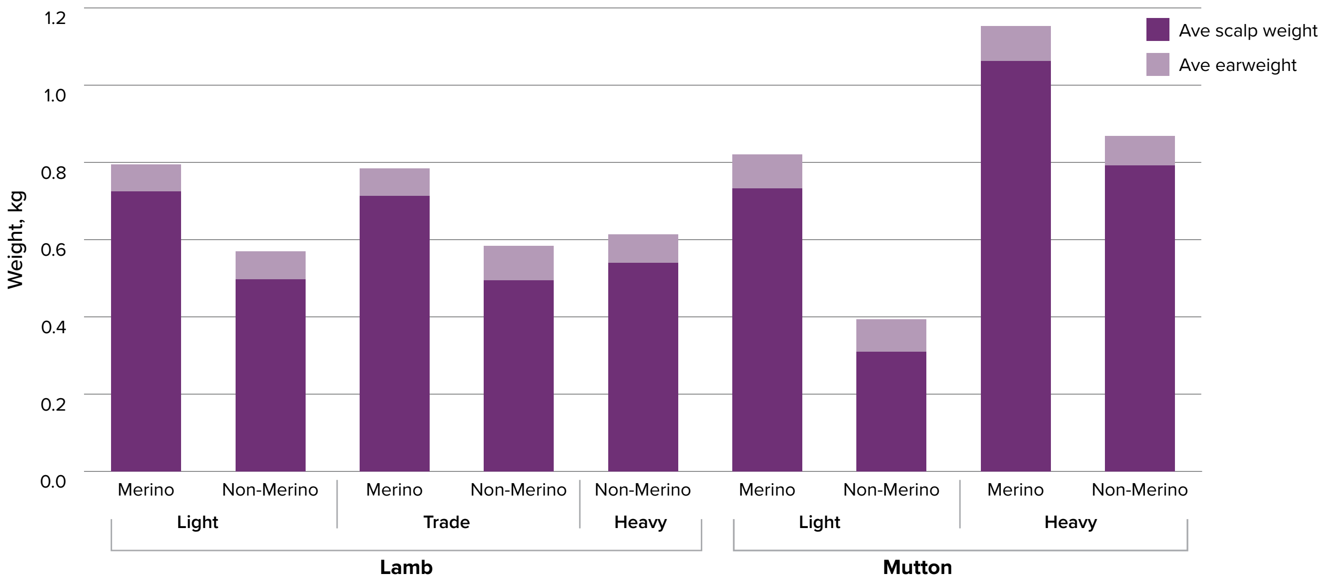


Figure 14: Average weight of scalp and ears by class



5.3 Skin co-products

5.3.1 Woolskins

Woolskins, depending on wool length, become garments, various types of rugs including infant care, car seat covers, Ugg boots, and sporting goods such as saddle pads and horse rugs.

5.3.2 Medical sheepskins

Selected skins are used for medical sheepskins. Medical sheepskin is sheepskin that is medically treated. HT, or high temperature skins are washable in water up to 80°C. UR medical skins will not be damaged by urine and/or faeces. AS 4480.1-1998 specifies requirements for tanned sheepskins and lambskins to be used to minimise the incidence, severity and duration of pressure ulcers. Medical research and clinical trials have shown that medical sheepskins are one of the most effective and economical barriers used for the prevention of pressure sores and pressure ulcers.

Medical sheepskins are tanned with antibacterial and anti-fungal chemicals; there is no chrome used in the tanning process at all. They have a higher density of wool fibres than standard sheepskins and can withstand washing. The denser, thicker wool pile distributes pressure more evenly, stops friction and shearing, absorbs moisture and maintains perfect body temperature. Australia pioneered work in developing high-quality sheepskins, and the internationally recognised Australian standard for Australian Medical Sheepskin, which have made a valuable contribution to healthcare. Further information on Australian Medical Sheepskins and AS 4480-1 can be found in the brochure (CSIRO, 1998)

5.3.3 Fellmongered skins

Fellmongery is the process of removing wool from the skin after it has been removed from the carcase and treating the skin for eventual conversion into leather. High-quality fellmongered skins are used for garments and book binding and restoration while low-quality fellmongered skins are used for linings and chamois leathers. Fellmongered wool is used in insulation products.

5.4 Markets and specifications

Skins are assorted into three categories:

- New season, unshorn, spring lambskins (November–February)
- Shorn lambskins
- Sheepskins from mature sheep
    - Merino sheep
    - Crossbred sheep

Skins are further classified by wool length and quality and by pelt quality. Pelt quality is determined by shape, vegetable matter, seed damage, cuts, tears etc. Third grade is still mainly free of defects in the prime area. Fourth and rejects are badly damaged and torn skins. These make up about 2% of total skin supply.

Pickled pelts are similarly classified by pelt quality shape and defects. Following further processing, pickled pelts without wool or flesh reveal more defects than salted skins. These total 12% of pelts. There is still a market for these pelts although at a much lower value.

Each category and classification of skin can command a different price. Price may also be affected by differing demand for wool on dressing types like rugs and Ugg boots, demand for suede leather, and finished product demand like garments and handbags.

5.4.1 Sheepskin categories

Table 23: Sheepskin categories

Sheep class	Wool length
Spring lamb	1.5–3.0″
Shorn lambs	0.25–0.5″
	0.5–2.0″
	Greater than 2″
Sheep	0–0.25″
	0.25–0.5″
	0.5–1″
	1–2″
	Greater than 2″
Crossbreds	0.5–1″
	Greater than 1″

Skins are further classified by defects with first grade being sound skins, through third grade with evident damage but still saleable. Fourth grade or rejects cannot be sold as whole skins.

5.5 Volumes and returns

According to the Australian Hide, Skin and Leather Exporters Association (AHSLEA, 2024) Australia exported salted sheep and lambskins to the value of $279 million in 2021. This represents 47% of the value of all hide and skin exports.

The wool length influences the price paid for sheepskins, either due to the demand for a wool-on skin, or for the return from the wool recovered from the skin during fellmongering.

This is demonstrated in Figure 15 showing the average maximum achieved lambskin prices in the period 2016–2018. Data is taken from MLA skin reports sourced from National Livestock Reporting Service.

Similarly, Figure 16 shows the skin pricing for Merino sheepskins.

Considering all categories and wool lengths, the fluctuations in skin price between 2004 and 2023 are shown in Figure 17, which gives the average price for each year.

Figure 15: Lambskin prices by wool length 2016–2018, c/skin

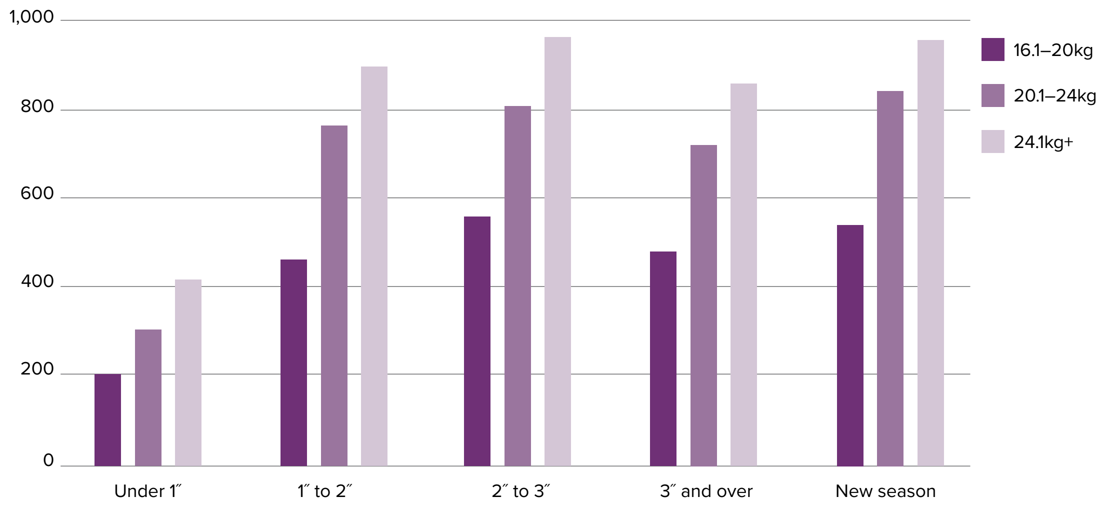


Figure 16: Merino sheepskin prices by wool length 2016–2018, c/skin

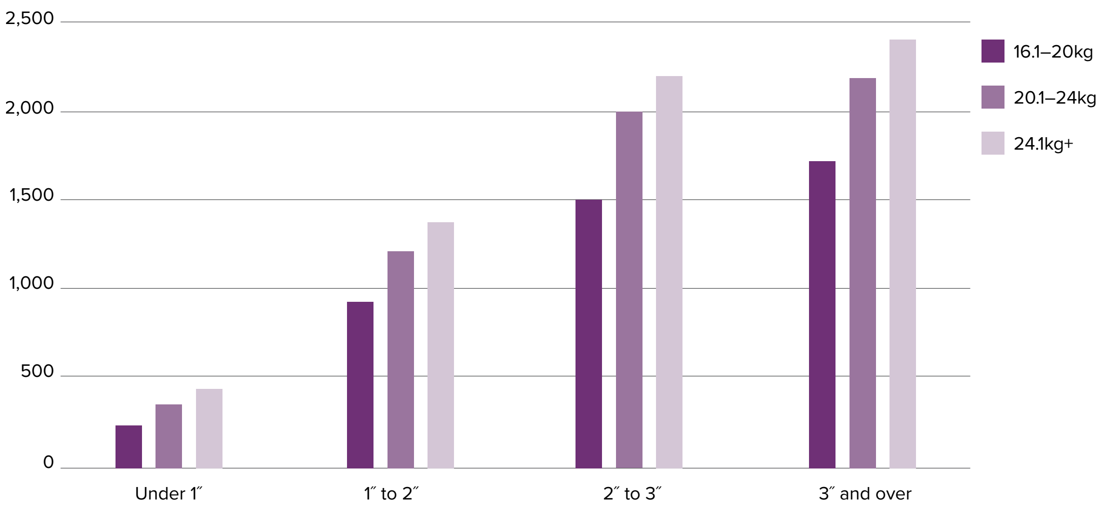


Figure 17: Average annual sheepskin prices 2004 to 2023

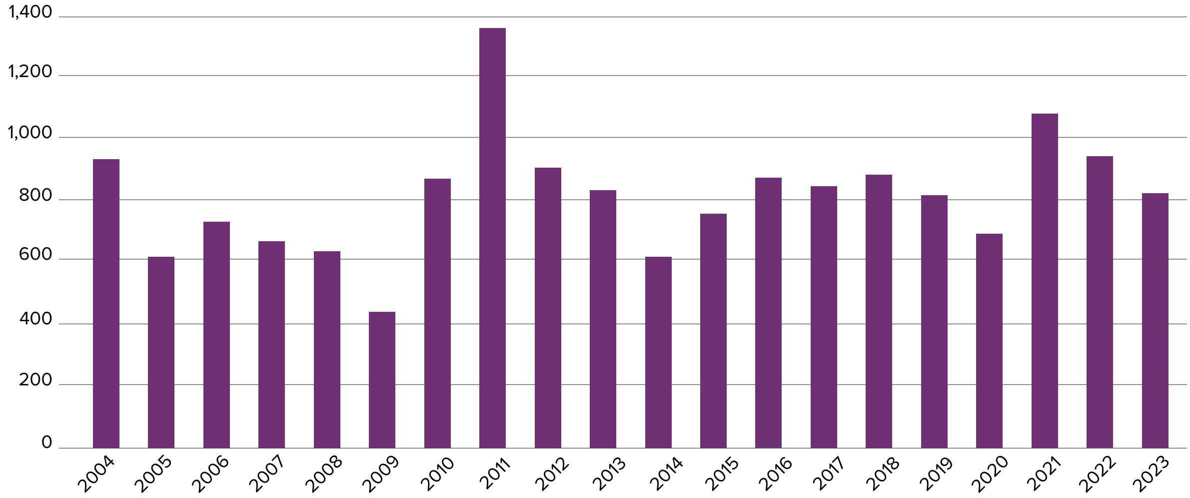
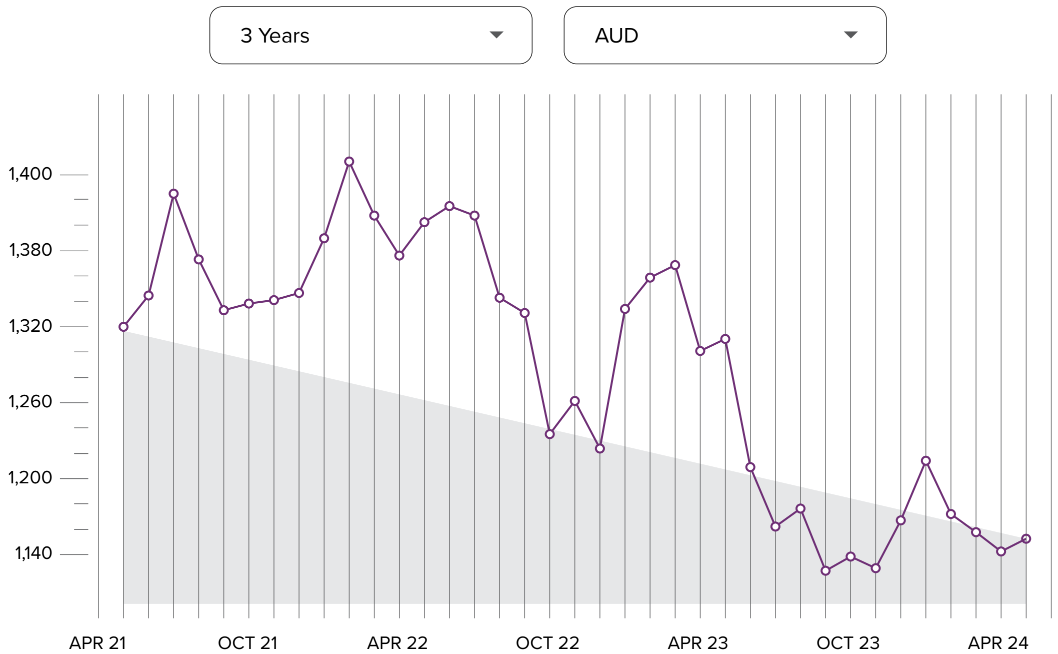


Figure 18: Average wool exchange EMI – source: AWI/AWEX



As for wool, the impact of the global financial crisis saw skin buyers utilising existing stocks and significant decrease in demand for both salted skins and pickled pelts. In early 2009, skin prices had fallen some 50–60% reaching near historic lows. Pickled pelts that had received US$90 per dozen dropped to US$35/doz. Demand for chamois leather was subdued and the low-value grain portion of the skin was very slow to move. With low demand for processed skins, prices continued to fall, resulting in many suppliers dumping their skins as the cost of skin removal exceeded actual value. By early 2010, although demand for leather garments remained mediocre, the demand for handbags and other products steadily increased as buyers needed new supplies to fulfil orders, their stocks having been run down. Strong sales of Ugg boots also ensured demand for salted wool-on skins. A concurrent reduction in ovine stocks across the globe was the catalyst for significant price improvements.

Following a drop in demand and price during COVID-19, a resurgence in demand from China in 2021 saw prices firming again. As an animal by-product, sheepskin supply is directly linked to the number of sheep being processed. Markets continue to be difficult to predict with demand largely dictated by China's fashion industry, particularly the footwear sector.

Data on wool price trends from Australian Wool innovation, wool.com, shows the variation and decline in wool pricing that affects the value of sheepskins. Information on wool pricing is shown in Figure 18.

5.6 Skin quality and defects

Following wool length, the degree of vegetable matter contamination affects the price obtained for each skin and is classified as free, light, or heavy contamination.

Skin quality defects may be present pre-slaughter, may be as a result of slaughter or skin removal or by subsequent handling. Skins are graded through each processing step. The following classifications may be used in classifying skins for sale:

First grade

Sound skins, good shape, free from deep flay marks and knife cuts, free from tears, free from visible seed or seed damage. May include light rib, particularly in the neck area.

Seconds

May include light rib, and skins with occasional neck and/or flank cuts and/or faults. Skins may show some light seed in the belly region. Otherwise, free or practically free of seed.

Third grade

Skins may have cuts, medium rib, light to medium seed or be misshapen – however the prime area is given to be free of serious defects.

Damaged

Pelts showing heavy rib and/or seed damage and/or misshapen or otherwise damaged. All extremely damaged or inferior pelts are excluded.

Pre-slaughter damages, or those resulting from on-farm practices are described in Table 24.

Further damage can occur as a result of abattoir practices as shown in Table 25.

The Merino skin does not produce durable leathers because the grain layer is weak and is easily damaged by abrasion and scratching. The number of wool follicles can be over 5,000 per cm^2. This high number of follicles and the structures associated with them produce a grain layer that is weaker and thicker than the grain layers of other sheep breeds. Many Merino skins are therefore processed into second quality leathers, or into chamois leathers. Chamois tanning is a special tanning process which uses fish oils to tan the skin.

Table 24: Defects in sheepskins as a result of on-farm practices

Type of defect	Cause and prevention
Seed	Grass seeds trapped in wool work their way into the skin. Seed damage is mostly seen as scar tissue from healed seed holes but seeds can also leave holes. Seeds embedded in the skin can cause damage during fleshing and in finishing operations.
Burr	Five types of burr affect woolskin processing. These are the medics, clover, Bathurst, noogoora and ring burrs. Damage from burrs occur mostly at the fleshing machine but burrs are also a focal point for felting.
Dermatitis	Mycotic dermatitis or lumpy wool is caused by a bacterial infection. The scabs or lumpy pieces in the wool are not removable during processing and these skins are fellmongered.
Inoculation abscesses	Animals are inoculated by injection against diseases such as pulpy kidney and tetanus. Infection at the inoculation site may cause an abscess to form leaving scars or a hole in the skin. Inoculation should be in the neck area.
Mulesing	The mules operation is performed to remove breech skin wrinkles to control fly strike. Scar tissue formed makes it more difficult to remove the skin from the carcase without damage.
Crutching	If animals are crutched too heavily, dressing skins are downgraded due to a large area of shorter wool.
Shearing damage	This is seen as uneven wool length and scars from the shearing comb.
Rib	Ribbiness is associated with Merino and Merino cross sheep. The majority of these skins have no application as dressing skins, although light rib is tolerated in products such as car seat covers, medical and infant care woolskins and some footwear.
Double hiding	This is a condition where the grain and corium layers of the skin delaminate from each other during processing.

Table 25: Defects in sheepskins as a result of abattoir practices

Type of defect	Cause and prevention
Cuts and flay marks	Usually occur in the opening up stage where knives are used.
Grain strain due to take off	This occurs both with hand take-off and mechanical skin pullers. It became a severe problem with the mechanical pullers and inverted dressing systems and has been investigated by MLA. It is suspected the problem worsened due to incorrect pulling techniques.
Fat	Can be minimised by careful pelt removal.
Shape and symmetry	Skin value is affected if unsymmetrical.

5.7 Fellmongering

Fellmongery is the process of removing wool from the sheepskin after it has been removed from the carcase, and treating the skin for eventual conversion into leather. The wool may be recovered, washed, and sold as fellmongered wool. The dewooled skin is pickled to preserve the pelt for storing or shipping prior to tanning.

5.7.1 Fellmongering steps

Depilation

Separation of wool from the skin. The main methods used are chemical wool dissolution or detachment of the wool by chemical, or enzymes. Strong alkali will dissolve the wool enhanced by the addition of reducing agents. Most commonly used chemicals are lime with sodium sulphide. It can be used on green or wetted back salted skins.

Sulphide can cause damage to the wool and the wool yield is 5% lower compared with enzymatic depilation. To minimise damage a lime sulphide can be painted or sprayed to the back of the skin to loosen the wool for mechanical removal.

Alternatively, the 'acetate process' can be used. Cathepsin enzymes are naturally occurring in the in lysosomes in cells in the skin. Disruption of the lysosome by lowering the pH releases the enzymes and their action can be increased by raising the temperature. An acetic acid spray is used to lower the pH to five to six and pelts are hung at 35°C for 12–24 hours. The wool can then be pulled from the skin and recovered.

Liming

The dewooled pelts are then tumbled in a lime solution to remove any remaining wool and epidermal layer. The alkali also causes the pelt to swell and solubilisation of some of the skin's structural components that need to be removed prior to pickling.

Deliming/bating

Deliming is initiated by the addition of ammonium salts and or CO_2, which buffers the pH to nine. The alkaline swelling is reduced, and the skins can now be washed to remove materials dissolved during the liming step. Bating enzymes are added to remove any remaining epidermis, and improve the softness, suppleness and surface qualities of the pelt.

The delimed skin can then be sent directly for processing to wet blue tanned skins but is usually preserved by pickling.

Pickling

Pickling is achieved by soaking the skins in sulphuric acid solution with salt. A fungicide may be added to extend the preservation period for the skins.

Further information on fellmongering of sheepskins is described by (Agriculture Western Australia, 1993).

5.8 Preservation

In order to prevent decay, sheepskins must be preserved soon after being removed from the carcase. Bacteria can destroy the skin (putrefaction) and render it unusable for making wool on skins or leather. As soon as the skin is removed from the animal it is susceptible to autolysis (self-digestion) and bacterial degradation, and the rate of degradation increases with temperature. Therefore, it is best to preserve the skins at their source. If there is a delay before treatment, the recommended methods will be less effective than expected.

If skins are chilled with ice or water prior to salting, more salt is required for curing because all the moisture must be saturated with salt. Therefore, owing to the amount of water held by the wool, the water should be removed before salting. A chilling method which does not wet the skins is the preferred treatment of sheepskins to be subsequently salted.

Sheepskins are predominantly dry salted by layering and salting, or dry tumbling in a drum.

The salt used is crushed to give a mix of finer crystals for the more effective preservation of sheepskins. Salt is often mixed with other preserving agents, or biocides, such as sodium fluoride and boric acid to levels of 1–2%.

Before a skin is tanned, the attached fat, muscle, and connective tissue must be removed. The fleshings are usually rendered. Fleshing of the skin prior to salting retains the meal and tallow with the abattoir and ensures the meal and tallow are free of any biocides mixed with the preservation salt.

5.9 Alternative outlets

The traditional outlet for sheepskins is with wool on as a tanned wool-on sheepskin, or after fellmongering, removing the wool and tanning the dewooled skin. The predominant protein in skins is collagen and in the wool is keratin. Alternative outlets for sheepskin can be as a raw material for the production of ovine collagen, gelatine, and collagen peptide, and ovine keratin.

5.9.1 Gelatine, collagen peptide

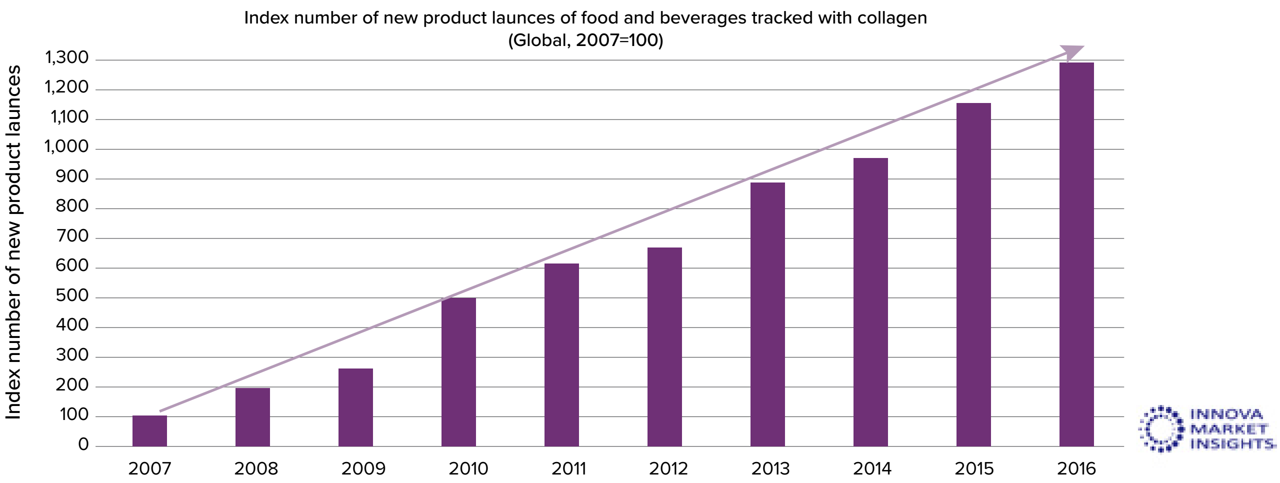
Sheep trotters and scalps were used in New Zealand in the 1950s and 1980s to make gelatine commercially. While the utilisation of these materials has been considered again, the availability and poor yield from the materials means the material is not commercially used today. The use of the sheepskin for gelatine requires the wool to be removed, and for an economical process, the wool recovered and sold as a fellmongered wool. With no significant fellmongery operations in Australia, market opportunities for the wool are limited.

Global gelatine markets are dominated by pig skin gelatine (40%), bovine hide (30%), and bovine bones (25%). Marine and poultry sources mainly make up the remaining 5%. Despite significant preference in some markets for sheepmeat, especially Middle Eastern markets, ovine gelatine is generally not commercially available, nor sought by gelatine users.

While there are currently no significant ovine collagen peptide product volumes on the market, the collagen peptide markets are more diverse and do seek alternate sources. A relatively new gelatine derivative, collagen peptide, has been growing in the market over the last 5–10 years. Global growth has

Figure 19: Growth of global collagen peptide market

More and more food and beverage products with collagen have been tracked for the last ten years, with an annual growth rate of 33%



averaged 33% year-on-year over the last 10 years while sales in Australia have escalated from 50 tonnes per annum in 2015 to 750 tonnes by 2020. Growth in the use of collagen peptides in food and beverage products is shown in Figure 19.

Although also derived from the hydrolysis of collagen, collagen peptides differ from gelatine by having a significantly lower average molecular weight. The molecular weight is such that collagen peptides are non-gelling but have improved bioavailability. In some jurisdictions collagen peptides must have a molecular weight of <10,000 Daltons. Commonly, the average molecular weight is between 2,000 to 4,000 Daltons. Some Asian producers are promoting products with a molecular weight of <1,000 Da, claiming faster absorption into the body.

Collagen peptides are sold for their health effects whereas gelatine is sold primarily for its functional food texture modifying abilities – gelling, thickening, binding etc. More background information can be found on the Gelatin Manufacturers Association of Asia Pacific (GMAP) website: gmap-gelatin.com/collagen-peptides/

Collagen peptides are food ingredients derived by enzymatic hydrolysis of collagen. Dedicated collagen peptide lines are used to prepare peptides directly from the skins, hides and bones. The process steps prior to extraction are similar to those used for gelatine. However instead of gently extracting in hot water, to preserve the protein chain length, the conditioned bones or hides are mechanically chopped, and enzymes are added to the warm water to quickly hydrolyse the collagen to short protein chains or individual peptide units.

It should be noted that collagen peptides are produced from the hydrolysis of pure collagen extracted from the skin. Other mixed protein hydrolysates can be prepared, as a protein source, by direct hydrolysis of skin and other animal wastes. Although providing a good, easily digestible protein source, these hydrolysates do not have the same functionality or applications as pure collagen peptide hydrolysates.

As for gelatine, the hydrolysed collagen peptide solutions are further purified and sterilised prior to drying.

Beyond its purity and organoleptic properties, the key functional parameter of collagen peptides is the molecular weight of the hydrolysed protein. Products of different molecular weight profile and different starting raw material are targeted at different health effects.

Around 100 notifications of food-health relationships have been notified to FSANZ for collagen peptides, or similar names such as hydrolysed collagen or collagen hydrolysate. The list continues to grow monthly.

The common health effects claimed include:

- promotes/stimulates/contributes to/supports body collagen production/renewal
- maintains/supports healthy skin and joints
- contributes to healthy skin structure/skin elasticity
- contributes to/supports normal joint function/health
- contributes to/supports/maintains healthy bone/bone structure
- helps to enhance muscle mass
- supports/maintains healthy hair and nail growth.

Nowadays, collagen has become an in-demand ingredient for healthy food development. Collagen production in the body decreases with age and poor diet. Consumers now seek to gain collagen through their diet. To meet this demand, collagen peptides are blended together in a variety of foods and beverages. These markets are discussed in detail in *Collagen in food and beverage industries* (Hashim, 2015).

While there are many products providing pure collagen peptides as powders, capsules, and tablets the list of products incorporating collagen peptides continues to grow and now includes products such as:

- protein sports supplements
- ready to drink sports drinks, carbonated beverages, teas, smoothies
- ready to consume dairy products, milk drinks, milk powders, yoghurt, ice cream
- protein bars, cereal bars
- breakfast products, granolas
- coffee creamers
- collagen gummies
- cakes, biscuits, and breads.

As for gelatine, the production process for collagen peptides from sheepskin requires the economic removal of the wool from the skin prior to treatment. The pickled pelt process provides an ideal pathway for sheep processors to collect and stabilise sheepskins prior to accumulation and transport to a collagen processing facility. The pickled pelt process also provides essential skin cleaning steps to remove unwanted impurities in the skin that can affect the taste and odour of the resulting collagen peptide.

The processing steps for making collagen peptide from pickled pelts from *Gelatine Handbook – Theory and Industrial Practice* (Schrieber R, 2007).

- alkaline pretreatment, caustic soda or lime
- acid neutralisation, sulphuric or hydrochloric acid
- extraction of collagen in water
- enzymatic hydrolysis until desired molecular weight is achieved
- purification
- sterilisation
- spray-drying and agglomeration.

An MLA report V.RMH.0079 (Green & Bryan, 2019) analyses the consumer trends affecting the market for high-value collagen products and provides recommendations based on these trends and market data.

A series of reports on ovine collagen are presented in section 5.10.

5.9.2 Keratin

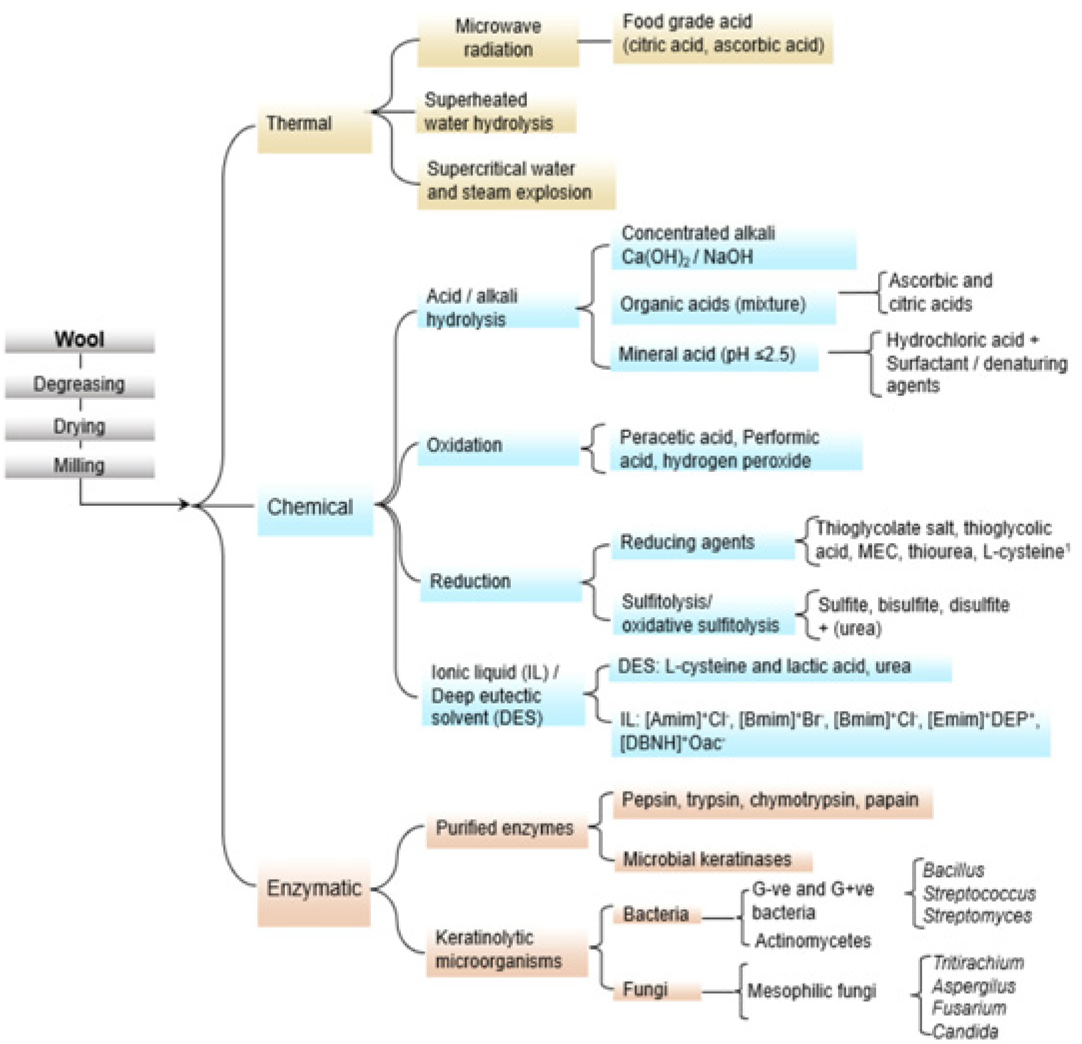
Keratin is the key structural material making up hair, wool, feathers, nails, horns and the outer layer of skin. The characterising amino acid in keratin is cystine. Cystine provides resistance to the body against harmful effects by enhancing the white blood cell activity and is essential for the proper functioning of the skin.

Functional keratin proteins are commercially extracted from wool fibres and used in dietary supplements and cosmetic products such as shampoos. Globally, cosmeceuticals are growing at over 5% per annum and are forecast to exceed $100 billion within three years. Keratin is also used in skin treatments for the clinical management of wounds and severe burns (Ranaweera, 2013).

Keratin can be obtained by extreme chemical or thermal breakdown of the wool fibre, but this can lead to uncontrolled fragments of inactive keratin. Keratin proteins form a double helix structure held together by strong covalent bonds. These disulphide bonds must be cleaved to create individual protein chains.

Various extraction methods for keratin from wool (Giteru, et al., 2022) are presented in Figure 20.

Figure 20: Classification of methods used in keratin extraction from wool



5.10 Available resources for maximising value

MLA has conducted some specific projects investigating opportunities for ovine collagen peptides and keratin.

5.10.1 Validation market desirability and useability of ovine collagen

Phase 1 P.PSH.1297 (Talwalkar, et al., 2022) and Phase 2 P.PSH.1394 (Talwalkar, et al., 2023).

The outcomes of these projects (P.PSH.1297, P.PSH.1394) have been the development of three new proof of concept technologies that enable quick processing of ovine skins. The process extracts not only collagen hydrolysate but also clean intact wool that can be further converted into a high-value keratin protein concentrate for application in food, nutraceutical and cosmetic industries.

By achieving a full valorisation of ovine skins, these technologies can potentially deliver significantly more returns to Australian sheep producers than what they currently receive from selling fresh skins.

Collagen products obtained from Australian sheep have unique market advantages:

- isolated disease-free herd in Australia, (only prion-free ovine in the world)
- safe, fully traceable from the 'farm to consumer'
- culturally acceptable worldwide (acceptable to Muslim, Hindu and Buddhist populations as opposed to porcine and bovine collagen).

Despite the significant global demand for collagen hydrolysate products, no company worldwide is currently able to meet the ever-growing market demand for collagen hydrolysates, in particular ovine sourced collagen. Similarly, while there are a small number of global manufacturers and suppliers of keratin hydrolysates, no Australian sheep processor is currently producing this valuable product.

5.10.2 Ovine collagen opportunities

Freeze Dry Industries (FDI) have been partnering with MLA Donor company on Bovine Hide – Extracting Food Grade Collagen from Beef Hides (P.PSH.1274). Another project (P.PSH.1347) was launched to explore the possibility of validating the collagen extraction processes for bovine hides – developed by FDI – for use on ovine skins and conduct research into the results.

The commercial opportunity of Australian ovine collagen was investigated and was found to be significant. By utilising low-quality sheepskins, the production will greatly benefit the Australian red meat industry. By utilising the skins, the cost that has been associated with disposing of them is removed and less waste will be created. This alone contributes to achieving carbon neutral status.

The organic extraction process previously developed by FDI for bovine hides was found to be suitable for ovine skins as well.

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