PPI

Customer requirements for meat and bone meal COPR.004

1997

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Published: August 1997

MEAT & LIVESTOCK
AUSTRALIA

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Summary

Australian renderers use a variety of equipment and processes to render a range of raw materials. However, the customers of the rendering industry, particularly those who use meat meal, are looking for a more or less standard product. It has always been a challenge for renderers to produce uniform product from variable raw material and processes but the customers can use alternative products if they cannot source meat meals of appropriate quality. Customers' views on the quality of meat meal have been collected. These views have been used to identify what aspects of meat meal quality require more control and to suggest processing techniques and equipment that can contribute to the necessary control.

Users of meat meal from the domestic stockfeed, petfood and fertiliser industries provided their views on meat meal quality. In addition, traders involved in meat meal exports also provided comments on meat meal quality.

The domestic stockfeed industry is the major user of meat meal. Stockfeeds manufacturers want to buy meat meals that comply consistently with the ARA/SFMAA agreed specifications. These specifications include values for crude protein; crude fat; ash; crude fibre; moisture; salt; pepsin digestibility and particle size. In addition, stockfeed manufacturers want meat meal made from fresh raw material in order to minimise the level of biogenic amines in meat meal. They also want consistency in the amino acid profile and the availability of amino acids in meat meal.

To provide products that that comply consistently with the ARA/SFMAA specifications, renderers must use raw material of consistent composition. They should be able to blend raw materials from different sources to give a uniform raw material mix, or at least be able to mix and blend finished meal. Raw materials should be rendered as soon as possible after collection and preferably within about two hours. Paunches should be cut and emptied and other gut materials should be cut and washed. Efficient gut cutting and washing can be achieved in a scissor type cutter such as the MIRINZ/IST gut cutter or Brentwood gut cutter combined with a Contra Shear-type rotary screen. The gut material should be cleaned to reduce the amount of fibre in meal, maintain a light colour and reduce the loss of available lysine through reactions with reducing sugars in paunch material.

Mills and presses must be well maintained to ensure that specifications for fat content and particle size are met. Milled meal does not have to be screened but screening is useful to ensure the appropriate particle size and to remove wool and hair from meal and thereby maintain high pepsin digestibility.

Stockfeed manufacturers indicated that meat meals produced at lower rendering temperatures have superior nutritional qualities. They do not have enough evidence about the effect of temperature on meal quality to warrant sourcing product from low temperature rendering plants or to pay a premium for low temperature rendered meal. Pressure cooked meat meal has a significantly lower nutritional value than wet rendered meals or meals produced by dry rendering at about 125°C.

Petfood manufacturers emphasise the palatability and digestibility of meat meal. Raw materials must be fresh when rendered and gut material must be well washed to achieve the required levels of palatability. In addition it may be necessary to add antioxidants to meat meal to prevent loss of palatability through rancidity. Digestibility refers to the overall digestibility of the product, not just pepsin digestibility. It is assumed that high levels of digestibility are achieved by low ash content (less than 20%) and use of low temperatures during rendering. Petfood manufacturers in Australia are opposed to the use of pressure cycles during rendering because of the effect on product digestibility. Wool and hair contribute to undigestible material in meat meal and product intended

for use in petfood should be screened to remove wool and hair and oversize bone chips which contribute to poor digestibility.

The petfood industry has indicated that there are opportunities for additional use of meat meal in premium petfood products. To take advantage of these opportunities renderers should improve and maintain the palatability and digestibility of meat meals and should produce specialty meals such as lamb and veal meal made from segregated raw materials derived from specific stock types.

The fertiliser industry uses relatively small amounts of meat meal but requires consistent levels of nitrogen and phosphorus in meat meals. The industry is not concerned about protein quality but needs meals with reasonable moisture content to prevent spoilage and reasonable fat content so the meal can be stored without caking.

There is an increasing demand for consistent quality in meat meals supplied to export markets. Problems arise through high fat content, oversize particles, hair and wool and excess fibre in meal. These aspects of meat meal quality can be controlled by maintenance of press and mills, washing raw material and screening finished meal. Export markets are also sensitive to the hygienic condition of meat meal. Renderers should take precautions to avoid recontamination of cooked product by complying with the ARA Code of Practice. Some countries also require that meat meals should be processed by specified heat treatments and these heat treatments may include pressure cooking. For this reason, traders involved in export marketing do not favour wet rendering systems although these systems would appear to have advantages in producing meals for domestic users.

An ideal rendering system to suit users of meat meal could include:

- Raw material collection systems that excluded contaminants such as metal and plastic.
- All paunches and bibles cut and emptied.
- All other gut material cut and washed through an efficient system such as scissor-type gut cutter and Contra-Shear rotary screen for washing and dewatering.
- Raw material rendered within two hours of collection.
- Multiple raw material bins to allow segregation of raw material according to species, stock type and bone content for production of specialist meals (this point is favoured by petfood manufacturers).
- Efficient blending of raw materials to provide a uniform raw material mix (this point is favoured by stockfeed manufacturers).
- Wet rendering systems, or dry rendering operating at a temperature of about 125°C (this point is not necessarily favoured by traders involved in export markets).
- Well maintained, high capacity presses to produce meal with consistent and low fat content.
- Well maintained mills to produce fine particle size.
- Screens to remove wool, hair and oversize particles from meal.
- Screens or air classification to remove bone particles from meal (this point is favoured by petfood manufacturers).
- Batch pressure treatment of finished meat meals to comply with importing country requirements for heat treatments.
- Control of recontamination of rendering product by following the ARA Code of Practice.
- Regular analysis of meat meals by renderers to verify product quality and consistency.

Introduction

The old adage "there is more than one way to skin a cat" is apposite for the Australian rendering industry. There are about 115 rendering sites processing from 5 tonnes to over 500 tonnes of raw material per day. Raw material composition varies from site to site. There are at least six distinctive types of rendering systems in use and also variations in the post-processing handling of meals. Some of the different approaches to rendering are summarised in Table 1.

In view of the possible combination of equipment and processing methods, renderers are interested in knowing what is the best method of rendering. Of course this question has no single answer because there are conflicting objectives that must be considered when deciding the most appropriate rendering system. For example rendering systems and equipment must be selected to suit the quantity and type of raw material, environmental consideration and EPA pressures, and possible requirements to sterilise product. In addition, selection of rendering equipment also takes into account production costs including productivity and energy costs, potential product quality, yield and capital costs. The most suitable rendering system or equipment will depend on the priorities placed on the different and sometimes conflicting objectives of rendering.

Renderers should also consider what the customers are looking for and what type of equipment or processing procedures can produce product suited to various customers. Meat meal and tallow are both used as ingredients in other products and the way they are produced can affect their potential uses. Thus, if renderers want to supply product to a particular market, or to expand the potential outlets for products they should understand what processing procedures, if any, have advantages in producing products for particular markets. In order to link processing methods to customer requirements users of meat meal were contacted to find out what preferences they have for different meat meal products.

Table 1: Summary of different approaches to rendering

Processing technique	Approximate % of rendering plants
Rendering system	
Batch dry rendering at atmospheric pressure	40
Batch dry rendering with pressure cycle	8
Continuous rendering tube cluster-type	29
Continuous rendering disc-type	4
Wet rendering - wet pressing	4
Wet rendering - decanter separation	12
Wet rendering - batch	3
Raw Material Handling	
Gut material cut and washed	85
Raw material preservation	6
Meal Handling	
All meal milled	86
Milled meal screened	80

Method

The views of end-users and buyers of meat meal were canvassed in face-to-face and telephone interviews. Interviews were conducted with five people from the stockfeed industry, two people from the petfood industry, two people from the fertiliser industry and three people from trading companies.

Stockfeed Manufacturers

Most of the meat and bone meal produced in Australia is used in stockfeed formulations in the domestic market. The MRC report on The Meat Meal and Tallow Industry and its Markets (Strategic Planning Update)[1] reported that in 1994, 267,000 tonnes of meat meal (60% of production) was used on the domestic market in livestock production.

Stockfeed manufacturers and all other users of meat meal stress the importance of being able to obtain product of known and consistent quality. To assist production of meat meal of consistent quality, the Australian Renderers Association (ARA) and the Stockfeed Manufacturers Association of Australia (SFMAA) have published an agreed set of specifications for meat meals. These specifications have been adopted by the National Agricultural Commodities Marketing Association

(NACMA). Most stockfeed manufacturers buy product according to these specifications and expect to be supplied product according to these specifications. The ARA/SFMAA specifications are shown in Appendix 1.

Stockfeed manufacturers are keen to point out that meat meal is not an essential ingredient in feed rations. Meat meal can be replaced by vegetable protein meals, mineral supplements and synthetic amino acids. However meat meal has the natural advantages of containing essential amino acids, additional energy from the fat content and highly available phosphorus. While meat meal is regarded an expensive source of protein, it is still cost-effective at restricted levels of inclusion in feeds because of the package of nutrients supplied in meat meal.

The inclusion levels of meat meal in stockfeed rations are limited by cost. Meat meal is regarded as a protein source but is only included up to the point at which the requirement for essential amino acids and phosphorus in the compounded feed are satisfied. Thereafter, additional protein is provided by vegetable protein sources. In practice meat meal is included in feeds at levels between 8-12%. Meat meal is about 30-50% of the protein meals in a ration, the balance of meat meal to other protein meals varies by State and depends on the availability of the different meals.

Meat meal used in stockfeeds is also limited by the amount of calcium in the ration. High levels of calcium can depress growth and the maximum calcium in a stockfeed is about 1.2%. This effectively limits meat meal inclusion to less than 12%.

It is not clear whether improvements or changes in meat meal quality would encourage stockfeed manufacturers to use more meat meal. However, stockfeed manufacturers have indicated that they avoid buying meat meal from manufacturers who cannot supply the appropriate quality. The processing procedures that relate to specific quality problems are:

Raw Material Handling

Freshness

Freshness of raw material is a very important consideration for stockfeed manufacturers. Some buyers of meat meal have indicated that they avoid buying product from service renderers because of the increased chance that after collection and transport of raw material, the material is not fresh by the time it is rendered. It is important to render fresh material because as the raw material ages there is a loss of amino acids through conversion of amino acids to biogenic amines. High levels of biogenic amines may be toxic or depress growth rates. From the stockfeed manufacturer's point-of-view, aged raw materials have the double disadvantage of loss of nutritive value through depletion of essential amino acids such as lysine and methionine, and possible depression of growth rates caused by increased levels of biogenic amines.

The ARA/SFMAA or NACMA specifications do not include a limit for biogenic amines in meat meal but stockfeed manufacturers prefer meat meal with total amines less than 150 mg/kg. Data contained in the MRC report on biogenic amines in meat meal[2] indicated that there is a risk of producing meat meal with a total amine level greater than 100 mg/kg from raw materials stored for more than 2 hours. However, meat meals containing less than 100 mg/kg of biogenic amines can be produced from raw materials that are 6 hours old.

Renderers should aim to process raw materials within two hours of collection to guarantee biogenic amine levels in meat meal at acceptable levels. Preservation techniques such as addition of acid to raw material may slow down the rate of generation of biogenic amines in raw material although the effect of preservation has not been investigated.

Washing

As far as possible, paunches and other gut material should be emptied and washed. Paunch contents contain reducing sugars. These sugars may react with the essential amino acid lysine in dry rendering processes resulting in loss of availability of lysine. Paunch and gut contents contribute crude fibre to meat meal and increasing the risk of exceeding the ARA/SFMAA specification of 3% maximum crude fibre. High levels of gut contents in raw materials can give meat meal a very dark colour as opposed to the light to dark brown colour specified in the ARA/SFMAA specification and will dilute the protein content of meat meal. For these reasons stockfeed manufacturers expect renderers to clean and wash raw material.

The Rendering Process

In general, stockfeed manufacturers take the view that the lower the temperature during rendering, the better the in-vivo amino acid availability of the meat meal. However, there is not enough information to warrant selection of meat meals for stockfeed based on the type of rendering system. The nutritive value of meat meals produced by various rendering techniques have been assessed in Australia[3]. These trials indicated that the lysine availability of wet rendered meat meal as measured by slope-ratio assay in pigs was 97%. The available lysine in meals produced in rendering systems that included a pressure cycle of 275 kPa for 30 minutes, or rendering processes with an extended time at 150°C were severely depleted. However, meat meal produced by dry rendering with an end-point temperature of 125°C held for four hours had only slightly reduced lysine availability. The conclusion from these experiments was that satisfactory available lysine levels are achieved in meals produced by wet rendering and most dry rendering. If a pressure cycle is used in dry rendering, or the end-point temperature is about 150°C there is significant loss of lysine availability.

Renderers should aim to process material in dry rendering systems at a temperature of about 125°C to maintain high levels of lysine availability.

Milling and Screening

The ARA/SFMAA specification for particle size is that 98% of the meal must pass through a 2 mm screen. Stockfeed manufacturers have indicated that they do not require that meat meal is screened, provided that the specification for particle size is met. Meat meal may be rejected by customers if the particle size is out of specification and stockfeed manufacturers may avoid buying meal from suppliers who cannot produce product to the specified particle size on a consistent basis. However, the mills used by Australian renderers are all capable of producing meal to the required specification. Failure to meet the specification may be a result of poor maintenance of milling of equipment, or could be due to pre-screening of meal before milling. Pre-screening results in a proportion of meat meal bypassing the mill. Although material that bypasses the mill should comply with the specification for particle size, bypassing adds to the risk of oversized particles in the finished product.

To comply with the specification for particle size, renderers should mill all meal, or in the case of pre-screening meal before the mill they should ensure that the screen size is no more than 2 mm.

Screening after the mill is not essential but is a useful precaution to ensure that the particle size is satisfactory. The main value of screen is to remove hair and wool from meat meal.

The ARA/SFMAA specifications do not specify a limit of hair and wool in meat meal but the general description included in the specification indicates that hair, wool and hide should be

excluded from raw material except that which is naturally adhering to heads and hooves. Stockfeed manufacturers have indicated that they would reject meat meal that contains excessive amounts of visible wool and hair although in the absence of a specification, it is hard to be precise about how much hair is excessive. Wool and hair both have a high crude protein content but the protein is not digestible unless it is pressure cooked or chemically hydrolysed. Therefore any wool or hair in meat meal will reduce the overall digestibility of protein in meat meal.

Renderers who process raw material that contains hair or wool should screen the milled meal.

Other Aspects of Quality

Amino Acid Balance

Although crude protein is an important meat meal specification, stockfeed manufacturers use meat meal for the essential amino acids it contains, not the crude protein. The balance of amino acids in meat meals depends entirely on the composition of the raw material. Protein from muscle material and red offals has the most appropriate blend of essential amino acids. As the proportion of collagen-type protein in raw material increases, the proportion of essential amino acids in the total protein will decrease. Collagen-type proteins are associated with skin, and bones and are relatively high in intestinal material. The crude protein content of a meat meal also reflects the raw material composition and it is expected that a high protein meal is made from predominantly soft offal material and therefore should have a good balance of essential amino acids while a low protein meal is made from more bony material and has a lower proportion of essential amino acids.

Analysis of amino acids is relatively expensive and stockfeed manufacturers rely on assumed amount of amino acids in meat meals based on occasional measurements. It is therefore important that renderers should maintain a consistent balance of raw materials in order to produce consistent product. If there are changes in raw material composition, for example a change in the balance between hard offals and soft offals, inclusion of skin pieces or return of concentrated stickwater from wet rendering there will be a corresponding change in the amino acid composition of the meat meal. Such changes in raw material composition may seem to be unavoidable to renderers but they have led to an impression that meat meal is inconsistent in quality compared vegetable protein concentrates.

Amino Acid Availability

The other aspect of the nutritive quality of meat meal is the bio-availability of amino acids. While the raw materials may contribute essential amino acids to a meat meal, the amino acids are not useful in a diet if they are not available for absorption by the target species. The availability of amino acids in feed can only be assessed in feeding trials but the potential damage to amino acids that may occur during processing can be assessed by the chemical tests of pepsin digestibility and available lysine. The pepsin digestibility of protein must be at least 85% according to the ARA/SFMAA specifications. Available lysine is not part of the ARA/SFMAA specification but lysine is expected to be a least 3.1% of the crude protein and at least 71% available in 50% protein meals.

The digestibility of protein is affected mainly by the presence of undigestible protein from hair, wool, horns and hooves in the meat meal. These materials are high in protein (about 80% crude protein). If a 50% crude protein meat meal contains 6% of wool and hair, this is equivalent to almost 9% undigestible protein in the meal. Pressure treatment can increase the availability of protein from wool and hair but as indicated above, can cause damage to other amino acids. High

levels of digestibility (90-95%) can be maintained by excluding hair wool hooves and horns from raw material or by screening the finished meal.

There are three mechanisms by which amino acid availability may be reduced during heat processing. These mechanisms are: total destruction of amino acid by heat; some amino acids, particularly lysine may react with reducing sugars in the so-called browning reaction and become unavailable, or amino acids may cross-link and become unavailable. These three types of amino acid damage are related to heat and all lead to loss of available lysine. As indicated above, available lysine of 80% or more can be maintained by using dry rendering processes with an end-point temperature of about 125°C, or by wet rendering.

The analytical tests for determining amino acid profile, protein digestibility and available lysine cannot be conducted on every load of meat meal. Stockfeed manufacturers therefore rely on renderers to deliver consistent product. The required quality and consistency is achieved by using a consistent blend of raw material, excluding wool, hair, horns and hooves, and by processing in consistent manner without pressure treatment or extended periods above 125°C.

Product Consistency and Addition of Blood

The consistency of meat meals in terms of amino acid profile, amino acid availability, fat, and ash content is most important to the stockfeed industry. The ingredients in a stockfeed ration are finely balanced and if any of the ingredients fail to deliver the expected amount of nutrient, the ration will not deliver the expected growth performance. The quality characteristics of meat meal cannot be measured for every batch and stockfeed manufacturers depending on their historical knowledge of meat meal to formulate a ration.

Addition of blood to meat meal to boost crude protein values is an example of how meat meal consistency can be upset. There is an expected amino acid balance in 50% protein meat meal. If the 50% protein level has been achieved by addition of blood, the amino acid balance will be different from 50% protein meal made from a non-blood containing mix of raw materials. Blood is used as an ingredient in stockfeed but the stockfeed blenders prefer to add known amounts of blood rather than have an unknown quantity of blood thrust upon them via meat meal.

Stockfeed manufacturers except that some suppliers of rendered materials do not have complete knowledge of the products they supply. Some stockfeed manufacturers conduct analysis of meat meals and may give feedback to the renderers. However, it should be incumbent on suppliers (i.e. the renderers) to regularly analyse their own product. Such analyses will help demonstrate that product consistency is maintained. It also gives renderers the opportunity to market their product according to a more detailed specification than the ARA/SFMAA generic specification. A complete product analysis would include, crude protein, crude fat, crude fibre, ash, phosphorus, calcium, moisture, salt, particle size, pepsin digestibility, amino acid profile, biogenic amines and lysine availability. The total cost of these analyses is likely to be about $1000.

Microbial Condition

The ARA/SFMAA specifications require that microbiological contamination of rendered product should be minimised but do not set a specification. The stockfeed manufacturers interviewed would like to buy Salmonella-free meat meal but give microbial condition a lesser priority than other aspects of quality. However, animal protein meals are excluded from rations for grandparent stock in the poultry industry because of the risk of Salmonella contamination.

Renderers can produce Salmonella-free meal by application of precautions such as separation of raw material and finished product and elimination of condensation in all meal handling equipment, as required by the ARA Code of Practice for Hygienic Rendering of Animal Products. The ARA/SFMAA specification states that microbial contamination should be minimised by following the ARA Code of Practice. Another possibility is to use anti-microbial additives such as Salcurb in the finished product. The use of anti-microbial additives is acceptable to stockfeed manufacturers but elimination of Salmonella by attention to processing hygiene is preferred.

Conclusion

Stockfeeds manufacturers are not looking for alternative meat meals, or a diversified range of products. They want products that are produced consistently to meet all the minimum requirement of the ARA/SFMAA specifications. To meet these requirements renderers should:

- Empty paunches and clean gut material to minimise reducing sugars in the raw material and to eliminate fibre which could dilute protein levels.
- Use a consistent mix of raw material to maintain a consistent amino acid profile in meat meal.
- Minimise hair, wool, hooves and horns in raw material to maintain high levels of protein digestibility, or screen finished meal to remove hair and wool.
- Mill all meal through a well maintained mill, or only allow meal with a particle size of less than 2 mm to bypass the mill.
- Comply with the ARA Code of Practice for hygienic rendering of animal products.

In addition to the requirements of the ARA/SFMAA specification, stockfeed manufacturers want meat meal made from fresh raw material in order to control biogenic amines. Material should be stored for less than 2 hours before rendering to ensure biogenic amine levels of less than 100 mg/kg meat meal.

Stockfeed manufacturers also require a reasonable level of lysine availability in meat meal. This is achieved by applying consistent heat treatments either in wet rendering systems or in dry rendering systems operated with end-point temperatures of approximately 125°C, with no pressure cycle.

Petfood

The petfood industry is the second most important user of meat meal in the domestic market.

About 5% of meat meal production (about 25,000 tonnes) is used in domestic petfood. Feeds produced for domestic pets are different from stockfeeds in that they are generally formulated for weight maintenance rather than weight gain. Also, petfoods must help to maintain the animal in a healthy condition with good coat condition; the food must be highly palatable so that the pet owner can see that it is relished by the pet; the odour and appearance of the food must be attractive to the owner and the food should not cause the pet to produce overly disagreeable faeces.

Despite the different emphasis on the requirements for petfoods, the specifications for meat meal used by petfood industry are similar to the specifications used by the stockfeed industry. However, there are no industry based specifications, petfood companies develop their own specifications which renderers supply to. It is understood that the specifications for meat meal used in petfood allow less fibre than specified in the ARA/SFMAA specifications, and specifically exclude addition of blood to meat meal. The specifications may also include addition of antioxidants. Petfood manufacturers are concerned about calcium levels in their product and their specifications do not allow for the high ash meat meal products that are included in the ARA/SFMAA specifications.

Like the stockfeed manufacturers, petfood manufacturers are concerned about the consistency of the quality of meat meal. Petfood companies tend to establish close relationships with their suppliers and make regular inspection of supplier's premises to ensure that required production standards are met. Petfood manufacturers are concerned about how meat meal is produced in addition to the finished product specification.

Petfood manufacturers also make the point that meat meal is not an essential ingredient in petfood. Other protein concentrates such as fish meal and poultry meal are preferred because they have better palatability and digestibility than meat meal. There are a range of petfoods manufactured to different quality specifications to suit different market segments. Meat and bone meals are generally excluded from use in the higher, quality, higher priced petfoods.

There is scope for increased use of meat and bone meals in petfood if renderers are prepared to adjust their processes and products to suit the petfood industry. In particular, meat meals with low ash, high digestibility and good palatability would be attractive to the petfood industry.

Palatability

The palatability of meat meal to dogs and cats is affected primarily by rancidity in the fat component of the meat meal, and secondly by the freshness and cleanliness of raw materials.

It is not clear what affects the degree of rancidity in meat meal but age of raw material must be one influence. Rancidity has two components, one is hydrolytic rancidity which is usually caused by microbial activity and results in an increase in free fatty acid. The other is oxidative rancidity which is a chemical reaction between fats and oxygen and usually (but not necessarily) results in an increase in peroxide value.

Both hydrolytic and oxidative rancidity contribute to loss of palatability of meat and bone meal.

It is known that fats in raw material hydrolyse (ie. free fatty acid increases) when material is stored before the rendering process. Hydrolysis stops when raw material is heated in the rendering process. Oxidative rancidity probably starts in raw materials and accelerates in the rendering process due to the high temperature and high degree of agitation. Meat meal particles are coated

with a thin layer of fat and in this condition there is a large surface area of fat exposed to oxygen and oxidation will continue in the finished meal.

Contact with metals, particularly copper, accelerates oxidative rancidity and copper should be avoided in rendering plants.

Loss of palatability due to rancidity can be minimised by processing raw materials as soon as possible. Some petfood manufacturers are considering specifying the maximum age of raw material at the time of processing. Rancidity can also be controlled by addition of antioxidants either into the rendering vessel or by spraying onto finished meat meal. Antioxidants slow down development of oxidative rancidity but do not influence hydrolytic rancidity. There are a range of possible antioxidants and the use of these additives should be discussed with the customers. The customer may have a preference for a particular antioxidant or may prefer no additives.

Palatability of meat meal is also affected by the presence of paunch material and intestinal contents in raw material. Raw material should be cut and well washed to remove as much gut contents as possible in order to produce a meat meal suitable for use in petfoods.

Petfood manufacturers may require that dead stock are excluded from raw materials. Dead stock cannot be considered to be fresh raw material and may affect palatability of meat meal because of putrefaction, development of rancidity of the fat and unemptied, uncleaned guts.

Protein Quality

Meat meal is used in petfoods for its protein contribution. The protein in meat meal is packaged with phosphorus, calcium and fat which increases its attractiveness in a petfood ration. And importantly, protein in the meat meal package is relatively palatable compared with vegetable protein sources. The quality of the protein in terms of amino acid balance and amino acid availability is not as crucial as it is in meat meal used in stockfeeds. Petfood manufacturers ensure that formulated diets have the necessary amino acid content but this may be achieved by adding slightly more than the absolute minimum requirement for protein. Petfood manufacturers expect a certain contribution of available amino acids from meat meal, based on their experience of feeding trials with diets containing meat meal, but because they add a slight excess of protein, small fluctuations in amino acid profile can be tolerated more so than in stockfeed rations. Maximum weight gain at minimum cost is not an objective for petfoods and consequently the protein quality of meat meal is less of a priority than the other quality characteristics of palatability and overall digestibility.

Digestibility

Petfood manufacturers are interested in the pepsin digestibility of protein in meat meal but are also concerned about the total digestibility of a feed including the digestibility of the fat and ash components. If the components of a feed are not readily digested, the required level of nutrients will not be absorbed by the animals and in addition, the undigested materials will increase the amount of faeces.

The pepsin digestibility of protein in meat meal is affected mainly by the presence of undigestible proteins from wool, hair, hooves and horns. If these items are excluded from raw materials or are screened out of the finished product the finished meat meal should have an acceptable pepsin digestibility of over 90%.

Petfood formulations are tested to determine in-vivo digestibility of feeds. The in-vivo total digestibility of meat meals is about 80-85%. At this level of digestibility, animals may absorb

sufficient nutrients but the undigested 15-20% of meat must contribute to faecal matter. Improved levels of digestibility would make meat meals more attractive for use in petfoods. They would increase the amount of meat meal that can be used in a ration, and the range of products in which meat meal can be used.

The factors that contribute to poor digestibility of meat meal (apart from inclusion of non-digestible proteins) are high ash levels and high processing temperatures. It is not clear how these factors influence digestibility but low ash meals (ash less than 20%) are regarded as more digestible than high ash meals. The temperature applied in rendering also affects the total digestibility of meat meal in petfood rations. Petfood manufacturers regard low temperature rendered meals as superior to high temperature rendered product but have not quantified the benefit of low temperature rendered meal. Pressure cooking of rendered product is regarded as a step back into the dark ages because of the adverse affects on total digestibility and colour of meat meal.

Ash

Although meat meals are used in petfoods for the contribution of phosphorus and calcium, the amount of calcium in petfood rations must be limited to about 1.5%. More meat meal could be used in petfoods but other protein meals have to be included to dilute the contribution of calcium from meat meal. Petfood manufacturers would like meat meal with an ash content of less than 20%. This would give them more flexibility to include meat meal at higher levels without putting too much calcium into the petfood. As mentioned above, the ash content of meat meal is related to total digestibility of meat meal and any moves to lower the ash content in a meal would make the meal more attractive as a petfood.

Other Quality Issues

Petfood manufacturers are concerned about metal and plastic contamination in meat meal (and fresh offals). Renderers who supply product to petfood manufacturers are expected to review carefully their production processes to identify and eliminate possible sources of physical contamination of product.

Meat meal produced for use in petfood should be well screened, preferably through a 2 mm screen, to help remove plastic and metal, hair and wool, and oversize bone particles which reduce the digestibility of the meal. Screening is a safeguard measure to reduce the risk of unwanted particles in the finished meal but petfood manufacturers would prefer that renderers use processing procedures that prevent the unwanted particles getting into the meal.

Opportunities for Increased Use of Meat Meal

As discussed, the main constraints on the use of meat meal in petfood diets is palatability and digestibility. Palatability can be improved by ensuring the raw material is fresh when it is rendered and by addition of antioxidant to meat meal. Digestibility can be improved by rendering at low temperature and minimising the ash content of the meal. However, fish meal and poultry meal have better palatability and digestibility than meat meal and are preferred to meat meal.

There may be opportunities to increase the range of products in which meat meal can be used by producing more specialised meals. Ovine meals are a good example of specialist meals that are particularly attractive to the petfood industry and command a premium price. The advantage of ovine meals is that they are presumed to be less allergenic than beef based products. Other specialist meals that are attractive are lamb, veal and poultry. The attraction of these meals, apart

from the perception that they are less allergenic than beef, is that they can contribute to enhanced product labelling. A petfood that contains a lamb or veal meal can be labelled as such.

If species and stock-type specific meals are produced with low ash ie. less than 20% ash, either by excluding bone from raw materials or by screening or air classification to remove bone from meal, there is a much better chance of meat meal being used in premium petfood products. The petfood market is continuing to develop more premium products and only meat meals with improved digestibility and produced from species or stock-type specific raw material will be used in the premium products.

Conclusion

Renderers producing meat meal for petfood should concentrate on processing raw material while it is fresh to improve palatability, and by minimising bone and ash content to improve digestibility. Meals made from raw material with a low bone content are most suitable. Gut material should be well washed and dead stock excluded from the raw material.

Low temperature rendered meal is likely to be more attractive and pressure cooking of meals for petfood should be avoided.

Physical contaminants such as plastic and metal must be excluded from meals and fine sieving of the finished meal will help keep these materials out of the meal. Sieving will also improve the digestibility of the meal by removing undigestible protein such as hair and wool and by removing oversized bone particles.

Meals made exclusively from a single species of raw material (other than beef) or from specific stock-types such as veal and lamb, could be used in premium petfood product, especially if the meal has a low ash content.

Fertiliser

A small amount of meat and bone meal is used as fertiliser. The amounts involved are not known but are assumed to be about 1,000 tonnes per year.

Meat meal is used in fertiliser for its nitrogen and phosphorus content. The nitrogen and phosphorus in meat meal have some advantages in that they are regarded as slow releasing and could be considered to be from organic material. However, the nitrogen and phosphorus in meat meal are highly priced compared with N and P from other sources and therefore use of meat meal in fertilisers is likely to remain on a small scale.

Fertiliser manufacturers are aware of the composition of meat meal and conduct analyses of samples but they do not purchase according to detailed specifications. Meat meals with insufficient nitrogen or phosphorus are not acceptable to fertiliser manufacturers but the point at which a meal is unacceptable is not clearly defined. Meat meals used for fertiliser must not be unpleasant to handle. This means that meals should not be smelly and the moisture content should be low enough to prevent any microbial growth and putrefaction of the meal.

High ash, low protein meat meal which may not be suitable for stockfeed or petfood use could be used in fertiliser but fertiliser manufacturers require samples for evaluation before they can assess the value of such meals in compounded fertilisers.

Exports

About 30% of Australian meat meal production is exported. The major markets are Japan, Indonesia, USA, Philippines and Taiwan. Some meat meal is exported directly by manufacturers, particularly to Japan and the USA, but traders are also involved. From the trader's point of view, Japan, Indonesia and other South East Asian countries are the major markets. The USA market is mostly for specialist ovine meals and those products are generally sold directly by the manufacturers into the USA.

Japan

The Japanese market buys according to the nitrogen and phosphorus content of meat meal. Although 45% protein meat meal is discounted compared with 50% meat meal, the discount is not pro-rata on the basis of the value of the protein content. The Japanese market allows credit for the extra phosphorus content of 45% protein meal.

Other specifications do not play a major role in the sale of meat meal into Japan. The Japanese market tends to buy according to brands and will buy product from sources that are known to supply the appropriate quality, without reference to detailed specifications. Therefore the key to supplying product into Japan is to establish a reputation for consistent quality product.

Meat meal sold to Japan should be accompanied by certification attesting to the heat treatment applied to the meal. The required heat treatments are either 115°C for a minimum of 1 hour by steam heat or 140°C for a minimum of 3 hours by dry heat. Specified heat treatments are not required for meat meal produced from raw materials that have passed ante and post-mortem inspection and which are wholesome and free from any contagious diseases.

The Japanese market is also sensitive to Salmonella contamination and expects that imported meals are free from Salmonella.

Indonesia

Indonesia buys meat meal primarily according to protein content. The value of meal is dependent on protein and low protein meal is discounted pro-rata according to the value of the protein. For example, if the price for 50% protein meat meal is $400 per tonne, the protein is worth $800 per tonne and the price of a 45% protein meal is $360. No allowance is made for the phosphorus content of the meal as it is in Japan.

Although meat meal supplied to Indonesia and is priced according to protein content there are other detailed specifications that should be met. Unlike Japan, Indonesia does not buy product from established brands but buys according to specification. Appendix 2 shows an Indonesian Government specification for meat meal. Private companies may not adhere strictly to this specification and may in fact have tighter specifications. Specifications of 10% fat maximum and minimum 5% phosphorus in 45% meat and bone meal are difficult to meet but are indicators of the increased awareness in overseas markets of the properties of meat meal and an increasing trend to careful specification of meat meal.

As with Japan, Indonesia is sensitive to Salmonella and Shigella contamination and expects meat meal to be free of these contaminants at the point of production.

General Exports

People trading in meat meal are finding it more difficult to source meat meal to match customer requirements. This may be partly because renderers are selling direct to domestic and overseas customers but is also because overseas customers want products that match detailed specifications. In the past, some customers for Australian meat meal have not been particularly discerning about the product they have bought but as they have gained more experience of the product, they are less likely to accept inferior product.

Many markets may only specify the protein content of meat meal but they may also be sensitive to other quality attributes. For example, meals with high fat content (over 16%) are very difficult to sell to export markets. Similarly, meals with excessive wool and hair, large particle size or dark colour because of excessive paunch contents may be rejected or at least result in no repeat orders. People involved in trading meat meal make the point that overseas buyers are becoming more educated about the properties of meat meal and will not accept poor quality product.

There are opportunities to sell specialist meals into export markets at premium prices. Apart from ovine meals exported to the USA, other importing countries are interested in sourcing 55% protein meals but not many Australian renderers (if any) are in a position to supply the necessary quantities of this type of product on a consistent basis.

Hygiene

A feature of overseas markets is the attention paid to product hygiene. As mentioned, Japan and Indonesia expect to be supplied with salmonella-free meal and some markets, particularly the EU, Japan, Mauritius, Malaysia, Singapore and Canada have specifications for heat treatments applied to meat meal to ensure destruction of pathogenic microbes in the meal. These heat treatments are shown in Appendix 3. Traders are concerned that there is an increasing trend towards specification of heat treatments by importing countries and believe that an expansion in the use of wet rendering processes could make it difficult to comply with requirements for heat treatments. This is in contrast to domestic users of meat meal in stockfeed and petfood rations who appear to favour lower rendering temperatures.

References

1. The meat meal and tallow industry and its markets. (Strategic Planning Update). Meat Research Corporation, 1996.
2. Biogenic Amines in Meat Meal. MRC Project Report US.021 Meat Research Corporation 1996.
3. Batterham, E.S., Darnell, R.E., Herbert, L.S. and Major, E.J. (1986) Effect of pressure and temperature on the availability of lysine in meat and bone meal as determined by slope-ratio assays with growing pigs, rats, chicks and chemical techniques. British Journal of Nutrition, v.55 p.441.

Appendix 1 ARA/SFMAA SPECIFICATIONS

ARA/SFMAA SPECIFICATION

MBM 55

Description:

Meat and bone meal shall be the product obtained by rendering, drying and grinding animal tissues and bones, exclusive of hair, wool, hide, except where it is naturally adhering to heads and hoofs. Where poultry offal is included this shall not include feathers except where whole carcases are used. The raw materials used for manufacture of meat and bone meal shall be fresh and sound and the rendered product shall have a fresh, meaty odour. Nothing other than an approved antioxidant may be added to the product prior to delivery.

Conformity with Stock Feed Regulations:

Meat and bone meal shall conform in composition and quality with the most recent regulations pertaining to meat and bone meal published under the relevant Stockfeeds Act in the Sate in which the product is manufactured. Nothing in this specification shall be construed as contrary to any relevant Acts and their regulations.

PHYSICAL PROPERTIES:

Colour - light to dark brown.

Texture - Minimum 98% to pass through a 2.00 mm (US Mesh No. 10) sieve.

MICROBIOLOGICAL REQUIREMENTS:

Meat and bone meal production should be aimed at minimising the level of microbiological contamination of the rendered product by the adoption of the ARA Code of Practice for Hygienic Production of Rendered Product.

CHEMICAL PROPERTIES:

Crude Protein
Minimum 55% on an "as-is" basis.

Crude Fat
Maximum 15% on an "as-is" basis.

Ash
Maximum 30% on an "as-is" basis.

Crude Fibre
Maximum 3% on an "as-is" basis.

Moisture
Minimum 4% Maximum 10%.

Salt
Maximum 1% on an "as-is" basis.

Pepsin Digestibility
Minimum 85% of the protein as determined by the method given in the official methods of analysis of the Association of Official Analytical Chemists (AOAC).

NIL ACCEPTANCE:

Toxic matter or chemicals prohibited by State laws against inclusion in stockfeeds, or any substance harmful to animal health. The product must be free from rodent and insect infestation.

ARA/SFMAA SPECIFICATION

MBM 50/38

Description:

Meat and bone meal shall be the product obtained by rendering, drying and grinding animal tissues and bones, exclusive of hair, wool, hide, except where it is naturally adhering to heads and hoofs. Where poultry offal is included this shall not include feathers except where whole carcases are used. The raw materials used for manufacture of meat and bone meal shall be fresh and sound and the rendered product shall have a fresh, meaty odour. Nothing other than an approved antioxidant may be added to the product prior to delivery.

Conformity with Stock Feed Regulations:

Meat and bone meal shall conform in composition and quality with the most recent regulations pertaining to meat and bone meal published under the relevant Stockfeeds Act in the Sate in which the product is manufactured. Nothing in this specification shall be construed as contrary to any relevant Acts and their regulations.

PHYSICAL PROPERTIES:

Colour - light to dark brown.

Texture - Minimum 98% to pass through a 2.00 mm (US Mesh No. 10) sieve.

MICROBIOLOGICAL REQUIREMENTS:

Meat and bone meal production should be aimed at minimising the level of microbiological contamination of the rendered product by the adoption of the ARA Code of Practice for Hygienic Production of Rendered Product.

CHEMICAL PROPERTIES:

Crude Protein
Minimum 50% on an "as-is" basis.

Crude Fat
Maximum 15% on an "as-is" basis.

Ash
Maximum 38% on an "as-is" basis.

Crude Fibre
Maximum 3% on an "as-is" basis.

Moisture
Minimum 4% Maximum 10%.

Salt
Maximum 1% on an "as-is" basis.

Pepsin Digestibility
Minimum 85% of the protein as determined by the method given in the official methods of analysis of the Association of Official Analytical Chemists (AOAC).

NIL ACCEPTANCE:

Toxic matter or chemicals prohibited by State laws against inclusion in stockfeeds, or any substance harmful to animal health. The product must be free from rodent and insect infestation.

ARA/SFMAA SPECIFICATION

MBM 50/36

Description:

Meat and bone meal shall be the product obtained by rendering, drying and grinding animal tissues and bones, exclusive of hair, wool, hide, except where it is naturally adhering to heads and hoofs. Where poultry offal is included this shall not include feathers except where whole carcases are used. The raw materials used for manufacture of meat and bone meal shall be fresh and sound and the rendered product shall have a fresh, meaty odour. Nothing other than an approved antioxidant may be added to the product prior to delivery.

Conformity with Stock Feed Regulations:

Meat and bone meal shall conform in composition and quality with the most recent regulations pertaining to meat and bone meal published under the relevant Stockfeeds Act in the Sate in which the product is manufactured. Nothing in this specification shall be construed as contrary to any relevant Acts and their regulations.

PHYSICAL PROPERTIES:

Colour - light to dark brown.

Texture - Minimum 98% to pass through a 2.00 mm (US Mesh No. 10) sieve.

MICROBIOLOGICAL REQUIREMENTS:

Meat and bone meal production should be aimed at minimising the level of microbiological contamination of the rendered product by the adoption of the ARA Code of Practice for Hygienic Production of Rendered Product.

CHEMICAL PROPERTIES:

Crude Protein
Minimum 50% on an "as-is" basis.

Crude Fat
Maximum 15% on an "as-is" basis.

Ash
Maximum 36% on an "as-is" basis.

Crude Fibre
Maximum 3% on an "as-is" basis.

Moisture
Minimum 4% Maximum 10%.

Salt
Maximum 1% on an "as-is" basis.

Pepsin Digestibility
Minimum 85% of the protein as determined by the method given in the official methods of analysis of the Association of Official Analytical Chemists (AOAC).

NIL ACCEPTANCE:

Toxic matter or chemicals prohibited by State laws against inclusion in stockfeeds, or any substance harmful to animal health. The product must be free from rodent and insect infestation.

ARA/SFMAA SPECIFICATION

MBM 50/32

Description:

Meat and bone meal shall be the product obtained by rendering, drying and grinding animal tissues and bones, exclusive of hair, wool, hide, except where it is naturally adhering to heads and hoofs. Where poultry offal is included this shall not include feathers except where whole carcases are used. The raw materials used for manufacture of meat and bone meal shall be fresh and sound and the rendered product shall have a fresh, meaty odour. Nothing other than an approved antioxidant may be added to the product prior to delivery.

Conformity with Stock Feed Regulations:

Meat and bone meal shall conform in composition and quality with the most recent regulations pertaining to meat and bone meal published under the relevant Stockfeeds Act in the Sate in which the product is manufactured. Nothing in this specification shall be construed as contrary to any relevant Acts and their regulations.

PHYSICAL PROPERTIES:

Colour - light to dark brown.

Texture - Minimum 98% to pass through a 2.00 mm (US Mesh No. 10) sieve.

MICROBIOLOGICAL REQUIREMENTS:

Meat and bone meal production should be aimed at minimising the level of microbiological contamination of the rendered product by the adoption of the ARA Code of Practice for Hygienic Production of Rendered Product.

CHEMICAL PROPERTIES:

Crude Protein
Minimum 50% on an "as-is" basis.

Crude Fat
Maximum 15% on an "as-is" basis.

Ash
Maximum 32% on an "as-is" basis.

Crude Fibre
Maximum 3% on an "as-is" basis.

Moisture
Minimum 4% Maximum 10%.

Salt
Maximum 1% on an "as-is" basis.

Pepsin Digestibility
Minimum 85% of the protein as determined by the method given in the official methods of analysis of the Association of Official Analytical Chemists (AOAC).

NIL ACCEPTANCE:

Toxic matter or chemicals prohibited by State laws against inclusion in stockfeeds, or any substance harmful to animal health. The product must be free from rodent and insect infestation.

ARA/SFMAA SPECIFICATION

MBM 50/28

Description:

Meat and bone meal shall be the product obtained by rendering, drying and grinding animal tissues and bones, exclusive of hair, wool, hide, except where it is naturally adhering to heads and hoofs. Where poultry offal is included this shall not include feathers except where whole carcases are used. The raw materials used for manufacture of meat and bone meal shall be fresh and sound and the rendered product shall have a fresh, meaty odour. Nothing other than an approved antioxidant may be added to the product prior to delivery.

Conformity with Stock Feed Regulations:

Meat and bone meal shall conform in composition and quality with the most recent regulations pertaining to meat and bone meal published under the relevant Stockfeeds Act in the Sate in which the product is manufactured. Nothing in this specification shall be construed as contrary to any relevant Acts and their regulations.

PHYSICAL PROPERTIES:

Colour - light to dark brown.

Texture - Minimum 98% to pass through a 2.00 mm (US Mesh No. 10) sieve.

MICROBIOLOGICAL REQUIREMENTS:

Meat and bone meal production should be aimed at minimising the level of microbiological contamination of the rendered product by the adoption of the ARA Code of Practice for Hygienic Production of Rendered Product.

CHEMICAL PROPERTIES:

Crude Protein
Minimum 50% on an "as-is" basis.

Crude Fat
Maximum 15% on an "as-is" basis.

Ash
Maximum 28% on an "as-is" basis.

Crude Fibre
Maximum 3% on an "as-is" basis.

Moisture
Minimum 4% Maximum 10%.

Salt
Maximum 1% on an "as-is" basis.

Pepsin Digestibility
Minimum 85% of the protein as determined by the method given in the official methods of analysis of the Association of Official Analytical Chemists (AOAC).

NIL ACCEPTANCE:

Toxic matter or chemicals prohibited by State laws against inclusion in stockfeeds, or any substance harmful to animal health. The product must be free from rodent and insect infestation.

ARA/SFMAA SPECIFICATION

MBM 48

Description:

Meat and bone meal shall be the product obtained by rendering, drying and grinding animal tissues and bones, exclusive of hair, wool, hide, except where it is naturally adhering to heads and hoofs. Where poultry offal is included this shall not include feathers except where whole carcases are used. The raw materials used for manufacture of meat and bone meal shall be fresh and sound and the rendered product shall have a fresh, meaty odour. Nothing other than an approved antioxidant may be added to the product prior to delivery.

Conformity with Stock Feed Regulations:

Meat and bone meal shall conform in composition and quality with the most recent regulations pertaining to meat and bone meal published under the relevant Stockfeeds Act in the Sate in which the product is manufactured. Nothing in this specification shall be construed as contrary to any relevant Acts and their regulations.

PHYSICAL PROPERTIES:

Colour - light to dark brown.

Texture - Minimum 98% to pass through a 2.00 mm (US Mesh No. 10) sieve.

MICROBIOLOGICAL REQUIREMENTS:

Meat and bone meal production should be aimed at minimising the level of microbiological contamination of the rendered product by the adoption of the ARA Code of Practice for Hygienic Production of Rendered Product.

CHEMICAL PROPERTIES:

Crude Protein
Minimum 48% on an "as-is" basis.

Crude Fat
Maximum 15% on an "as-is" basis.

Ash
Maximum 37% on an "as-is" basis.

Crude Fibre
Maximum 3% on an "as-is" basis.

Moisture
Minimum 4% Maximum 10%.

Salt
Maximum 1% on an "as-is" basis.

Pepsin Digestibility
Minimum 85% of the protein as determined by the method given in the official methods of analysis of the Association of Official Analytical Chemists (AOAC).

NIL ACCEPTANCE:

Toxic matter or chemicals prohibited by State laws against inclusion in stockfeeds, or any substance harmful to animal health. The product must be free from rodent and insect infestation.

ARA/SFMAA SPECIFICATION

MBM 45

Description:

Meat and bone meal shall be the product obtained by rendering, drying and grinding animal tissues and bones, exclusive of hair, wool, hide, except where it is naturally adhering to heads and hoofs. Where poultry offal is included this shall not include feathers except where whole carcases are used. The raw materials used for manufacture of meat and bone meal shall be fresh and sound and the rendered product shall have a fresh, meaty odour. Nothing other than an approved antioxidant may be added to the product prior to delivery.

Conformity with Stock Feed Regulations:

Meat and bone meal shall conform in composition and quality with the most recent regulations pertaining to meat and bone meal published under the relevant Stockfeeds Act in the Sate in which the product is manufactured. Nothing in this specification shall be construed as contrary to any relevant Acts and their regulations.

PHYSICAL PROPERTIES:

Colour - light to dark brown.

Texture - Minimum 98% to pass through a 2.00 mm (US Mesh No. 10) sieve.

MICROBIOLOGICAL REQUIREMENTS:

Meat and bone meal production should be aimed at minimising the level of microbiological contamination of the rendered product by the adoption of the ARA Code of Practice for Hygienic Production of Rendered Product.

CHEMICAL PROPERTIES:

Crude Protein
Minimum 45% on an "as-is" basis.

Crude Fat
Maximum 15% on an "as-is" basis.

Ash
Maximum 38% on an "as-is" basis.

Crude Fibre
Maximum 3% on an "as-is" basis.

Moisture
Minimum 4% Maximum 10%.

Salt
Maximum 1% on an "as-is" basis.

Pepsin Digestibility
Minimum 85% of the protein as determined by the method given in the official methods of analysis of the Association of Official Analytical Chemists (AOAC).

NIL ACCEPTANCE:

Toxic matter or chemicals prohibited by State laws against inclusion in stockfeeds, or any substance harmful to animal health. The product must be free from rodent and insect infestation.

Appendix 2 Indonesian Government Specifications for Meat Meals

Quality Characteristic	Meat and Bone Meal	Meat Meal
Moisture (% max)	10	10
Protein (% min)	45	55
Fibre (% max)	3.0	2.5
Ash (% max)	37	25
Fat (% max)	10	8
Calcium (% max)	11	8
Phosphorus (% min)	5	4
Salt (% max)	0.6	0.6
Salmonella/Shigella	negative	negative
Wool and hair (% max)	1	1
Pepsin digestibility (% min)	82	85

Appendix 3 Summary of heat treatments required to be applied to meat meal by importing countries

EU

Material must be treated at 133°C and 3 bar (absolute) pressure for at least 20 minutes. The particle size of the material must be less than 50 mm.

Japan

Material must be treated at 115°C for 1 hour in steam heat; or at 140°C for 3 hours in dry heat.

Singapore, Malaysia, Mauritius

Material must be treated either by:

a) a dry heat of 140°C for not less than 3 hours; or

b) moist heat under steam pressure of not less than 1.4 kg per cm^2 (1.3 atmospheres or 130 kPa equivalent to 125°C) for fifteen minutes; or

c) treatment of the bones after they are broken, with the vapour of benzene boiling between 95°C and 115°C for not less than four hours, live steam to be thereafter admitted for one hour.

Canada

Bone meal/hoof and horn meal must be treated at 121°C for at least 1 hour.

Meat and bone meal/meat meal/blood meal/liver meal must be treated at 104°C for at least 20 minutes.

Feather meal must be treated at 121°C for at least 1 hour or 149°C for at least 15 minutes.