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After completing an honours degree in Agricultural Science at the University of Western Australia, Elizabeth embarked on a career as an animal nutritionist providing least cost feed formulations and technical services to a range of intensive and extensive livestock industries for some of Australia's leading animal health and nutrition companies.

Research in areas of broiler and equine nutrition has seen Elizabeth publish multiple articles in her career with several book chapters to her credit. Elizabeth is also an adjunct lecturer in animal nutrition at the University of Qld. Elizabeth has served on RIRDC Research Committees, and serves on a Standards Australia Committee for stockfeed.

Based with Symbio Alliance for over 10 years and with extensive experience in formulation of premixes and finished feeds, Elizabeth is well qualified to provide technical advice to industry on aspects of quality control and analytical support of stockfeed products and their ingredients.

"Testing terminology for tallow and animal protein meals"

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Consumers are increasingly aware of, and sensitive to, food safety and its linkage with animal production, including feeding practices. Food safety hazards associated with animal feed can be biological, chemical or physical. The outbreak of BSE and the Belgium Dioxin Crisis, are well known examples of how stockfeed quality impacts on the human food chain.

The Australian Renderers Association (ARA) Inc. has long recognized this important link between product quality and the potential impacts on the human food chain. The ARA has effectively minimized many of these risks via its introduction of the *Australian Standard for Hygienic Rendering of Animal Products – AS 5008.* The challenge still remains however in the implementation of this standard and particularly, in the understanding of the analytical processes on which such a standard hinges.

How well routine or violation testing meets the expectations of the stockfeed manufacturer and ultimately the human consumer is not well understood, with the right questions often only being asked after a food safety breach has occurred. AS 5008 provides an excellent framework for setting priorities for routine analytical surveillance but many employees, new to the industry, may have difficulty understanding analytical terms and their meaning. Moreover, industry "newbies" may not be aware of the importance of representative sampling and what that entails.

It is also important that the industry and individual companies do not set testing standards that cannot be maintained via even robust analytical methods. An understanding of measurement uncertainty and the sources of error is required.

This paper and accompanying presentation will attempt to demystify some of the terminology associated with analytical testing and also identify sources of error that may impact on the accuracy and usefulness of test results.

Key analytical properties for tallow and animal protein meals

Analytical testing is used for 2 major purposes:

1. Quality control
    a. Monitoring of manufacturing processes
    b. Verification of supplier claims
    c. Identification of any contamination or pathogens – identified in HACCP plan
2. Quality standards
    a. Verification of standards for trade
    b. Validation against HACCP parameters

The Australian Standard for Hygienic Rendering of Animal Products - AS5008:2007 and Pocket Guides, specify the quality control specification and tests for each of the rendered products. It is against this standard of course, that the result of any testing needs to be assessed. This standard also stipulates the preferred method that should be applied in determining each of the target parameters. This is not always possible or practical as analytical methods evolve and improve over time as innovations in instruments and procedures are embraced. The potential impacts of different methodologies for completing each test will be discussed within each category of test.

Chemistry analysis

The major nutrients/parameters being measured are as follows:

- ***Protein*** – expressed as Crude Protein % w/w. the %w/w refers to % weight for weight. This value is arrived at by measuring the nitrogen content and using a conversion factor of 6.25 (based on the amino acid composition of animal proteins). The ARA standard stipulates a DUMAS method which is a combustion method. LECO is a instrument brand based on the DUMAS combustion method. Kjeldahl is an older method (invented 125 years ago) that is subtly different to combustion methods and will produce a different result.
- ***Fat*** – expressed as Crude Fat, Ether Extract or Fat %w/w. Fat is composed of fatty acids and these become important in oil quality standards. The ARA standard stipulates a method AOAC 920.39 which is a gravimetric method recommended in the matrices of animal feed. AOAC 960.39 is a similar method but one specific for meat products.
- ***Moisture*** – also expressed as % dry matter w/w. The total of dry matter and moisture content should be 100%. Ideally any moisture reading should be conducted when the sample has reached a point where further drying (in an

oven) produces no further change in weight. Most commonly this would be 4-6 hours but could be overnight.

- ***Fibre*** – measured as Crude Fibre %w/w representing the insoluble carbohydrate and cellulose fractions that may persist in the final product. This is distinct from an estimate of wool and hair which is conducted to identify the % of keratin material in a sample.
- ***Ash*** – this is the bone or mineral portion of the sample left after combustion. Results are expressed as a %w/w. Interestingly the ARA recommended method which dates back to a 1942 reference, stipulates 600 degrees for 2 hours whereas more current methods specify 550 degrees for 4 hours. These 2 methods will produce different results as demonstrated in a comparison in 2012[1] and recommendations for modification to AOAC Official Method 942.05 were suggested based on statistical analysis of the data and a review of the literature.
- ***Pepsin digestibility*** – It is necessary to know not only the amount of protein in a sample but also have an indication of the protein quality. This can be achieved by crudely replicating the action of an animal's digestive tract in the laboratory. This is called in vitro digestibility assay which is based on the incubation of a sample with a single digestive enzyme, Pepsin under controlled conditions. After the period of incubation amino acids and peptides are released allowing the undigested protein to be separated and quantified and expressed as a % of total protein. A higher value for pepsin digestibility indicates a more digestible protein source. Processing temperatures and methods can negatively impact on pepsin digestibility as can presence of contaminants such as horn.
- ***Calcium and phosphorus*** – these elements are important in the formulation of animal feed rations and are quantified using atomic emission spectrometry. The results are expressed as %w/w.
- ***Amino acid profile*** – this test measures the quality of protein and reports the relative concentration of each of up to 20 amino acid as a %w/w. The report needs to show if the results are expressed as a % protein in the original sample or as a %w/w of the sample as a whole.
- ***Free fatty acids*** – this is a measure of the level of hydrolysis of the tallow sample which can lead to off flavours or odours in the product. The higher the FFA content, the lower the quality of the tallow. There is evidence in poultry diets that the apparent metabolizable energy content of fats linearly decreased with increasing FFA content[4].Expressed as %w/w

- ***MIU*** – moisture, insoluble impurities and unsaponifiable matter– insoluble impurities in tallow are usually bits of bone, hair or sand that has contaminated the product. Presence of water and insoluble impurities increases the rate of oxidation and hydrolysis of the product. Unsaponifiable matter is a measure that grades the tallows suitability for making soap.
- ***Peroxide value*** – is an indicator of the degree of oxidation of the tallow or it's level of rancidity. It is expressed as mEq/kg or milli equivalents per kilogram. High quality fats will have a PV value between 1 and 2 mEq/kg whereas rancid fats may run as high as 20 mEq/kg.

When reading results, it needs to be understood whether results have been reported on a dry weight or as received basis. Since meat and bone meal is quite dry, the difference is not large but it is important when comparing results or providing results to clients that the basis for the test is clearly understood and conveyed.

Microbiological analysis

- ***Salmonella*** – these pathogen micro-organisms are readily destroyed by the rendering process but can persist on equipment so post production contamination can occur. Results are reported as detected or not detected per 25 gram or 250 gram sample. It is possible to go to identification of the specific salmonella species present but this is not required for animal feed samples at this stage. Australian standard rather than AOAC methods are more commonly applied in Australia but there should be no difference in the sensitivity or results for the 2 methodologies.
- ***E Coli*** – these micro-organisms are also destroyed through rendering. These results are expressed as cfu/g or colony forming units per gram.
- ***Clostridium perfringens*** – this spore forming micro-organisms is used as a sentinel test for the efficacy of the rendering process in destroying spore forming bacteria. These results are expressed as cfu/g or colony forming units per gram.

It needs to be remembered that there is no "0" result possible in analytical chemistry or microbiology. The report can only show the lowest level of detection for the method. For Clostridium perfringens this maybe 10 cfu/g so unless the sample tests above 10 cfu/g the result will show "<10 cfu/g".

Similarly for a protein result on tallow, the level of detection (LOD) maybe 0.5% for that method for that matrix type, therefore the result will show "<0.5% w/w. This

does not mean there is no protein in the sample, it just means that the method did not permit a result below 0.5% to be reported with any confidence. The Limit of Reporting (LOR) may also me slight different from LOD as it takes account of specific issues with a sample time, not just the instrument or test method limit (LOD).

Sources of error (Measurement uncertainty)

No measurement is without some uncertainty. Consider having two watches on your wrist – they won't tell exactly the same time even if they were set to the same time just a few hours ago. Measurement uncertainty is the doubt that exists about the result of any measurement. Even the best made watch will drift over time so that there is always a margin of doubt. A tape measure maybe 2 metres long "give or take" a centimetre.

Uncertainty is not error. Error is the difference between the true measured value whereas uncertainty is the quantification of the doubt of a measurement result. In analytical testing, we try to correct for any known errors – having instruments externally calibrated, using stone benches under weighing balances, running "standards" as QC checks and by employing a myriad of other control measures. Any error whose value is not known becomes a source of uncertainty. There are a number of known and unknown sources of error in measurement:

- The accuracy of the sampling – this is the greatest source of error for most results. The sample needs to be representative of the whole batch. Clearly trying to establish the level of mould contamination in a 300 tonne load of wheat from a single grain will not produce a realistic result. There are many sources of uncertainty and error in measurements that cannot be controlled so it is critical to minimize as much as possible, the greatest source of error which is the sampling protocol followed. The Food and Agricultural Authority (FAO) have compiled an excellent document outlining the protocols for sampling[3] and this states that:

  "The use of recognized international sampling methods will ensure a standardized administrative and technical approach and will facilitate the interpretation of results of analysis related to lots or consignments of feed.

  For rendered products, the impact of variable particle size, bone versus meat meal, clumping and temperature variations across a load will all compile to prevent a less than representative sample unless rigorous protocols are employed.

- Method used – some methods are applicable to a particular matrix type and less suitable for another.
- Instrument used – instruments can "drift" over time, can lose sensitivity due to age or electrical noise or suffer wear. Such error is usually managed through calibration protocols but cannot always be predicted or quantified.
- Operator skill – there is always an element of human input to any measurement. Eyesight is often challenged by fine measurements. Automation has reduced the incidence of human error but it still exists.
- The environment - temperature, air pressure, humidity and many other conditions can affect the measuring instrument or the item being measured.
- Rounding – most measurements are recorded to 2 or 3 decimal places but the confidence limit for the method/matrix may only allow reporting to a single decimal place which means that each measurement must be rounded.

The mathematics for estimating measurement uncertainty (MU) can be quite complex and includes estimates of confidence limits and the margin or interval of error for each measurement taken. If potential errors in sampling are included, the measurement uncertainty for a single sample for a test maybe in the order of +/- 10%. This has important implications when raw materials such as meat and bone meal are traded on protein content with credits applicable for any deviation from claim. This is unrealistic for a result from a single sample when the testing method has an MU of 10%. In effect, the laboratory would consider the 50% CP MBM to have "passed" if the result was between 45 and 55%. Thankfully, the MU is rarely that large for a relatively homogenous product such as MBM but it is statistically possible.

There are also external sources of error. If samples are sent for the same test to 2 different laboratories, the results will be different. The results will be more different if 2 different methods are used.

Near Infrared Spectroscopy (NIR) is a popular and potentially accurate instrument for measuring some chemistry and even some microbiological parameters. It needs to be remembered that NIR rely on calibration sets across a large range of results for each analyte being examined. The instruments also need to be regularly reviewed and cross checked for drift with samples routinely validated using wet chemistry methods. Clearly an NIR scan is unlikely to give the same result as the comparable test using wet chemistry.

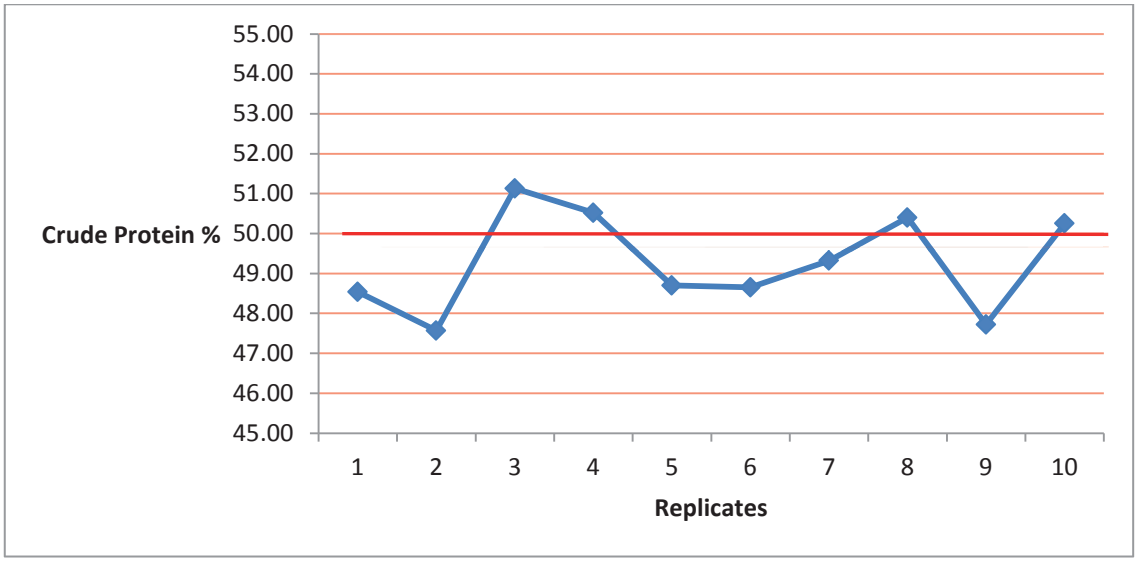
Reducing the source of error

"Measure thrice – cut once"[2] is a well know expression that reminds us to thoroughly measure something before we permanently modify (cut) it. The more measurements you use, the better the estimate you will have of the 'true' value. The

ideal would be to find the mean from an infinite set of values. The more results you use, the closer you get to that ideal estimate of the mean. [2]

The surest way of reducing MU is to take multiple measurements and report the average. Below is an example of repeated protein tests on a 50% CP MBM sample.

Figure 1: 10 replicate protein results on 50% CP MBM



The MU for this test was estimated at +/- 10% so a result between 45 and 55% would constitute a "pass" by the laboratory but certainly not by the renderer. The average of the 10 results was 49.3% but it is clear that there were a larger number of results below the target than above and in the case of replicate # 2, the result of 47.5% would have had dire financial consequences if this was relied on as the sole test result.

As mentioned, the error associated with sampling is usually the greatest source of error contributing to measurement uncertainty. The original sample may not be homogenous or truly representative of the whole batch. Following stated guidelines for sampling[3] is essential in minimizing variability in test results.

Interpreting results

The rendering industry is fortunate in having clear standards and guidelines against which to check analytical results. This prevents the challenge of not knowing whether a certain result is a "pass" or "fail". Whenever testing is completed the QA Manager needs to know ahead of time what action will be taken on the basis of a result above or below the target value. Assuming the same laboratory is using the same method for each sample submitted, variability due to analytical influences should be minimized and the result should be a true reflection of the concentration

of the target analyte in the sample. If the tolerance for results is tight, as is the case in a trade contract on $/unit CP, then an allowance needs to be made for the MU for the method and the number of replicates tested adjusted accordingly. Whether that sample is a true reflection of the whole batch will depend on the robustness of the sampling protocol employed.

Conclusion

Money spent on analytical testing will be wasted if there is not a clear understanding of the expected result and what action will be taken in the event of result falling outside the tolerance limits for that result. The impact of measurement uncertainty needs to be taken into consideration when establishing the tolerance limits for a result. If the tolerance is tight then it maybe necessary to test multiple replicates and report the average rather than relying on a single result.

Error can be minimized by ensuring that a robust sampling protocol is employed, that the same laboratory is used for each batch of samples and that the same methods are applied on each occasion.

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   J. WISEMAN and F. SALVADOR

Effect of processing conditions on product

Ken Bruerton

Dr. Ken Bruerton

Dr Bruerton graduated with honours in Science at Monash University, Australia, in 1970, majoring in Biochemistry. He undertook post-graduate study in Biochemistry at the University of Queensland and graduated in 1977. After post-doctoral research at the University of Adelaide, Dr Bruerton joined the animal feed industry as a nutritionist in 1979. After 9 years working for a national nutritional consultancy group he formed his own consulting company providing technical services to the industry. He has now spent more than 20 years in private consultancy. He has worked extensively in Asia and consults regularly in Australia, the Pacific Islands, Turkey, Russia, Korea and Japan. Dr Bruerton currently services clients in the egg, broiler, pig and cattle industries, providing nutrition advice, development of feeding programs, advice on raw material selection and on livestock management.

The effect of processing conditions on the digestibility of meat and bone meal and tallow

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Introduction

Meat and bone meal and tallow are important sources of digestible amino acids and energy for pigs, poultry and companion animals. The way in which they are manufactured can affect the digestibility of the nutrients they provide. This paper examines the range of conditions under which they are produced and attempts to relate those conditions to the nutritional quality of the end product.

Production conditions for meat and bone meal and tallow

Most of the meat and bone meals and tallows produced in Australia and New Zealand are manufactured by 2 main processes, Dry or Wet rendering at high temperature or low temperature. High Temperature dry rendering is either a batch or continuous process, where the meals are cooked initially at 100-105°C until the water is driven off then further heated to between 125°C and 140°C. Holding times at the higher temperature vary from plant to plant. Wet Rendering can either be a batch or semi-continuous process with higher temperature (90-140°C) or a low temperature continuous process, where the cooking temperature is generally around or below 100°C but where drying temperatures can vary from 105-125°C. The conditions of these are summarized in Table 1.

Table 1. Rendering methods for Australian meat and bone meal (CSIRO, 1997)

Rendering Type	Mode of Operation	Temperature Range (°C)
Dry	Batch	105-130
	Continuous	105-140
Wet	Batch/Semi-Continuous	90-140
	Continuous low temperature	60-95

Almost all plants are different and the range of processing conditions is complex with temperatures ranging from 90-140oC and contain examples of both batch and continuous process. The processes, temperatures and times for some Australian plants are shown in Table 2.

Table 2. Processing conditions for some Australian rendering plants.

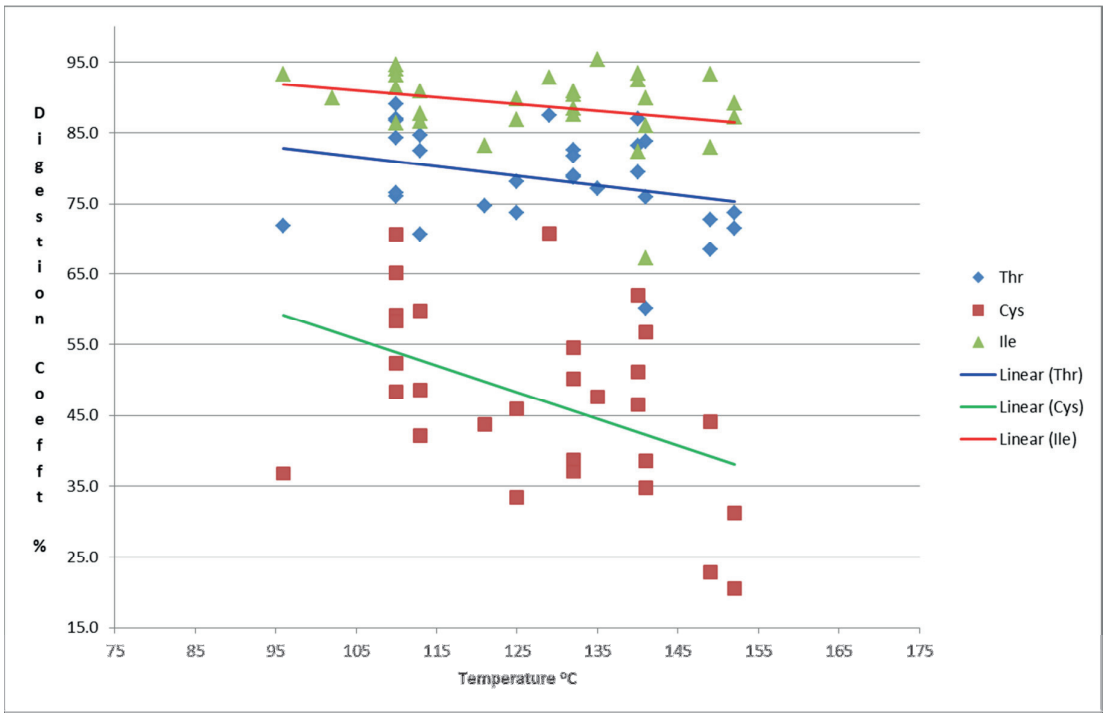
Rendering Conditions	Cooking			Drying		
	Cooking Temp °C	Pressure Bar	Time at Temp Min	Drying temp °C	Drying Time Min	Total time at Temp Min
Batch dry-rendering at atmospheric pressure	125-130	1	30			30
Continuous dry-rendering	125-140	1	30-40			30-40
Continuous wet-rendering	90-100		4	105-125	20	25

The effect of processing conditions on digestibility and bioavailability of amino acids in meat and bone meal

The main economic consequence of variation in processing conditions for end-users of meat and bone meals is the variability of amino acid digestibility and the availability of those amino acids to the animal. There have been numerous reports of differences in amino acid digestibility in meat and bone meals for poultry (Skurray and Cumming, 1974; Wang et al, 1997; Wang and Parsons, 1998; Ravindran et al, 2005) and amino acid availability for pigs, poultry and rats (Batterham et al, 1986). Further, digestibility coefficients for a given meal are different in broiler chicks, turkey poults and laying hens (Aededokun at al, 2012). It has been shown that, generally, higher processing temperatures resulted in lower digestibilities of amino acids (Wang and Parsons, 1998; Parsons, 1999; Karakas et al, 2001).

Wang and Parsons (1998) using the True Digestibility method of Sibbald (1979) in caecectomised roosters reported that increasing processing temperature decreased the digestion coefficients of amino acids in 16 samples of meat and bone meal processed under different conditions. The results for the amino acids cysteine, threonine and isoleucine are shown in Figure 1.

Figure 1. True Digestible Digestion coefficients of Meat and bone meals subjected to different processing conditions.



Clearly, the rate of decline of digestibility is different for each of the amino acid shown, with Cysteine showing the most rapid decline. In this experiment Isoleucine was the least affected although its rate of decline was similar to that of Threonine. Lysine, although not shown, overlapped Threonine and Isoleucine.

Similar results have been shown in pigs using the slope ratio analysis which is a growth response technique (Batterham et al, 1986). The slope ratio assay, by measuring a growth response, is

estimating utilization or availability of the nutrient rather than digestibility. This should be a more sensitive estimate of damage to proteins because a damaged amino acid side chain may be digested by the animal but not utilized for protein synthesis. The disadvantage of the slope ration growth assay is that only one amino acid can be measured at a time and, consequently, it is more expensive and resource intensive (van Barneveld et al 1994) than other analysis techniques.

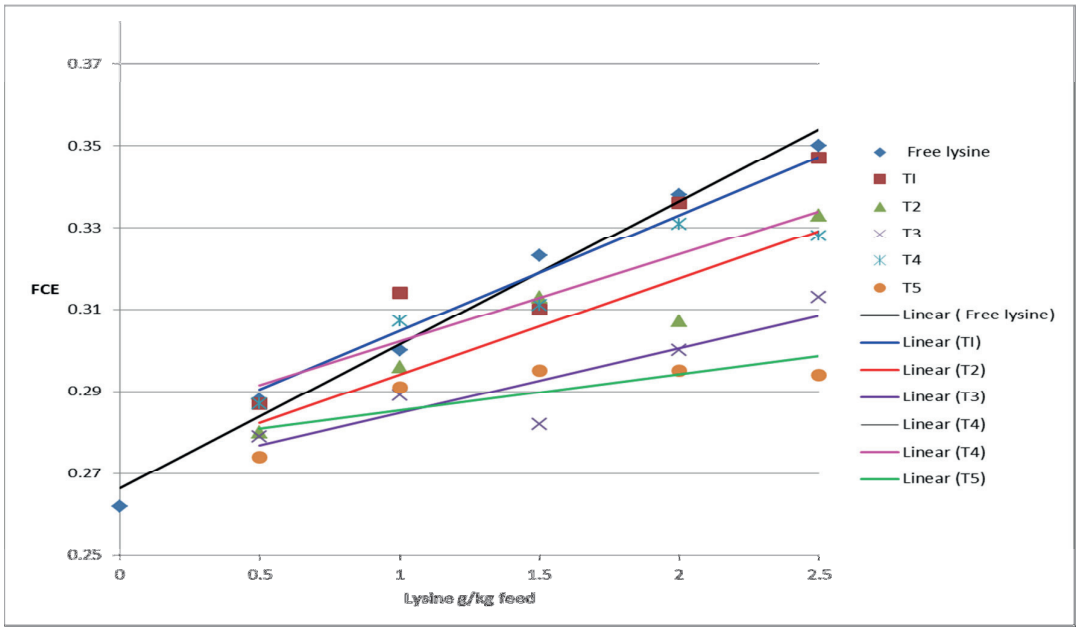
The growth response to the limiting nutrient, in this case lysine, was measured using a lysine deficient basal diet to which was added graded levels of lysine either from L-Lysine HCl or from one of five meat and bone meal samples. The range of concentrations has been selected such that the response is linear. The processing conditions of the five meat and bone meal samples are shown in Table 3. Conditions ranged from low temperature wet rendered meal, through high temperature meal subjected to pressure, to meal subjected to high temperature cooking for an extended period of time.

Table 3. Conditions of treatment of meat and bone meals (Batterham et al 1986).

T1	Control - low temp wet rendered; no further treatment							
Treatment	Early Treatment		Late Treatment					
	Temp °C	Time min	Press Bar	Temp °C	Time min	Press Bar	Temp °C	Time min
T2	100	10	2.75	141	30	1	125	120
T3	100	120	2.75	141	30	1	125	30
T4	125		1	125	240			
T5	125		1	150	240			

The parameter measured was carcass feed conversion efficiency, which is the kg of carcass gain per kg of feed consumed. The data in Figure 2 represent a rearrangement of the results of Batterham et al, (1986) showing them in graphic form rather than tabular. This more clearly shows the linearity of the response and the separation between treatments, demonstrating the effect of more severe rendering conditions.

Figure 2. FCE response in pigs fed meat and bone meals after heat and/or pressure treatment.

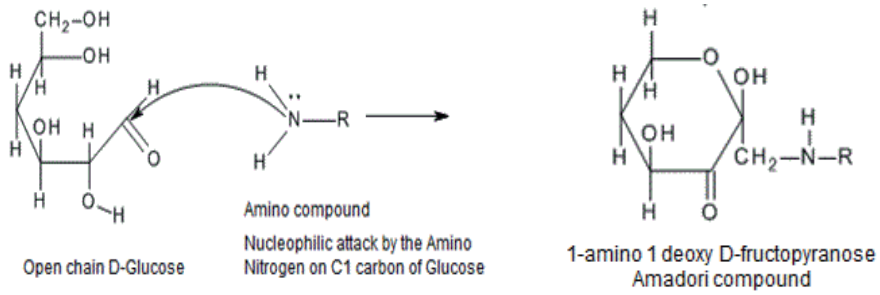


Treatments T3, meal subjected to pressure as well as high temperature and T5, meal rendered at high temperature for an extended time, showed the lowest lysine availability. Although it may be argued that conditions represented by T5 are not seen in commercial rendering it serves to illustrate the principle that a higher level of heat degrades lysine availability. Further, T3 illustrates that meals rendered under pressure will have lower lysine availability than meals rendered at atmospheric pressure. Even T1, the low temperature wet rendered meal, showed a small reduction in lysine availability compared to lysine HCl (free Lysine).

The chemistry of heat damage to protein meals

Whenever proteins are heated the potential to damage the original protein structure exists. However, what reactions are taking place and how they affect digestion and utilization are unclear (van Barneveld et al, 1994). Some of these changes, such as denaturation - the unfolding of proteins from their natural state - occur at low temperatures and may be beneficial to digestion because digestive protease enzymes have easier access to the protein chains. However, at higher temperatures chemical reactions between amino acid side chains can cause largely irreversible cross linking of protein chains. Further, reactions between amino acid side chains and free sugars in the medium can result in indigestible amino glycosyl compounds. These latter reactions, known as Maillard reactions, are a characteristic of high temperature treatments of meat such as cooking and rendering (Erbersdobler, 1977). The general form of these reactions is shown in Figure 3. The ε-amino group of lysine reacts with a reducing sugar to produce, through a complex set of chemical rearrangements, a so called Amadori compound). It has been demonstrated that up to 46% of lysine became unavailable in foods subjected to heating (Erbersdobler, 1991).

Figure 3. Basic Maillard reaction after Wikipedia (https://en.wikipedia.org/wiki/Maillard_reaction)



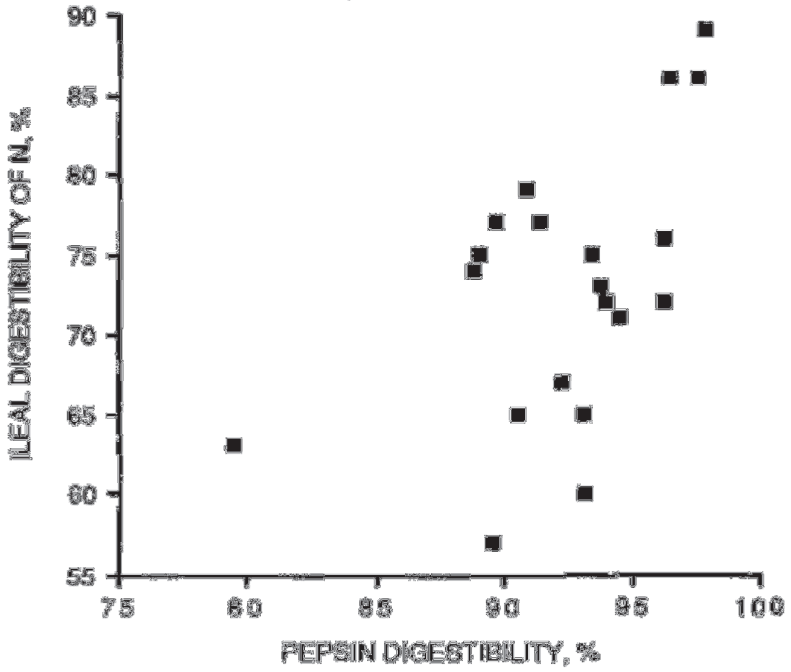
Is Pepsin Digestibility a good indication of protein and amino acid digestibility?

Incubating animal protein samples with the mammalian digestive enzyme pepsin has been used for many years as a guide to protein digestibility. The traditional method used was originally developed by the Association of Official Analytical Chemists (AOAC) in the US in the early70's and the current version of the test is AOAC 971.09-1973(1999). The analysis involves digesting the sample in a solution of porcine pepsin at 37°C for 16 hr at low pH. N% is determined on the original sample and the insoluble residue and the N% digested calculated by difference.

Pepsin digestibility has been compared to biological digestibility of protein in pigs and poultry.

Knabe et al (1989) showed that in growing pigs there was no significant correlation between Ileal digestible N and Pepsin digestibility of meat and bone meal samples (Figure 4).

Figure 4. (from Knabe et al 1989). Comparison of Pepsin digestibility and Ileal digestible N of meat and bone meal.



Hendricks et al (2002) examined 94 samples of meat and bone meal from New Zealand and found no correlation between pepsin digestibility and digestible amino acid nitrogen. In poultry, Parsons and co-workers (Parsons et al, 1997; Kim et al, 2015) investigated the effect of decreasing the concentration of enzyme by factors of 10 and 100. They found that at lower levels of pepsin the spread of amino acid digestibilities was wider when comparing meat and bone meals processed under different conditions. It was also apparent (Parsons et al, 1997) that the rank order of pepsin digestibility of meals was not preserved when lower concentrations of enzyme were used in the digestion. Further, digesting meals with 0.002% pepsin, although it gave an even wider spread of results, produced protein digestibilities lower than biological determinations.

The work was repeated recently (Davis et al, 2015) to investigate whether the tendency toward lower processing temperatures had improved pepsin digestibilities. These authors concluded that pepsin digestibility, even at lower concentrations of pepsin, was only useful in detecting large differences in digestibility of meat and bone meal samples.

Is there a way forward in assessing amino acid digestibility?

Near Infra-red reflectance spectroscopy (NIR) is now commonly used to measure several parameters used in characterizing feed ingredients such as crude protein, moisture and fat. Calibrations are available from instrument suppliers or may be developed from first principles using wet chemistry to

provide a calibration curve. Once robust calibration curves have been established sample analysis is rapid and convenient.

The technique has been improved and there are now calibrations available for predicting total amino acid contents of ingredients (Fontaine et al, 2001; Kovalenko et at, 2006) and in some cases digestible amino acids (Fiene et al, 2006).

Nutrition companies with large data banks of data on biological measurements of total and digestible amino acids can now use those data to develop calibrations for total and digestible amino acids for feed ingredients. One such example is shown in Table 4.

Table 4. Amino acid digestibility for 3 samples of beef meat and bone meal from a single meat works.

	Queensland			
Sample ID	MBM 1	MBM 2	MBM 3	Mean
Lysine Digestibility	81.24	83.85	85.10	83.40
Methionine Digestibility	85.21	87.26	87.66	86.71
Cystine Digestibility	59.75	64.02	68.14	63.97
Met+Cys	75.54	78.55	80.94	78.34
Threonine Digestibility	77.48	79.70	80.34	79.17
Tryptophan Digestibility	76.17	78.08	79.21	77.82
Valine Digestibility	84.41	85.17	85.37	84.98
Isoleucine Digestibility	86.13	87.47	88.13	87.24
Leucine Digestibility	85.57	86.62	86.60	86.27
Phenylalanine Digestibility	86.65	87.31	87.09	87.02
Histidine Digestibility	81.88	83.81	84.99	83.56
Arginine Digestibility	88.79	89.24	89.46	89.16

The results in Table 4 were taken from a NIR prediction performed by Adisseo (www.adisseo.com) from samples supplied by an end user. The samples were from separate deliveries but from a single meat works. These data allow nutritionists to characterize samples from a supplier and build up a robust specification for formulation of diets. The rank order of individual amino acid digestibility is preserved across the 3 samples. Digestibilities for MBM3>MBM2>MBM1. This method also offers nutritionists a tool for the economic evaluation of meat and bone meals.

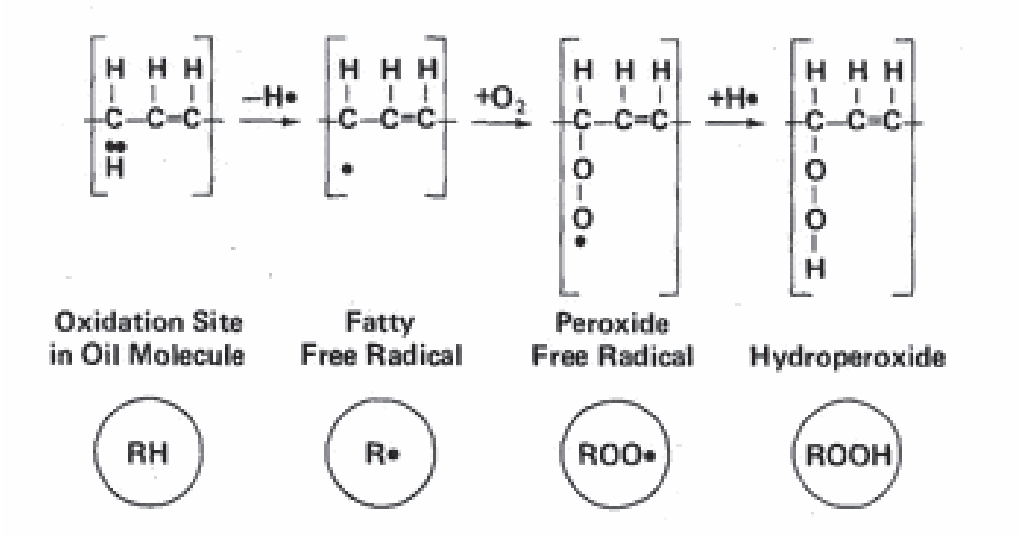
The effect of processing conditions on tallow

There are two main quality criteria of tallow that are important in animal nutrition. They are the level of free fatty acids and the oxidation status. Free fatty acids (FFA) result from the enzymic or bacterial hydrolysis of triglycerides. This can occur when material, prior to render, comes in contact with digestive lipases from gut contents. During the rendering process temperatures above 65^{o}C cause denaturation and inactivation of these enzymes such that FFA levels are an indication of the freshness of the material rendered. For the purposes of stockfeed production, although there may be exceptions, tallow containing up to 20% FFA is considered acceptable by most poultry and pig nutritionists. However, the higher the level of FFA the more susceptible the fat is to oxidation at elevated temperatures and the formation of peroxides.

Oxidation in fats begins with the departure of a proton from a fatty acid forming a free radical (Sherwin, 1978). This then combines with atmospheric oxygen to form an unstable peroxide free radical, a very reactive compound which can result in further free radical formation and, ultimately

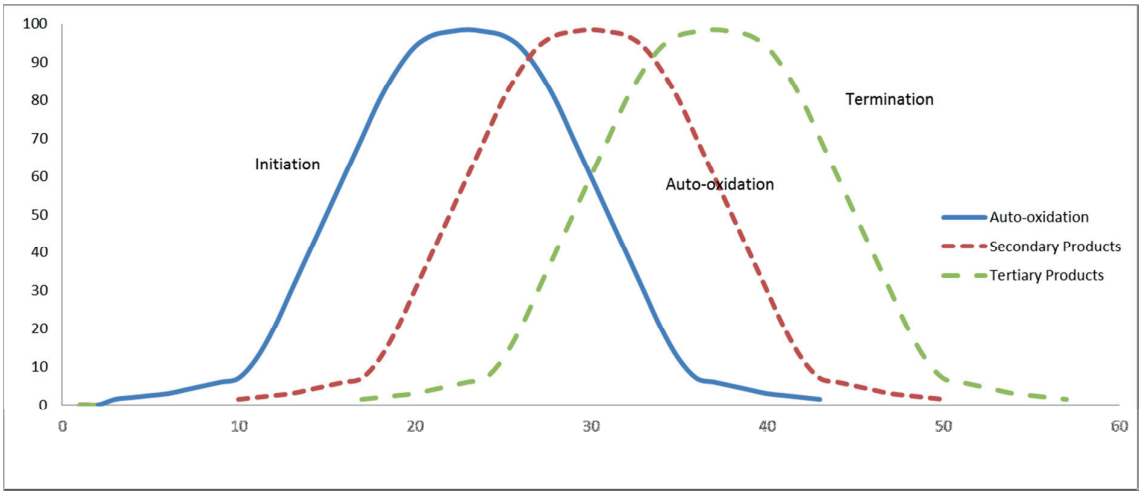
in the formation of a hydro peroxide (Figure 5). In growing animals they can result in reduced growth and increased susceptibility to disease.

Figure 5. Hydroperoxide formation in fats (from Sherwin, 1978)



The process of oxidative rancidity of fats passes through three stages (Figure 6). In the first stage (Initiation) there is a production of peroxides that can break down into free radicals which, in the second stage (Auto-oxidation) react with free fatty acids and other fats in a cascade effect to produce further reactive compounds. During the final stage (Termination) compounds such as hydrocarbons, aldehydes and ketones are produced and these impart the characteristic odour of rancid fats.

Figure 6. Process of oxidation in fats (Kirstein, 2007).



The industry method of determining the oxidation level of fats is the Peroxide Value where reactive species are expressed as milliequivalents per kg (meq/kg). There is some debate about how relevant this measure is to the actual oxidative state of a sample because if oxidation has proceeded to the tertiary stage the fat will be rancid but may have a lower PV value at a point earlier in the cycle.

Kirstein (2007) suggests that the olfactory detection level for tertiary compounds in rancid animal fats is 20-40 meq/kg and that tallow with a PV between 5-20% is commonly accepted in the US as being suitable for feed use. The provenance of that value, according to Kirstein, is doubtful. Further, Sharma et al (2013) suggest that fat with a PV value between15-20 meq/kg is rancid. It would be safer, therefore, to apply a maximum of <15 meq/kg as being suitable for feeding broiler chicks and piglets where the risk of oxidative damage is highest.

Conclusions

Heat treatment reduces bioavailability of amino acids in meat and bone meals. The more severe the conditions of rendering, the higher the loss of amino acid availability.

Reduced digestibility has been demonstrated in poultry and pigs by measuring disappearance of amino acids from the gut in the former and by measuring the growth responses in the latter. However, the biological methods of measuring digestible or available amino acids in protein meals are expensive and time consuming. Given the variability of meals from plant to plant and even from the same plant these methods are only applicable to feed formulation in a broader sense.

Although useful in detecting large differences in digestibility, the pepsin digestibility assay was not a good predictor of amino acid digestibility in meat and bone meal.

NIR prediction of amino acid digestibility now appears reliable enough to use as a formulation tool and for economic evaluation of competing meals.

Although difficult to quantify, it is likely that tallows produced at lower temperatures will be subject to less oxidative damage and be more suitable for use in animal feeds.

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R&D is Innovation in Action

Shane Leath

Shane Leith

Shane is a chemical engineer with more years under his belt than he cares to remember. Shane brings experience from several processing industries including: cryogenics with BOC Gases; Oil with Caltex and a subsidiary of Downers; and meat processing and rendering. For the past 14 years he has worked for AgResearch Ltd (a NZ government owned research institute) as a Senior Research Engineer. His research topics include non-invasive measurements and modelling, which have been applied more recently to modelling and validating rendering processes. He is a member of the Science Advisory Panel for the World Rendering Organisation.

Innovation is where no idea is a dumb idea

Shane Leath

Senior Research Engineer

AgResearch Ltd

Member: WRO-Science Advisory Panel

Innovation is often thought of as a step change in technology or product. However innovation may also occur due to incremental changes in business practice and personnel behaviour, and may be sourced internally or externally. Highly innovative companies encourage and celebrate ideas. (Suggested read: http://www.chicagobooth.edu/capideas/magazine/fall-2014/four-ways-companies-can-encourage-innovation).

The challenge for management is to encourage and harness the power of innovation as an enabler to improve business performance. Whilst innovative ideas may not be practical to implement right now or cost effective right now or fit within the current business, over the long term a lack of investment in, and/or a lack of encouragement of, innovation may lead to a loss of competitiveness through higher costs, less flexibility or a lack of product range.

Innovation within the Rendering Industry could target: product attributes such as nutrition and palatability; increasing the value of products or reducing their cost of production; or investigating emerging processes and products. Sources of innovation to consider include your business relationships, and accessing or developing learning cultures.

Innovative relationships

Innovative relationships are built over time and develop where trust and a mutual willingness to explore opportunities has been demonstrated.

Clients may prompt innovation by their stated desire for product consistency, certainty of supply, new products or novel product characteristics, or solutions to their problems.

> Are you collecting and assessing feedback from your clients?
>
> Which or your client's issues could your company help them solve?

Suppliers can only succeed by supplying solutions to your needs and their competitiveness leads them to offer innovative products, processes and systems. For example, where would the industry be if suppliers had not developed alternatives to the vats of 2000 years ago, leading to batch pressure cookers and more recently continuous processing systems? Technologies such as presses, decanters, evaporators and heat recovery systems were not invented solely for the rendering industry, yet the industry has quickly adopted these innovations when they were offered by suppliers.

> Are your suppliers looking for innovative solutions to your problems?
>
> Which of your suppliers do you trust enough to discuss the opportunities and strategies of your business?

Value Networks (rather than [linear] value chains) generally offer premiums for differentiated products for (in order of decreasing margins) performance, reliability, convenience and finally lowest price for commodities ("The Innovator's Dilemma", C.M.

Christensen, 2000). Understanding their value network allows innovative companies to consider whether to, or not to:

- Move up, or down, the value network slightly (but watch out for push back from existing parties/clients), or
- Leverage existing skills across the network into a slightly move valuable market, or
- Leave the value chain for a more sustainable value network

How can you better leverage the value chain that you operate in?

Other Industries are potential sources of inexpensive innovation, with rendering examples being decanters and presses that have reduced costs and/or enabled higher recovery rates.

Your **Peers** are probably facing many of the same issues as you. In areas where the companies are not competing or issues are common (e.g. resource consents, odour, waste, raw materials) the costs and rewards of innovation can be shared. Peers may also include personnel with similar responsibilities in other industries, whether these industries are similar to yours or not.

Learning Cultures

Operators and Staff (in companies encouraging innovation) are a "free" source of ideas and suggestions. Staff can initiate discussions with innovative outcomes by asking, and answering, questions such as:

- This bit of equipment is always giving us a problem.... how do we fix it once and for all time?
- Is there a better/safer/faster way of doing this?
- What would happen if....?

What systems does your organisation have to encourage ideas to be voiced?

How are you capturing and evaluating these potential innovations?

Don't underestimate the power and value of a "donut" (incentive).

Research Institutes are looking at the products and processes of the future; with Low Temperature Rendering and biofuels being two prior exemplars for the rendering industry. Rendering companies and rendering supply companies <u>are</u> currently working with research organisations on new products and processes driven by requests for innovation from the rendering industry.

If your company is not involved in these projects, then which of your competitors is?

Summary

Innovation is a competitive advantage both at a company and industry level. Companies that harness innovation from internal and external sources are likely to enjoy a stronger position in their value network. Therefore encouragement of "dumb" ideas represents a high value investment in the future of each company and the rendering industry.

Manufacturers of rendering plant equipment – the latest in design & improvements

Sverre Golten

- Born in the USA by Norwegian parents 9 June 1949
- Grew up in Oslo, Norway
- Resident in Thailand since 1983
- Married to his Thai wife since 1988
- 5 children aged 25, 24,17, 14 and 6 years
- Norwegian Navy submarine diver and instructor for 2.5 years
- Studied mechanical engineering at ETH Zürich 1971-77
- Worked in the family business, Goltens, in Oslo and Singapore 1977-83
- Was asked to start Stord Bartz (later Atlas Stord) Thailand in 1983 to sell fishmeal plants in Southeast Asia
- Started manufacturing of fishmeal plants in Thailand in 1986
- Took over the company in 1998 and renamed it A & S Thai Works (ASTW)
- Made ASTW grow from 30 employees in 1998 to 210 in 2015

ARA Symposium

21-23 July 2015

Presentation by Mr. Sverre Golten
CEO and owner, A & S Thai Works

ASTW

A & S Thai Works (ASTW)

- Has been established in Thailand since 33 years
- Makes fishmeal and rendering equipment, plants and machinery.
- Employs about 210 people.
- Has the benefit of having R&D, marketing, design, production, installation and service all under one roof. Everybody cooperates and knows what is going on.

Workshops and offices

ASTW 1

- Total Area: 4,800 sq.m.
- Building Area: 2,700 sq.m.

ASTW 2

- Total Area: 8,000 sq.m.
- Building Area: 5,700 sq.m.

ASTW

We have installed about 260 fishmeal and rendering plants since 1986, 24 of them rendering plants in Australia and New Zealand since year 2000, including high temp and low temp plants as well as blood drying plants.

ASTW

ASTW was established as Stord Bartz Thailand, later Atlas Stord Thailand, until 1998 when Sverre Golten acquired the company that he had been leading from the outset, and renamed it A & S Thai Works. We inherited all the original technology from Stord Norway and have spent a considerable amount of time and resources developing and improving this technology further.

But…
Where we should be today…

… is not here but at your rendering plants, on the machine floor, checking out your equipment, making layouts and proposing how to improve your operation.

Our Niche

Every company should have its specialty, a niche – to be able to offer something which is better than the competition, or something that nobody else offers.
ASTW has such a niche.

Installation

When we started selling the first fishmeal plants in the late eighties, we quickly discovered that a supplier has to include installation of the complete plants for any customer in any country.

ASTW

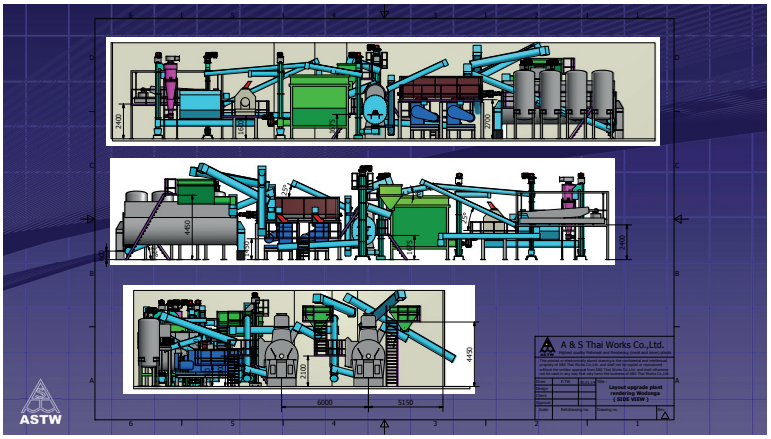
Finding skilled labour locally with the knowledge to install a complex rendering plant is next to impossible. The components for the biggest plants arrive in 22 x 40 foot containers. Our people know every nut and bolt that come in those containers, enabling a crew of 10-16 technicians to do the installation within 2-3 months.
Therefore, ASTW always includes installation in the quotations for plants and equipment.

ASTW

Over time, we have refined this way of working, and so far, we have installed 260 plants and machinery in Asia, whereof 24 in Australia and New Zealand, all at a fixed price.

Our installation section currently employs 42 experienced technicians who install plants all over the world. We have installed more than 30 plants in some of the most dangerous places on earth like Yemen and Pakistan.

ASTW



The most difficult places to install new rendering plants are in Australia and New Zealand, as the existing plants can never be stopped during installation, except sometimes on Sundays and maybe on Saturdays… if we are lucky.
A good example of this is Wodonga Rendering, where we recently completed the installation and commissioning of a 22 ton/hr. high temp plant.

ASTW

Bypass screw conveyors at Wodonga Rendering.
The plant never had to stop 6 d/w during installation

ASTW

At Wodonga, we had up to 16 technicians, electricians, a draftsman and programmers spending 6 months to install and commission the new rendering plant, located within the same limited area where the old, worn out plant was operating simultaneously 6 days per week. The customer didn't lose a day of operation, and all safety regulations were followed.

ASTW

PLC/Scada programmers, present all the time during Installation, plus a draftsman and an electrician.

ASTW

"This is impossible to do!"

- is what people said before and during installation and even after the completion.

Yes, it was fiercely difficult but we did it, because this is our niche and what we do!

ASTW

Several plants in Australia are nearly worn out and in dire need of replacement. Others need expansion of capacity. In both cases, keeping the plant running while the new one is being installed is of vital importance. Although it may seem difficult or even impossible to do the necessary upgrades without production stop, we do it.

ASTW

Our standard plants

LTR = Low Temperature Rendering
Sizes: 5, 7, 10 or 15 t/hr input

HTR = High Temperature Rendering
Sizes: 5, 7, 10 or 15 t/hr input

Blood drying plants, normal or vacuum
Sizes: 1.5, 3, 5 or 8 t/hr input raw blood

This is how we work 1

- We visit your plant with our draftsmen measuring and drawing the whole plant “as is” and “as can be” in 3-5 days while at site. Few customers have proper layout drawings covering the existing plant and buildings.
- Within 1-2 weeks, our office staff quote the whole plant including installation and commissioning, and include a list of all expected and unexpected costs that we believe will occur, or may occur, – so no surprises.

ASTW

This is how we work 2

- Upon order we send a larger team of draftsmen and installation staff to fine-tune the design and plan in detail how the new plant can be installed while the old plant is operating. We often prepare and install temporary by-pass lines, even running outside the processing building.
- Installation can take 3-6 months with a team of 10-16 technicians depending on the size of the plant and the area available in the old building.

ASTW

This is how we work 3

- During installation the following people from ASTW will be on site at all times: the installation team, a draftsman, an electrician and one or two PLC/Scada programmers.
- All possible efforts are made to coordinate the work with the local companies and craftsmen who perform the electric and civil work as well as other jobs. From our experience, the local crews have rarely outpaced our technicians. The opposite has often been the case.

ASTW

It's a demanding job

Last but not least: it takes great flexibility, patience and stamina to complete such installation jobs. A project period is hard work involving great changes for all involved. For those who have been operating the old plant in the same way for many years, the installation period often comes as a dramatic change.

ASTW

The smell of money

Early on, we learned to process the most difficult material in our industry; trawled fish mixed with sand and shell that has been in the fishing boat hold in tropical waters for 2 weeks without refrigeration. It looks like grey mud and stinks to high heaven. Later we learned the rendering materials. The lessons learned from treating materials like this has greatly benefited the development of our rendering machines, especially the cookers and driers.

ASTW

Offer good machinery!

Making a good installation is not enough to satisfy our rendering customers. We have to offer state of the art machinery as well.
We have an obsession at ASTW:
To make the strongest and most efficient machinery without compromise, with the lowest energy consumption, most wear resistant, best material flow and longest life time in the market.

ASTW

Rotor discs with gusset stay bars

ASTW

We have spent years to improve and develop the disc driers and cookers. We have succeeded, and know that we have reached a deeper understanding about the functionality of the disc machines. – And we can explain why.

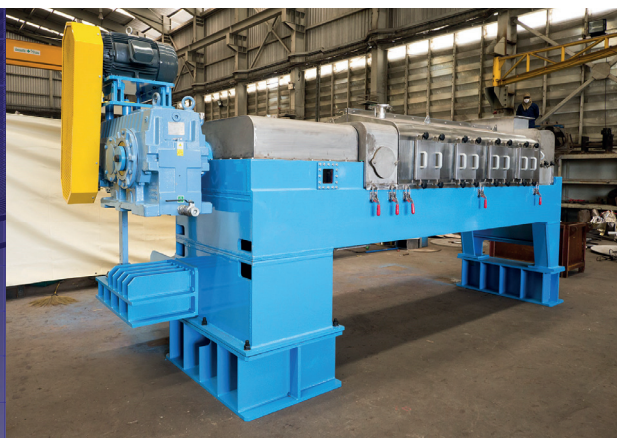
ASTW

Drier stator with bulb jacket

ASTW disc cookers/driers features:

- Gusset stay bars, stiffer design and no more stay bolt leaks
- More distance between the discs for better material flow and less wear
- Steam jackets
- Better internal “breathing” system, steam goes faster in and condensate faster out
- Lower rotor speed for less wear without loss of capacity and less fines for high temp cooker application
- And many other improvements…

ASTW Twin Screw Press



The strongest twin screw presses

- The “Stord” type twin screw presses were originally designed for light duty fishmeal production and are not always strong enough for the heavy-duty rendering applications.
  The frames of our ASTW presses for low-temp plants are made from 40 mm steel plate and have over-dimensioned roller bearings in oil bath and forged shafts.
- The gearbox is not home-made but a high-tech shaft mounted SEW gearbox. The result is less friction and up to 30% less electric load compared to older designs. The screws are solid stainless steel and the stainless steel bridges are positioned closer together for higher strength. Screens are 12 mm thick.

ASTW

Pre-heater
with bulb jacket

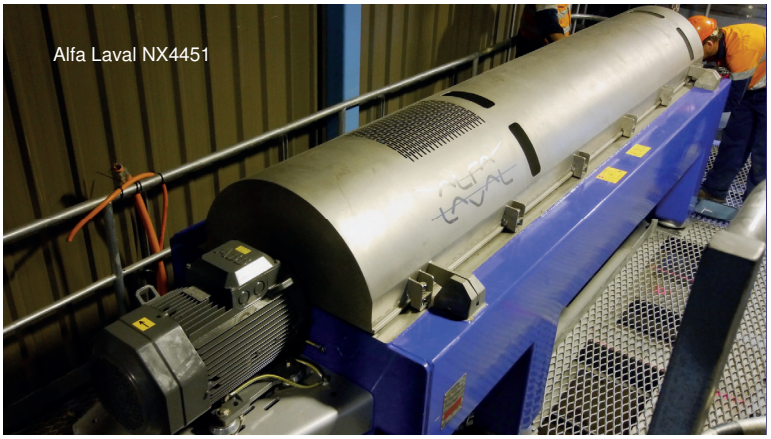
ASTW

About steam jackets

We include steam jackets on all our disc machines; pre-heaters, driers and cookers. We have in certain cases measured that more than 30% of evaporation takes place in a disc drier steam jacket, which has only 15% of the heating surface. That is more than double the evaporation rate than from the discs. – Try to turn off a steam jacket during operation and observe how much the capacity drops.
Steam jackets gives superior and cheap heating surface!

… and that is a fact!

ASTW



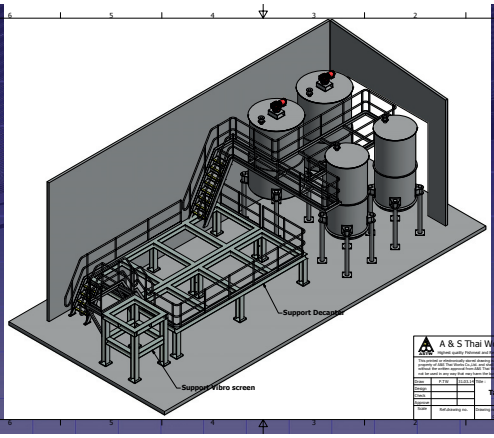
Decanters, separators and WHE

We are working closely with Alfa Laval on solutions and installation of:

- Decanters, Separators
- WHE, Waste Heat Evaporators

ASTW

Tallow system for Alfa Laval NX 4451 decanter

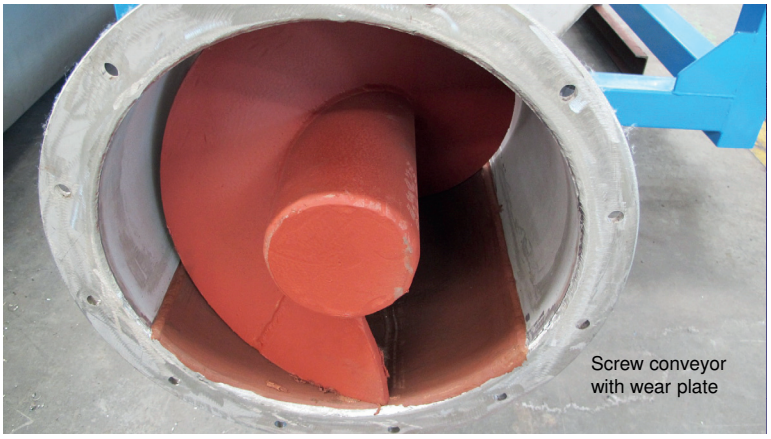


ASTW

The humble screw conveyor

At ASTW, we feel that we have succeeded in making the ultimate screw conveyors for rendering applications, both wet and dry side and for raw material transport from abattoir to rendering plant. We are making very stiff 4.5 and 6 mm stainless troughs with a fully welded wear-plate made from hardened steel that works like a plain bearing and reduces wear on both the trough and the screw. Screw flights are mostly 12 mm boiler carbon steel plate.

ASTW

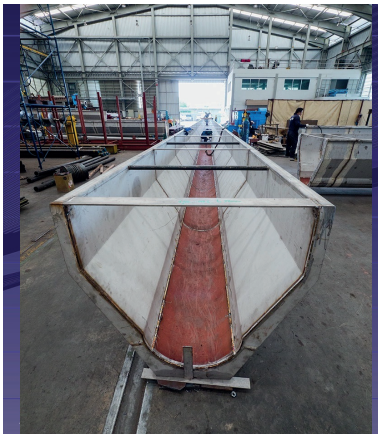


Screw conveyor with wear plate

150 meters of screw conveyors - - -

An Example:
Earlier this year, ASTW installed 150 meters of 500 mm key hole screw conveyors for un-hogged bovine raw material from abattoir to rendering plant bin.
Included built in CIP nozzles for automatic daily cleaning. We expect very little wear and this is almost an install and forget installation.

ASTW



Vertical screw conveyors

We are making our fourth generation of vertical screw conveyors and use up to 7 units for one plant for press cake and M&B meal. The troughs are octagon shaped, with the eight sided troughs preventing rotation. Capacity up to 40 t/hr with 30 kW motor.

Vertical screw conveyors in combination with meal bins, 2 x 200 cum, another product from ASTW.

ASTW

Container and truck loader

After seeing a number of meal loading systems, prototypes and in production, we found that all of them were really prototypes and compromises. So, we developed our own: Telescopic, automated with a capacity of 20 tons loading meal into a 20 foot container in 30 minutes.

Automatic or semi automatic operation.
We feel we have succeeded in engineering a professional design without compromises.

ASTW

Installation of rendering plants, an irony – and a request

We often travel to Australian rendering plants upcountry, and for hours, we see nothing but open fields. Upon arrival we more often than not have to install a new rendering plant in an old, cramped building that should have been double the size for the plant of its capacity.

ASTW

… more irony

The customer, who owns 200 or 2000 acres of land, says he cannot get the approval for even a small building extension, or the approval takes 2 years or is too cumbersome and just too hard.

So the new plant is hard to install and even harder to maintain, safety is an issue during installation and maintenance as all machines are clustered tightly together, and working conditions and health risks are often abysmal.

ASTW

… while

In Asia, where many countries are underdeveloped and densely populated, almost all plants and machinery are installed in large buildings with an abundance of space.

Something could be done about this.

ASTW

We always observe - - -

Exported Australian meat promotes Australia's good name, and no gourmet restaurant in Asia with any self-respect would ever omit to include Australian beef or lamb in the menu as its most exclusive and most expensive dishes.

This could not happen without the rendering plants!

Thank you for your attention.

ASTW

Derek Henderson

General Manager – Keith Engineering (Australia) Pty Ltd

- Derek was born and raised in the industrial town of Motherwell, in the west of Scotland
- He is product of the Scottish public schooling and tertiary education system
- Derek started his engineering career in the discipline of Structural Engineering in 1978
- He immigrated to South Africa in 1981, defecting from a career in Structural Engineering to train as a Mechanical Engineer, later specialising in material handling, which by 1987 had led to the meat processing industry.
- In 1990 Derek jointly floated Abattoir Plant & Equipment in Johannesburg - a company specialising in the design, manufacture and supply of equipment to the abattoir and related industries
- The rapidly changing dynamics of that region as well as the meat industry at this time saw the new business focus strongly on rendering.
- By 1994 Abattoir Plant & Equipment had formed a business relationship with Keith Engineering, acting as their soul Southern African distributors, promoting and supporting the Keith Continuous Rendering Process throughout Southern Africa
- Opportunity encouraged Derek to relocate to Australia in 2002 when he joined the employment of Keith Engineering Australia, taking on the role of General Manager in 2011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2
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3
Our new fabrication shop, with 50 Tonne lifting capacity.
DEMAG
DEMAG

KEITH ENGINEERING

4

Our new machine shop, with the latest CNC machining capability.

KEITH ENGINEERING

5

Our new store, stocked with a full compliment of spare parts, including rental and exchange equipment to back up and support our valued customers.

KEITH ENGINEERING

6

Our new dispatch and yard area.

KEITH ENGINEERING

7

Our new office complex offering a functional and welcoming working environment to our loyal and long serving staff.

KEITH ENGINEERING

8

We pride ourselves in being one of the few Australian manufacturers having the confidence to invest into the future of Australian manufacturing.

KEITH ENGINEERING

9

KEITH ENGINEERING

- Keith Engineering are very proactive in plant, process and machinery design.
- We have been building rendering plants in Australia since the 1950's and there are many of these old plants still running today, in fact no doubt the only Keith plants some of you here may have seen.
- Our ever evolving process, equipment design and automation sees a new Keith rendering plant, looking and operating somewhat differently today.

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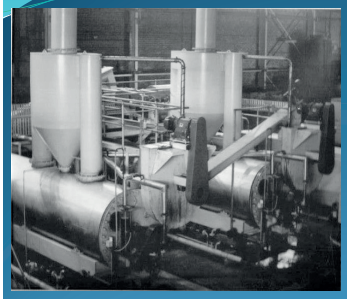
10



Some amongst you may be be thinking “it’s not that different! The new plant still has a PreBreaker, a Cooker, a Press and a Hammer Mill.”

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And so, the motor car still has four wheels, an internal combustion engine and a steering wheel! Does that make it the same? Or simply tell us that the basic design has stood the test of time. Sometimes we need to look deeper than what we see on the surface.

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WHATS NEW?

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13

'MANLESS' METAL DETECTION

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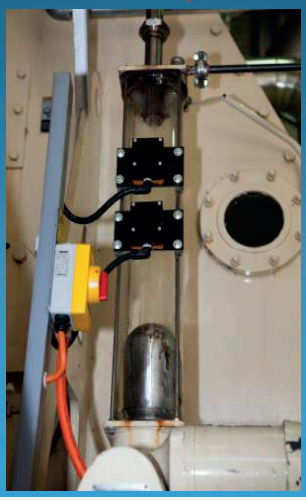
14

EFFECTIVE LEVEL CONTROLS ON COOKERS, THOSE THAT SEE PAST FOAMING



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FOAMING PREVENTION IN COOKERS


KEITH
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16
LIVE BOTTOM RAW MATERIAL BINS


KEITH
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17
BOTTOM DISCHARGE COOKERS
HOT


KEITH
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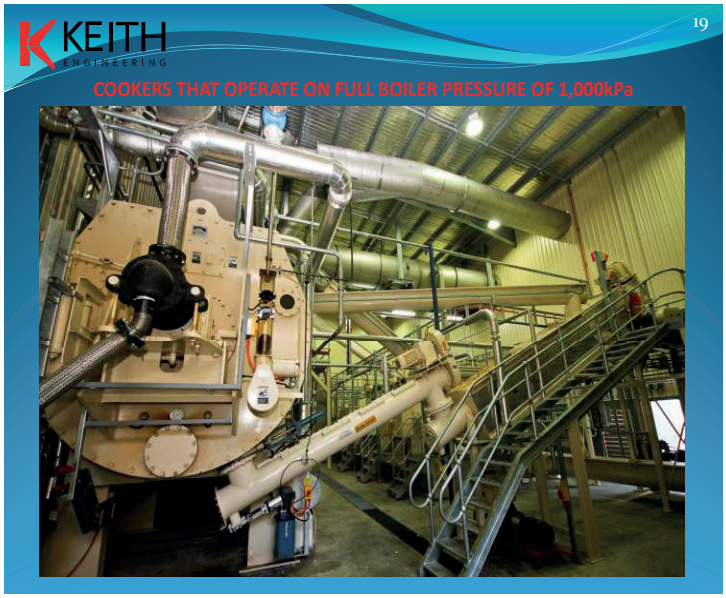
18
INCLINE CRAX DRAINERS


KEITH
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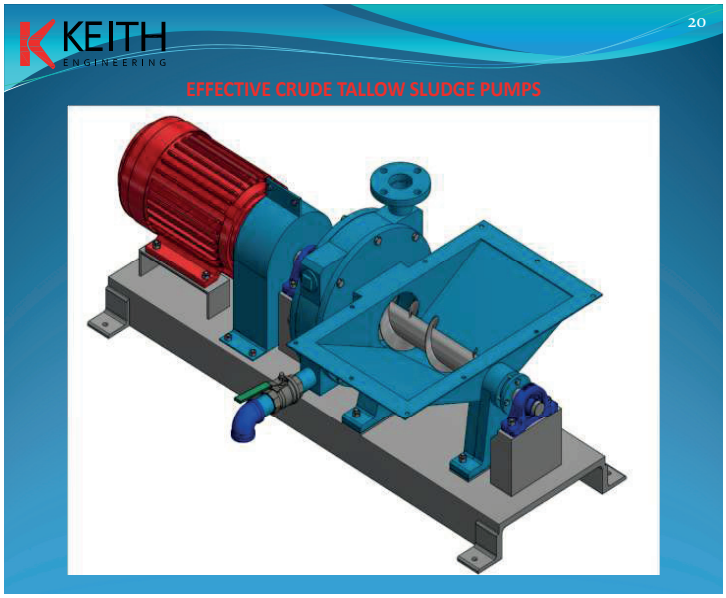
19
COOKERS THAT OPERATE ON FULL BOILER PRESSURE OF 1,000kPa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20
EFFECTIVE CRUDE TALLOW SLUDGE PUMPS


KEITH
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21
AUTOMATED FINES REMOVAL FROM PRESSES


KEITH
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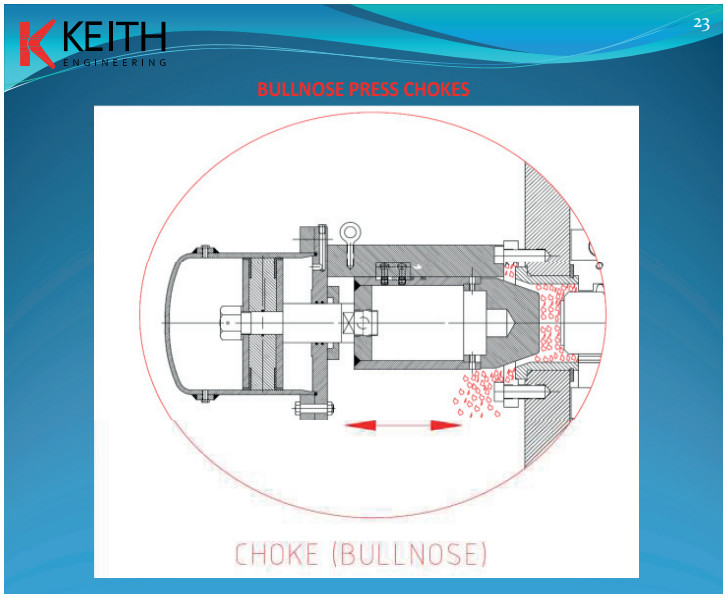
22
AUTOMATED FINES RETURN SYSTEMS


KEITH
ENGINEERING
23
BULLNOSE PRESS CHOKES
CHOKE (BULLNOSE)


KEITH
ENGINEERING
24
10" SCREW PRESS
1066, 1037, 1038 & 1210 DUKE PRESS ALL FULLY BACKED UP OUT OF OUR STORES


KEITH
ENGINEERING
25
FULLY ENCLOSED AND GATED PRESS DISCHARGE HOODS


KEITH
ENGINEERING
26
PRE DECANTER FINES SCREENING


KEITH
ENGINEERING
27
PRE SEPARATOR TALLOW CONDITIONING

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28

FULLY AUTOMATED NON CHEMICAL WOOL HYDROLYSATION

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29

EFFECTIVE PLANT AND EQUIPMENT VENTILATION

KEITH ENGINEERING

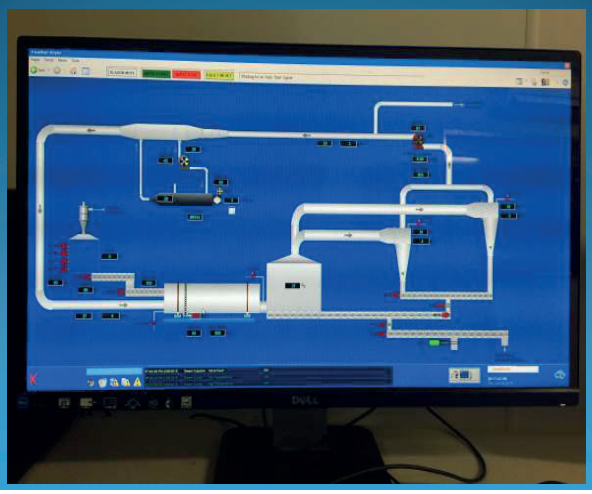
30

DIRECT AND INDIVIDUAL DRIVES FITTED TO ALL EQUIPMENT

KEITH ENGINEERING

31

AUTOMATION AND REDUCED OPERATOR INPUT



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32

CCTV MONITORING OF DIFFICULT TO ACCESS AREAS

KEITH ENGINEERING

33

PLANT OPERATION DATA RECORDING AND ACCESS TO OPERATION HISTORY

"SCADA" OR SUPERVISORY CONTROL AND DATA ACQUISITION

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34

CONTROL DEVICES

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35

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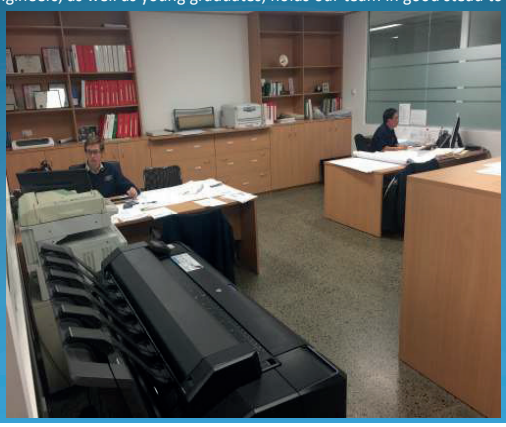
The innovation and development of new process and equipment technology holds high place within Keith Engineering having a mix of old heads, experienced process specialists and engineers, as well as young graduates, holds our team in good stead to do so.



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As an Australian Manufacturer, in order that we remain competitive we must reduce the labour component, the cost of labour being our only disadvantage.

To reduce the labour component we have two options.

1) Manufacture off shore

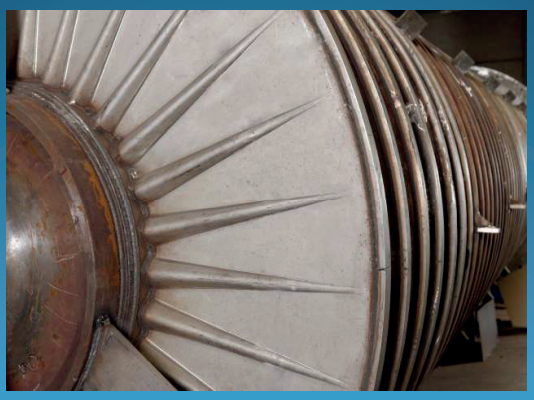
OR

2) Be smarter in our design and manufacturing methods.

The later being our preferred option which as you can see we have invested into.

37

WAVE DISC TECHNOLOGY



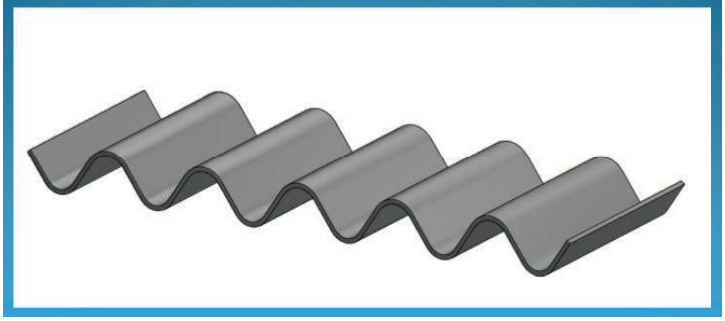
Wave Disc Technology is one such example of looking outside the square.

There were many motivations in developing Wave Disc Design. For those of you who are close to Disc Dryers or Cookers some of these reasons will be better understood.

38

WAVE DISC TECHNOLOGY

- The wave in the disc, like corrugated sheeting stiffens the disc plate.



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WAVE DISC TECHNOLOGY

- The wave in the disc reduces the necessity for welded stay pins.

- The reduction of stay pins or other welded disc stiffening reduces the risk of weld failure, or cracking.

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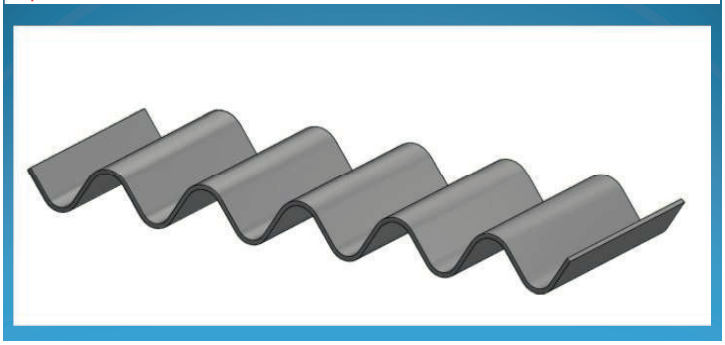
WAVE DISC TECHNOLOGY

- The wave in the disc better accepts thermal movement and is therefore less susceptible to thermal fatigue and cracking.



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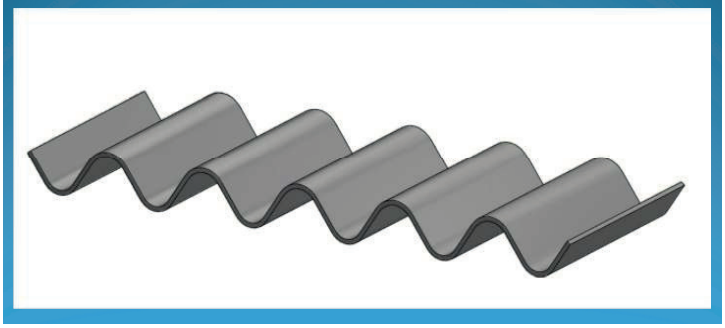
41

WAVE DISC TECHNOLOGY

- The Wave Disc Profile allows more heating surface area per square metre of disc.
- The Wave Disc allows better product agitation at slower disc speeds.



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WAVE DISC TECHNOLOGY

- The Wave Disc is currently in production at Low Temperature Rendering Facilities in Pre Cooker/Pre Heater applications. Initial results are proving the theory.

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QUADPASS™ ROTARY DRUM DRYER

- Through our close relationship and association with The Dupps Company in the U.S.A. We are also pleased to announce – new for the Australian Industry, The Dupps QuadPass™ Rotating Drum Dryer.

- Suitable for dewatered blood drying, hydrolysed feather drying, and low temperature rendered crax drying applications, within our industry.

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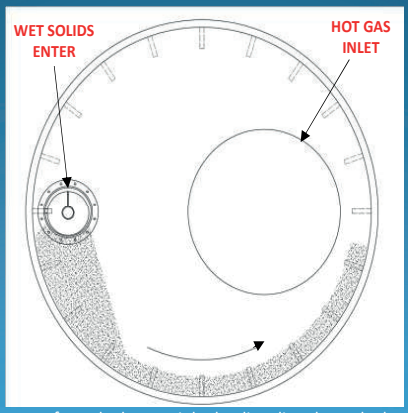
- The QuadPass™ Dryer, so named due to the revolutionary four pass, or four zone drum technology.



- Wet solids enter away from the hot gas inlet landing directly on the hot internal spiral type flighting, moving the material into the drum.
- As the drum rotates the flights lift the 'wet' feed upwards, not unlike a screw conveyor.

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- With further rotation and contact with the drum, the drying solids are gradually released by the changing flight configuration and fall downward through the hot gases, in a thin cascading curtain.

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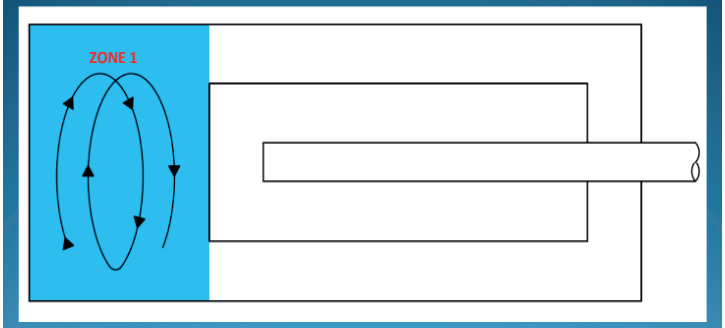

- The repeated cycle of "Lift and Fall" in the first zone occurs in an environment of low air velocity, not dissimilar to a conventional single pass Rotary Drum Dryer.

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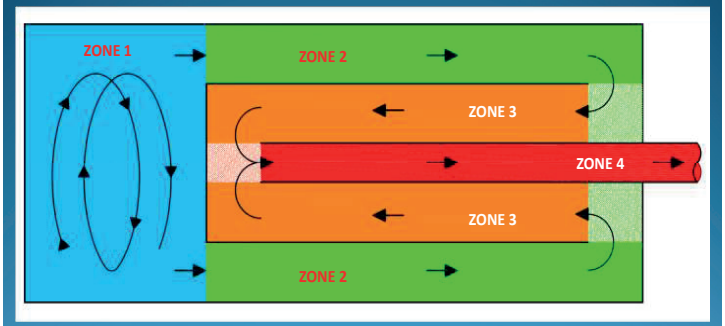

- Unlike a single pass Dryer, final drying takes place in zones 2, 3 and 4. Each zone having a reduction in cross sectional area, therefore accelerating the drying particles out of the dryer drum.
- This prevents over drying and charring, reducing VOC (Volatile Organic Compounds) emission and product degradation.
- Four passes maximises floor space usage as well as the efficiency of drying gases when compared to any other Rotary Drum Dryer.

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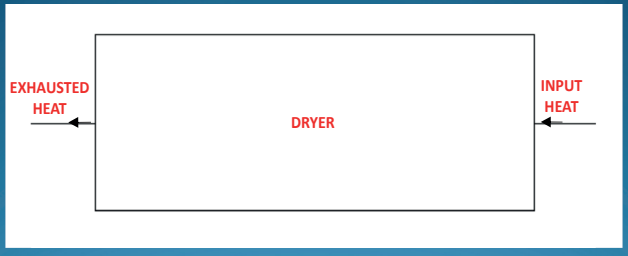
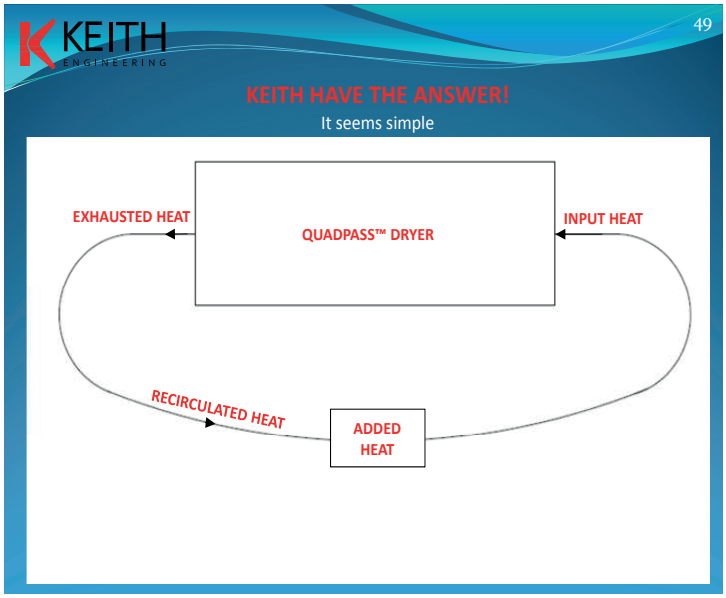


- Air dryers are ideal for small blood drying applications.
- The downside, or disadvantage of any air dryer is the volume of hot air exhausted.
- This odorous exhaust air needs to be treated.
- To be treated it must first be cooled.
- Cooling requires infrastructure and infrastructure costs money.
- Spending money to reject energy doesn't make any common sense and therefore rejected heat energy should be minimised.
- The larger the production rate, the more energy is wasted and the higher the cost in infrastructure to reject this energy.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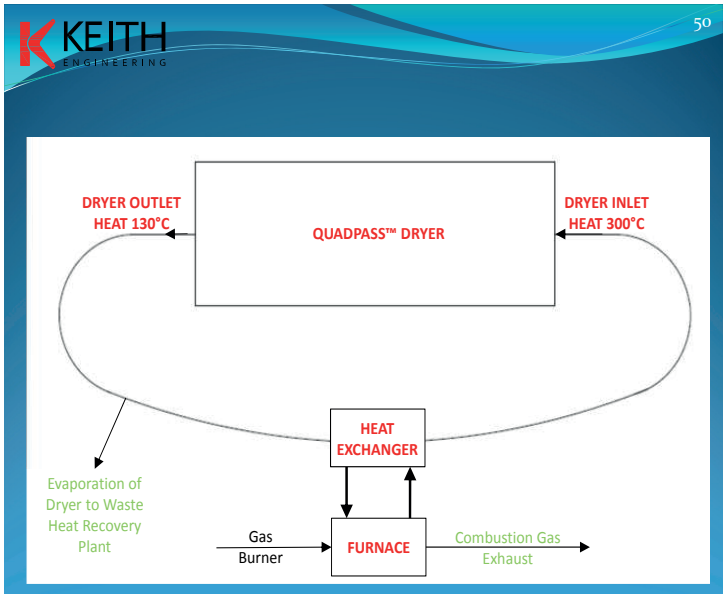
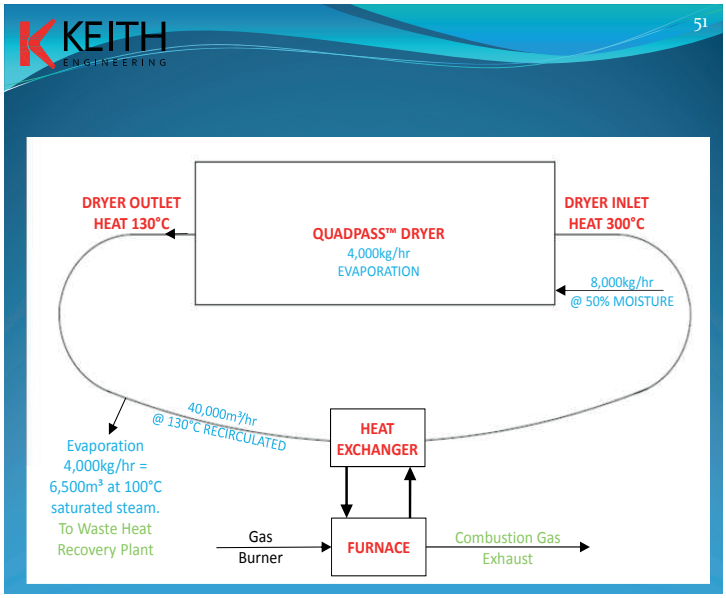
49
KEITH HAVE THE ANSWER!
It seems simple
EXHAUSTED HEAT
QUADPASS™ DRYER
INPUT HEAT
RECIRCULATED HEAT
ADDED HEAT


KEITH ENGINEERING
50
DRYER OUTLET HEAT 130°C
QUADPASS™ DRYER
DRYER INLET HEAT 300°C
HEAT EXCHANGER
Evaporation of Dryer to Waste Heat Recovery Plant
Gas Burner
FURNACE
Combustion Gas Exhaust


KEITH ENGINEERING
51
DRYER OUTLET HEAT 130°C
QUADPASS™ DRYER
4,000kg/hr
EVAPORATION
DRYER INLET HEAT 300°C
8,000kg/hr
@ 50% MOISTURE
40,000m³/hr
@ 130°C RECIRCULATED
HEAT EXCHANGER
Evaporation 4,000kg/hr = 6,500m³ at 100°C saturated steam. To Waste Heat Recovery Plant
Gas Burner
FURNACE
Combustion Gas Exhaust

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Talk to us about our new QuadPass™ Airless Dryer.

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KEITH ENGINEERING

Talk to us about any of the slides that interest you, we will be at booth 24 over the duration of the Symposium.

Thankyou!

Driving Innovation – Processing R & D

Doug McNicholl

Doug McNicholl

Doug is the Environment and Sustainability R&D Program Manager at the Australian Meat

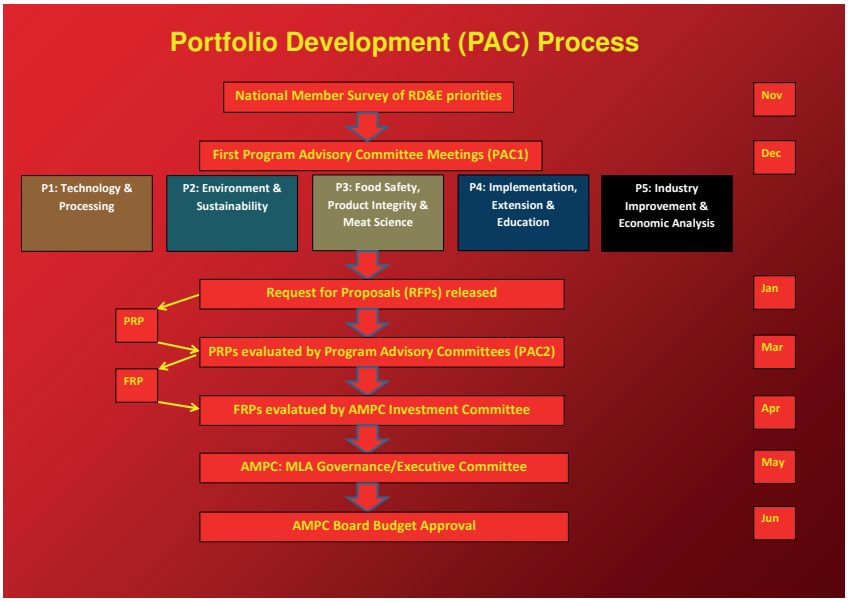
Processor Corporation (AMPC), where he is responsible for the development and implementation of R&D programs that deliver environmental and sustainability outcomes for the Australian Red Meat Processing Industry. Key areas of research centre around; effective management of utilities (energy and water) and waste with the objectives to improve environmental performance, reduce operating costs and generate additional revenue where possible.


About AMPC
A National Rural R&D Corporation that provides R&D marketing services and investments for the Australian red meat processing industry
MISSION: to support a sustainable competitive Australian red meat processing industry that meets customer, consumer & community expectations


AMPC's Goals are to:
improve industry efficiency & competitiveness
develop new & maintain existing markets
improve capability of workforce
increase productivity & value capture through technology & product innovation
enhance environmental sustainability


Research Programs:
Core Program (AMPC)
Joint Program (AMPC/MLA)
Plant Initiated Project (PIP) Program (AMPC/Member/Federal Government)


AMPC Core Program
Provides new innovations in areas such as automation, sustainability, food safety and capability development
Administered and delivered by AMPC and supported by industry wide consultation process


Portfolio Development (PAC) Process
National Member Survey of RD&E priorities
Nov
First Program Advisory Committee Meetings (PAC1)
Dec
P1: Technology & Processing
P2: Environment & Sustainability
P3: Food Safety, Product Integrity & Meat Science
P4: Implementation, Extension & Education
P5: Industry Improvement & Economic Analysis
Request for Proposals (RFPs) released
Jan
PRP
PRPs evaluated by Program Advisory Committees (PAC2)
Mar
FRP
FRPs evalatued by AMPC Investment Committee
Apr
AMPC: MLA Governance/Executive Committee
May
AMPC Board Budget Approval
Jun


P1: Technology & Processing
Innovations that improve efficiency, reduce the cost of production and facilitate improved value capture.
Examples:
Automation & Robotics
Manual Assist Technologies
Visioning & Sensing Systems


P2: Environment & Sustainability
Innovations that improve the sustainability of the red meat processing industry in terms of environmental, economic and social outcomes.
Examples:
Energy Efficiency & Renewable Energy
Water Efficiency, Reuse & Recycling
Solid & Liquid Waste Treatment
Animal Health & Welfare
Biodiversity


P3: Food Safety, Product Integrity & Meat Science
Innovations that enable high standards of food safety, product integrity and improved eating quality.
Examples:
On line/real time pathogen detection
Improved packaging technologies
Novel processing interventions


P4: Implementation, Extension & Education
The effective communication of R&D outputs to stakeholders and the support of key training initiatives.
Examples:
Meat Inspection & Quality Assurance Network
Meat Inspection Training Network
Webinars, Reports, Fact Sheets, Case Studies


P5: Industry Improvement & Economic Analysis
Industry analysis, the evaluation of the impact of AMPC investments and mechanisms to improve industry performance.
Examples:
Global Competitor Analysis
Program Evaluations
Industry Data


Partnerships
Meat and Livestock Australia
Administers funding from the Commonwealth for processor initiated projects (PIPs) through the MLA Donor Company,
Administers matching funding from the Commonwealth for Core R&D projects on behalf of wider industry.
Australian Meat Industry Council
Advises on priorities, consultation processes.
MINTRAC
Advises on delivery and delivers research outcomes to industry.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New Age Methane Capture

Justin Caldwell

Justin Caldwell

Justin started within the Beef industry in 1992 within the engineering and maintenance of abattoir facilities and continued this for 8 years. Justin started work in 2000 with Nippon Beef Packers Pty Ltd within their Hide processing sector as a Maintenance and Project Engineer conducting installation and maintenance of hide processing equipment and associated processes at various sites. Associated processes included the treatment of solid waste and waste water through various treatment levels varying from primary to tertiary treatment including biological systems. Due to a downturn in the hide industry work duties were transferred in 2012 to the Oakey Beef Exports facility as the Project and Mechanical Engineer. Duties include Engineering and Project management as well as maintenance of plant and facilities including food processing equipment and water treatment systems. Other duties include process improvement and environmental management of systems incorporated to the operating facility.

Report on Microfiltration at Clemson University

Erika Weltzien

Erika Weltzien

Erika Weltzien is Vice President, Business Development and Innovation, for Rothsay, a Division of Darling International Canada Inc. Erika is responsible for leading business development opportunities as well as an ERP implementation for Rothsay. She has over 20 years' experience in the rendering, feed, and hog production industries. She began her career with Maple Leaf Animal Nutrition, holding various positions in sales, product development, quality assurance, and nutrition before joining Rothsay in 2002. In 2008, Erika was promoted to the role of Vice President, Six Sigma, responsible for the alignment of Six Sigma with the business strategies of the Agribusiness group.

Erika is Chairman of the Fats and Proteins Research Foundation. In 2010, she led a strategic review that resulted in the reorganization of the FPRF and a new direction. She is an active member of the National Renderers Association and is a past chair of the Animal Nutrition Association of Canada (ANAC) Nutrition Council.

Erika holds a Bachelor of Science degree in Animal Science and a Master of Science degree in Monogastric Nutrition from the University of Alberta.

Ultrafiltration to Treat Rendering Facility Wastewaters

Scott M. Husson*, Daniel Wandera, and Jinxiang Zhou

Department of Chemical and Biomolecular Engineering, Clemson University, Clemson, SC 29634-0909 (*correspondence: shusson@clemson.edu)

Presented at the 13th Australian Renderers Association International Symposium by

Erika Weltzien, Chairman Fats and Proteins Research Foundation – July 2015

Abstract

The rendering industry protects the environment by processing animal by-products into feed ingredients, materials, fuels, among other products, rather than entering them into a landfill. During this processing, rendering plants generate large volumes of highly impaired wastewater containing high total suspended solids, fats, oils and greases, and proteins.

In this contribution, we describe our research demonstrating the successful use of membrane filtration for the additive-free treatment of high-strength rendering facility wastewaters. The experimental tasks were to 1) evaluate the performance of ultrafiltration (UF) membranes in the primary treatment of rendering wastewater; 2) test how filtration operating conditions (i.e., cross-flow velocity, transmembrane pressure, and total suspended solids) impact membrane performance; 3) measure the threshold flux for UF membranes that enables long-term, steady-state operation; 4) evaluate cleaning protocols for ultrafiltration membranes; and 5) examine dual-stage membrane processes involving UF for primary stage treatment, followed by nanofiltration (NF) or reverse osmosis (RO) for polishing stage treatment.

Background (Excerpt reprinted with permission [1])

Treatment of rendering facility wastewater rarely has been explored by membrane scientists and engineers. These wastewaters contain large amounts of dissolved solids and suspended particles, resulting from the complicated interactions among fats, protein, ashes and fibers [2]. Rendering wastewaters, unlike many wastewater types, contain a high concentration of nutrients that must be recovered in the treatment process to convert them into other valuable products (e.g. meat meal) [3]. Treatment involves a multi-step process: i) the primary removal of all large suspended particles; ii) the secondary removal of organic contaminants using biological methods; iii) the removal of pathogenic organisms through disinfection; iv) and the tertiary removal of ammonia, total nitrogen, phosphorus and residual suspended solids [4]. Dissolved air flotation (DAF) is the preferred primary method of treatment; however, it requires large quantities of chemicals (e.g. polymeric flocculants and pH adjusting compounds) to increase the interactions among particles and improve removal efficiency, which incurs a significant consumables cost [5]. DAF also results in unnecessary oxidization and degradation of the nutrients, which further reduces the value of the final product.

Unlike DAF, membrane technologies have low operating costs and can be used to recover the

wastewater nutrients without introduction of chemical additives. Furthermore, membrane units can operate on a variable concentration waste stream; thus, modest fluctuations in the feed concentration, a common feature of rendering facility wastewater, will not require process adjustments [5]. There have been some, albeit limited number of reports on the use of membrane technologies for poultry processing wastewaters. Avula et al. [6] provide an excellent overview of work done. However, surprisingly, reports on the use of membranes for treatment of rendering facility wastewaters are scarce [5]. These previous studies of poultry processing and rendering facility wastewaters neither comprehensively discussed the impact of operation parameters (e.g. cross flow velocity, pressure, feed concentration, and permeate flux) on membrane performance, nor investigated the mechanisms causing membrane fouling.

Objectives

The overall goal of this research program is to explore replacement of DAF with membrane technologies. In pursuit of this goal, a series of studies has been conducted to investigate the use of ultrafiltration (UF) membranes to treat rendering facility wastewaters without the polymeric flocculants and chemical additions needed by DAF. A theme of the work has been to control fouling by process optimization and efficient membrane cleaning practices. These studies also provide baseline data for pilot scale testing.

The primary objectives of these research studies were to understand the mechanisms leading to fouling of UF membranes during treatment of rendering facility wastewaters, to evaluate how the process parameters affected membrane performance, and to develop effective and efficient membrane cleaning protocols. To identify process conditions that control fouling during long-term operation, measurements have been done to determine threshold flux values at various feed conditions. While much of the focus has been on UF for primary treatment, we also evaluated dual-stage membrane processes involving UF for primary stage treatment, followed by nanofiltration (NF) or reverse osmosis (RO) for polishing stage treatment.

Description of studies completed and in progress

***Study 1: Fouling-Resistant Membranes for Additive-Free Treatment of Rendering Facility Wastewater* (Excerpts reprinted with permission [7])**

Prior to working in this field of study, Husson and coworkers had developed a special procedure to modify the surface of filtration membranes with specialty polymers to improve their resistance to fouling during the treatment of oily waters and to allow them to be cleaned by a chemical-free water rinse step [8-10]. In this first study, we investigated the use of these fouling-resistant, easy-to-clean membranes for treating rendering facility wastewaters.

The objectives of this study were to test the performance of the membranes using highly impaired waters (COD > 29000 mg/L, total solids > 11000 mg/L) provided by a rendering facility, to characterize the membrane surface pre- and post-filtration to determine the extent of fouling, and to evaluate the use of a cold-water rinse to clean the fouled membranes. Cross-flow membrane filtration experiments were carried out, and membrane performance was

evaluated by measuring productivity (i.e., the volumetric filtrate flux), capacity (i.e., the total volume processed per unit membrane area before the membrane must be cleaned), and effluent water quality (COD, turbidity, total dissolved solids, and pH). Cleaning involved membrane relaxation (where filtration was paused) followed by a cold-water rinse.

Low molecular weight cutoff (MWCO) membranes showed stable permeate fluxes without the need for intermittent cleaning, characteristic of systems with low degrees of internal fouling. For higher MWCO membranes, flux decline was more severe. While polymer-modified membranes processed ~26% more permeate than unmodified membranes in this case, flux recovery after a membrane cleaning step was low and similar for unmodified and modified membranes, characteristic of high degrees of internal fouling. All membranes reduced turbidity nearly 100% and COD was reduced 70-84%. These results indicated that low MWCO ultrafiltration membranes designed for treatment of oily waters can be used for primary treatment of other highly impaired wastewaters, and the use of high MWCO ultrafiltration membranes would require further development and optimization of cleaning protocols.

All membranes achieved low removal of TDS. This result is explained by the fact that salts are the primary contributor to TDS, and uncharged UF membranes are not designed for salt rejection. Thus, there is the need for a polishing step such as reverse osmosis to allow direct discharge or beneficial use of the treated water.

Study 2: Polishing Step Membrane Purification of Rendering Facility Wastewater

Results of Study 1 showed that ultrafiltration is effective for achieving significant reduction in turbidity and COD at high flux. Ultrafiltration membranes, however, are not designed for removal of low molecular weight compounds and salts that contribute to COD and TDS. Rather, they provide an initial purification step that can be followed by a polishing step such as nanofiltration (NF) or reverse osmosis (RO) to recover clean water for direct discharge or beneficial use. Figure 1 shows the two-stage treatment process. The use of such membrane cascades is common, and seawater desalination is one example where ultrafiltration followed by RO is used in practice.

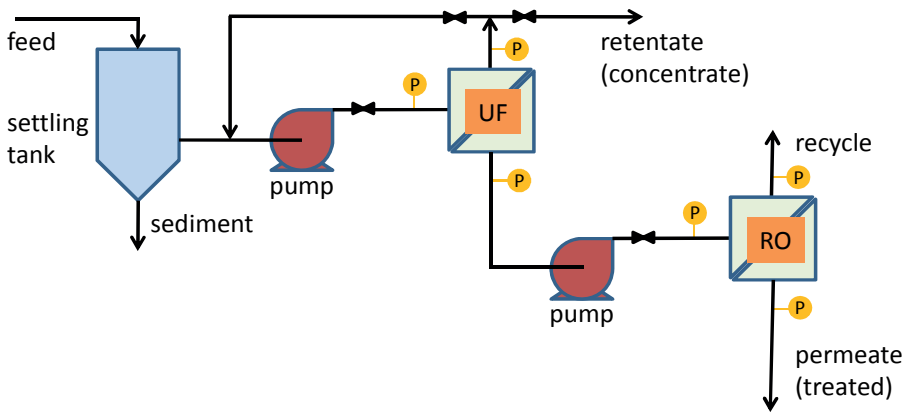

Figure 1. Two-stage membrane treatment process for rendering facility wastewater. Study 2 provided performance and economic data for the second 'polishing' step.

The objectives of this study were to determine the performance of commercial RO and NF membranes for secondary treatment of rendering facility wastewater following an ultrafiltration step, characterize the membrane surface pre- and post-filtration to assess fouling, develop a cleaning procedure to remove foulants, and perform a preliminary cost analysis for operating the dual-stage membrane separation process.

We studied the performance of ten commercial NF and RO membranes using rendering facility wastewater samples following initial purification by our proven additive-free ultrafiltration step. Membranes were selected to provide a range of manufacturer-reported characteristics (material of construction, permeability, salt rejection). Performance in direct-flow filtration tests did not correlate to material of construction; however, initial flux decline correlated to pure water permeability, with one exception. Because wastewater from only one facility was used, it is not possible to draw generalized conclusions about which membrane or membrane type works most effectively for treatment of rendering facility wastewaters. But we can conclude that direct-flow filtration provides an effective and time-efficient screening tool to reduce the level of effort in long-term cross-flow measurements. It should be used as a tool to down-select membranes for each new wastewater application.

All of the NF and RO membranes reduced COD and TDS levels well beyond what is capable in ultrafiltration. A cascade of UF/NF or UF/RO membranes reduce COD and TDS levels by as much as 99% relative to the initial feed, without the addition of chemicals or polymers used in DAF. One NF and one RO membrane were selected for long-term cross-flow filtration studies, as these gave stable flux and yielded good water quality during direct-flow filtration. Toray's 70UB RO membrane outperformed Koch's MPF-34 NFmembrane during long-term cross-flow filtration. Capacity prior to cleaning for the 70UB membrane was found to be roughly 1600 L/m^2.

Membrane cleaning was not an objective of this project; however, two preliminary experiments were done. Membrane cleaning with caustic was effective for removal of foulant; however, cleaning with surfactant alone was ineffective, suggesting foulants are inorganic salts. Energy-dispersive x-ray spectroscopy measurements further supported fouling by inorganic metal salts. Again, we cannot generalize these findings to wastewaters from other facilities, but we do suggest that the use of elemental mapping on fouled membrane surfaces provides clues on the nature of the foulant that can be used to guide cleaning studies.

Preliminary cost analysis work

Table 1 compares the estimated costs of energy and consumables for dissolved air filtration to those for membrane treatment steps. Data are presented for total annual operating costs to run a 160 gal/min process. In this table, all membrane lifetimes were expected to be only 1 year, far shorter than the manufacturer suggested lifetimes. Table 2 compares the costs using the suggested lifetimes of 2 years for UF membranes and 5 years for NF and RO membranes.

From Table 2, the estimated operating costs for the combined UF/NF or UF/RO dual-stage

membrane filtration process are less than about 40% of the current DAF process. That is, we estimate that the operating cost for the membrane treatment process to be $1.20/1000 gal compared to $3.20/1000 gal for DAF. Chemicals were the largest cost center for DAF, representing nearly 94% of the overall treatment cost, compared to less than 2% of the overall cost for membrane steps. Membranes were the largest cost center for the membrane process. Not surprisingly, anything that can extend membrane lifetime (e.g., reducing the frequency of cleaning by making the surface fouling-resistant) will have a direct economic benefit.

Table 1. Annual cost estimations of membrane operations based on our lab scale rendering facility wastewater treatment data. In this calculation, membrane lifetimes are assumed to be only 1 year.

Unit Operations	Pumping Cost	Membrane/ Chemical Cost	Annual Total Operating Cost	Cost Percentage Compared to DAF
	$	$	$	%
Ultrafiltration*	17,308	31,932	49,240	18.3
Nanofiltration	44,430	52,168	96,597	35.9
Reverse Osmosis	62,145	28,982	91,127	33.9
DAF	8,410	260,698	269,107	100.0

*UF data are based the operation under 650 kPa working pressure

Table 2. Annual cost estimations of membrane operations based on our lab scale rendering facility wastewater treatment data. In this calculation, manufacturer suggested membrane lifetimes are assumed.

Unit Operations	Pumping Cost	Membrane/ Chemical Cost	Annual Total Operating Cost	Percentage Compared to DAF
	$	$	$	%
Ultrafiltration*	17,308	15,966	33,274	12.4
Nanofiltraton	44,430	10,434	54,863	20.4
Reverse Osmosis	62,145	5,796	67,941	25.2
DAF	8,410	260,698	269,107	100.0

*UF data are based the operation under 650 kPa working pressure

Following ongoing work on membrane cleaning described earlier, a detailed cost analysis should be undertaken for the dual-stage membrane filtration process. This cost analysis should consider recirculation of retentate. That is to say, the numbers provided in this work are preliminary estimates and need more scrutiny.

Study 3: The Roles of Cross-Flow Velocity and Retentate Solids Content on Ultrafiltration of Rendering Facility Wastewater **(Excerpts reprinted with permission [1])**

Ultrafiltration performance depends on operating conditions such cross-flow velocity (u), retentate solids concentration (C_{RS}), and transmembrane pressure (TMP). Understanding and, ultimately, being able to predict how these conditions impact permeate flux is what we sought to learn in this project. This knowledge is important because flux ultimately determines the area of membrane that is required to process the wastewater, and membrane cost represents the largest annual operating cost for this process.

Modeling of direct flow filtration data revealed that early stage fouling was indicative of a cake formation pore blocking mechanism, which was followed by cake layer growth that depended on concentration. Modeling of cross flow filtration data determined that the cake layer contributed the dominant resistance to flow through the membrane. The cake layer was highly compressible. Thus, while higher transmembrane pressure provided a larger driving force for water transport, a higher resistance caused by cake layer compression counteracted this driving force. Cross flow velocity and membrane type (polysulfone and regenerated cellulose) and initial pure water permeability (from 10 to 70 $L \cdot m^{-2} \cdot h^{-1} \cdot bar^{-1}$) had only minor effects on the measured steady state flux. This result suggests that, in terms of membrane design, increasing membrane pure water permeability alone may not necessarily enhance filtration flux.

Study 4: Evaluation of Membrane Cleaning Procedures and Determination of Operational Lifetimes for Ultrafiltration Membranes Used to Treat Rendering Facility Wastewaters *– in progress* **(Excerpts reprinted with permission [1])**

In these prior studies, we identified operating conditions where a stable permeate flux was observed for prolonged periods. Figure 2 illustrates this condition, where, at steady state, the rate of solids transfer to the membrane surface by fluid flow is equal to the rate of solids transfer away from the membrane surface by diffusion, and a nearly constant flux is established. If we increase fluid flow to the surface (e.g., by increasing feed pressure), eventually we reach operating conditions where membrane fouling occurs. The so-called *threshold* flux divides the low fouling regime, characterized by a nearly constant rate of fouling, from the high fouling regime [11].

The goal of a successful design is to achieve high flux while keeping fouling rates acceptable [11]. Therefore, operating just below the threshold flux is appealing. Since the fouling propensity depends on characteristics of the feed, the membrane and their interactions, threshold flux is application-dependent. Thus, in this study, we measured the threshold flux for two ultrafiltration membranes used in primary treatment of rendering facility wastewater. Threshold flux can be determined in one of two ways: Constant-pressure filtration can be used to construct a plot of the rate of flux decline versus *initial* flux. Alternatively, constant-flux filtration can be used to construct a plot of rate of pressure increase versus flux. We performed measurements using constant-flux filtration, which has the advantage that the independent variable (flux) is fixed. It also better reflects the operation of most large wastewater processing plants, which are controlled by the required flux and limited by the available pressure [12].

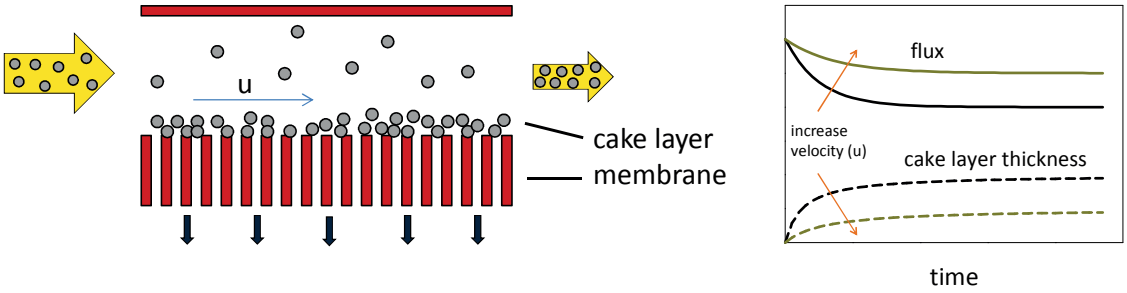

Figure 2. Illustration of cake layer formation in cross-flow filtration and its impact on flux.

The threshold flux was around 15 $Lm^{-2}h^{-1}$ for the original wastewater. We also compared the threshold flux with different concentrations of wastewater: 1/10 diluted wastewater and 1/45 diluted wastewater. There was a significant increase in the threshold flux to 56 $Lm^{-2}h^{-1}$ at the lowest concentration, consistent with the fact that less foulant material is delivered to the membrane surface with the lower concentration feed streams. In all of these measurements, the cross flow velocity was 0.2 m/s. At threshold flux, the rate of pressure increase was 0.01 bar/min, meaning that the pressure required to maintain constant flux would have to be increased by 1 bar every 100 min. With a reasonable goal to limit increases to within 5 bar before cleaning, at least three cleanings per day would be required. Depending upon the cleaning practices in force at a particular plant, membrane cleaning frequencies can vary anywhere from 5 to 96 times/day [13,14].

Filtration/cleaning cycles have been carried out with direct-flow filtration using four different UF membranes for comparison. Specifically, the comparison has focused on pressure change over time during constant flux filtration, and pure water flux recovery after cleaning with water rinse. The results indicate that regenerated cellulose membranes and activated polysulfone membranes show the best performance during multi-cycle tests. Ongoing work is evaluating cleaning protocols for these two membranes during long-term cross-flow filtration of rendering facility wastewaters operating just below threshold flux. Using data from filtration and cleaning cycles, it will be possible to estimate projected membrane lifetimes for this application, which is especially important for refining our operating cost estimations.

Upcoming work

Study 5: Low-Energy Process for Concentration of Stick Water – in progress

Dewatering of stick water to recover edible protein conventionally is done by evaporation and drying (e.g., in a drum dryer or disc dryer). In these high temperature operations, some degradation of substances important to the nutrition value of the recovered protein will occur. Spray drying or spray granulation [15] may be an option, as the short residence times minimize degradation reactions. Still, initial dewatering is needed prior to the drying step. Anecdotal information suggests that stick water feed solids concentration to the spray dryer should be >50 wt% for practical operation. Beyond operational considerations, higher feed solids may also decrease off-flavor intensity for some protein products [16].

The goal of this study is to develop a new, low-energy membrane process for the concentration of stick water to high solids levels. The proposed work is motivated by the success of a preliminary proof-of-concept measurement that has shown that membrane process under consideration is capable of concentrating chicken feather stick water from 10 wt% solids to 38 wt% solids at room temperature in a simple batch concentration process. A back-of-the-envelope cost calculation shows that the proposed process uses 1.3% of the energy that would be required to thermally evaporate the same volume of water, assuming no heat integration. This energy (cost) reduction is attributed to the fact that the membrane process does not require a phase change of water from liquid to vapor. Replacing the energy-intensive evaporative process with the proposed low-energy membrane process is expected to improve process economics.

The initial data, which are very promising, examined only whether concentration was possible. Several operating variables influence the rate of water removal and the maximum achievable concentration. Our work will develop a comprehensive understanding of how these factors impact the rate of water removal and the maximum achievable stick water concentration.

Summary of findings to date

Our results have demonstrated that UF membranes can treat rendering facility wastewaters without the polymeric and pH-adjusting additives required by dissolved air flotation. Operating below threshold flux enables long-term, steady-state processing. Dual stage processes involving UF/NF or UF/RO membranes are able to reduce chemical oxygen demand and total dissolved solids by as much as 99% in the original wastewater and can be accomplished without addition of any chemicals or polymers.

In addition to experimental work, a preliminary cost analysis compared the operating costs (energy and consumables) of the membrane filtration processes to DAF. Assuming realistic membrane lifetimes, the results suggest that operating costs for combined UF/NF and UF/RO systems would be approximately US $1.20 per 1000 gallons of wastewater, compared to roughly $3.20/1000 gal of wastewater for DAF. In addition to the significantly lower projected operating costs for the membrane processes, there are likely to be other economic benefits associated with the removal of chemical additives from the wastewater treatment process.

Acknowledgments

SMH, DW, and JZ wish to acknowledge the financial support of the Animal Co-Products Research and Education Center (ACREC) at Clemson University with funding from the Fats and Protein Research Foundation. We thank Hydration Technology Innovations for providing membranes.

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Improving your meal quality by contaminant reduction

Kevin Baker

Kevin Baker

General Manager of MAGNATTACK™ Global

MAGNATTACK™ Global are an Australian owned and operated company offering endorsed and extensively patented magnetic separation equipment solutions for extraction of metal fragments and contamination from food products in raw material intakes through to final products.

Over the past 25 years, MAGNATTACK™ Global has developed into renowned leaders in magnetic separation due to its commitment to the food industry with positive contribution to product security and food safety. Offering technical support and back-up for MAGNATTACK™ products worldwide with export sales and support now available in the USA via our distributors.

A key product development for MAGNATTACK™ Global is the MAG-RAM™ self-cleaning system specifically developed for a large meat processor experiencing serious metal contamination issues. Results of this innovative development have been very successful within the rendering industry, targeted to remove the dreaded wires from drenching capsule springs, along with other dangerous metal fragments from final meat meal product.

MAGNATTACK™ Global aim to ensure final products including liquids, powders and granular products are free of magnetic fragments and provide internationally endorsed solutions for the most difficult of applications. Quick cleaning and automatic magnetic cleaning is emphasised.

MAGNATTACK™ GLOBAL

HACCP INTERNATIONAL FOOD SAFETY PROGRAMME CERTIFICATION

International Endorsement by HACCP Australia

IMPROVING YOUR MEAT MEAL QUALITY THROUGH CONTAMINANT REDUCTION

Reduce risks of metal contamination from drenching capsules

Serious contamination issues have been identified within Australian meat processing facilities with final meat meal product presenting with tiny, sharp metal fragments.

PROBLEM

- ***Foreign matter control***
- ***Metal contamination in processed meat meal product***
- ***Risk to pets and livestock***

Reduce risks of metal contamination from drenching capsules

CAUSE

The cause of the most serious contamination is traced to spring parts contained in drenching capsules within the sheep's stomach.

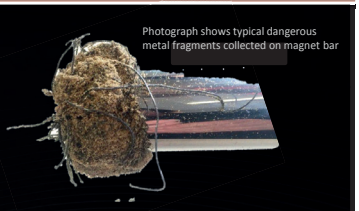
During the rendering process, the small capsules left in the sheep's stomach are ground up and milled with the offal causing metal contamination in the final meat meal products. As a result, tiny very sharp spring wire fragments made of 400 series stainless steel are all through the product.

The above photograph shows a hand held test magnet in a vacuum extraction bag, showing magnetic wire pieces and fine iron extracted by a self cleaning MAGNATTACK™ MAG-RAM™ installation with very little product 'carry over'.

Reduce risks of metal contamination from drenching capsules

EFFECT

- Customer complaints
- Product and brand name damage
- Damage to extruders and pelletisers
- Injury to pets and/or livestock



Photograph shows typical dangerous metal fragments collected on magnet bar

MAG-RAM™ CUSTOMISED SOLUTION

Years of research & development, trials and patented technology resulted in the revolutionary MAG-RAM™ RE80™ Self Cleaning Magnet solution designed to extract weakly magnetic fragments, such as internal components shown in the above photograph, work hardened stainless steel, magnetic stone fragments, etc.

Designed & manufactured in Australia by MAGNATTACK™ Global.
Fully endorsed by HACCP International.

MAGNATTACK™ GLOBAL — IMPROVING YOUR MEAL QUALITY THROUGH CONTAMINANT REDUCTION

Reduce risks of metal contamination from drenching capsules

MAG-RAM™

The RE80™ +10,000 gauss self cleaning system is very versatile and can even be installed in difficult to access locations.

The pneumatic magnetic rams clean periodically on a timer using either stand alone or PLC controls.

Frequency of cleaning parameters can be adjusted according to the level of contamination and throughput.

MAG-RAM™ Self Cleaning Installation in hard to reach elevated position at a meat processing facility in Goulburn, NSW.

HACCP INTERNATIONAL FOOD SAFETY PROGRAMME CERTIFICATION

MAGNATTACK™ GLOBAL — IMPROVING YOUR MEAL QUALITY THROUGH CONTAMINANT REDUCTION

MAG-RAM™ PHOTO GALLERY

HACCP INTERNATIONAL FOOD SAFETY PROGRAMME CERTIFICATION

Product Bulletin No.171

MAG-RAM™

A REVOLUTION IN THE MAGNETIC SEPARATION WORLD!

The MAG-RAM™ is a very versatile machine that has the ability to collect weakly magnetic fragments such as work hardened stainless steel and magnetic stone particles and can be automatically cleaned both during production and after/before production runs.

Applications range from extraction of stone, work hardened stainless steel, wear iron and tramp metal from sugar, grain and bulk products.

Each Magnet is the ram of a pneumatic cylinder which when retracted, wipes the magnetics to the end of the ram and into a magnetics chamber at the back of the magnet housing.

RARE EARTH MAGNETIC SEPARATION TECHNOLOGY
Fully designed and manufactured by MAGNATTACK™ Global - available worldwide.

MAGNATTACK™ GLOBAL

MAG-RAM™

- RE80™ 10,000 Gauss
- Product security
- Reduce OH&S issues caused from cleaning heavy Magnets
- Eliminate risk of metal fragment issues caused by magnets not being cleaned (no operator error)
- Machinery and plant protection
- Customer satisfaction

HACCP International Endorsed

Units can be sized to suit existing chutes and hoppers and replace existing low strength or inefficient grate magnet configurations.

The unit can be supplied with standalone automatic controls in an IP66 stainless steel enclosure or the unit can utilise in house PLC pneumatic controls.

Ram sizes range from 19mm > 63mm Dia and can be configured in single magnet bars through to multiple Rams in Housing.

The Rams rotate/twist when retracting to equalise abrasive wear and avoid material buildup.

RARE EARTH MAGNETIC SEPARATION TECHNOLOGY
Fully designed and manufactured by MAGNATTACK™ Global - available worldwide.

MAGNATTACK™ GLOBAL

NEW DEVELOPMENT

Metal Detectable Ear Tags

Improve your meal quality through contaminant reduction

MAGNATTACK™ Global have proved that it is possible to make plastic ear tags magnetic in such a way that the MAG-RAM™ system can extract troublesome fragments of these also.

MAGNATTACK™ Global are happy to consult with manufacturers of the plastic ear tags regarding this technology, if the industry is interested in pursuing this further.

Some plastic manufacturers have expressed interest, however there are hurdles to be overcome regarding electronic tags.

MAGNATTACK™ GLOBAL *IMPROVING YOUR MEAL QUALITY THROUGH CONTAMINANT REDUCTION*

Drying using Solar Heat Capture

Phil Kemp

Philip Kemp

Graduated with Bachelor of Rural Science (UNE) 1972 with particular interests in biochemistry, animal nutrition and animal production.

Has spent most of his working life in the pastoral industry mostly with sheep as a producer of wool and meat as well as a nutritional consultant within the industry.

Started biotechnology development in the late ninety nineties which has continued until now.

Currently operates a lamb feedlot and stock feed business in southern Queensland as well as Technical Director for ADTRendering Pty Ltd and Warrego Rendering Pty Ltd at Charleville.

Drying using solar heating

P. Kemp, ARA Workshop, July 2015

The use of solar heat for drying has its origins in a new ultra low temperature rendering process. The original concept was the thought of a mobile processing plant to make meat and bone meal out of plague numbers of kangaroos in western Queensland.

The basic biochemical theory was that if the product was treated with an alkali the high pH would give bacterial sterility so all that would be needed was to dry the material and then mill it.

After some initial research and development a dehydration plant was established to process the waste from a kangaroo boning works at Morven in Central Queensland. This plant operated successfully until the Queensland Government adopted the Hilmer Report and wrecked the State's kangaroo industry. After some time this plant was moved to South East Queensland and fish and prawn waste were successfully processed; however the company that purchased the prawn meal reneged on their deal so the plant shut down.

By this stage we had learnt a lot about the process and BSE was now a topical issue. We then progressed down the path of TSE inactivation in meat and bone meals and reached an inactivation of > 4.8 logs (the limit if measurement of the Western Blot method used) but by this time BSE was no longer topical and the interest had waned. However energy was now the big interest so we knew that the process could be adapted for lower energy rendering.

After more delay and with the assistance of David Kassulke and MLA a demonstration plant using solar heating was built at Charleville in association with the Western Exporters goat abattoir.

The process works along the same lines as a standard low temperature system. The product is first sized with a pre breaker, hogger and disc grinder. It was known from prior experience that the product could not be finely ground as this would cause problems when the product is hydrolysed in the dryer. The sizing presented the most difficulties and some weird and wonderful solutions were tried until we came up with the disc grinder which works extremely well. It is simple, requires less than half the power of a grinder and is easy and cheap to maintain.

The product then passes through a series of heater tubes to loosen the tallow. Because the product retains a course nature the product is pressed as it exits the heater tubes to remove the large solids. The fine solids and liquid fractions then pass through a decanter to remove more of the solids. This system works well with the residual fat content in the meal being 5 – 8 %.The next phase is the dryer and where the product is hydrolysed to give us sterility

and then dried. As the wet solids are loaded into the dryer the alkali is added. After drying the product is milled.

The dryer is just a large rotary dryer with a large volume of warm air passing through it. The inlet air is drawn from a solar heat collector with a modulating gas burner positioned in the intake manifold to the dryer. At the start of a drying cycle as much air as possible is drawn through the dryer – in the order of 12 – 15 M^3 per second. As the product dries this volume has to be reduced to minimise the amount of product in the air stream. The relative humidity of the exhaust air is 100% until late in the drying cycle. On just a warm day the air drawn from the solar collector can be 45 – 50^0C. The slower the drying cycle the better the efficiency because better use can be made from the heat from the solar collector. Under normal operating conditions with the gas burner on a low fire, the exhaust air from the dryer runs at only 50^0C.

The solar collector is just a shed with a pitch of 20^0 to the north, 48 meters long and 13 meters wide. The roof has a double skin and the air is drawn up through this gap. There is a manifold at the top to collect the air which then delivers to a duct that goes to the dryer. The amazing thing is that even on the hottest day the inside of the shed remains cool even though it is totally enclosed and used as a store room.

Our energy efficiencies so far are at the lower end for low temperature rendering using 3.29 GJ of energy per ton of water evaporated in the warmer months and 3.35 GJ per ton in the autumn. All energy used has been included in these calculations as there is a power meter for the whole plant from which the power reading was taken and a gas meter on the gas line into the plant so even the heating of the wash down water and the electricity to pump it are included. We were a little disappointed in these numbers but we are sure that they will improve as we develop the plant more. We have actually dried 1500 – 2000 Kg batches with solar heat alone and this has worked well except it takes a little longer and we have to fire the burner on low at the finish of the cycle to ensure the water is drawn from the larger pieces of raw material. In these instances our efficiency would be about 2 GJ or less per ton of water evaporated.

Therefore the efficiency of this method of rendering to a large degree is simply dependent on the amount of waste or solar heat that can be collected. There are many instances where waste heat is available especially at abattoirs with things like chiller condensers and rooves, especially those over the chillers.

This process was developed by a couple of bush blokes with a bit of biochemical knowledge and some inspiration. The plant at Charleville was designed and built by a couple of bush blokes with a bit of fabrication experience except for the specialist equipment. We have proven that it works well and significant energy savings can be made. Now that it is proven moving forward, specialist energy engineers will be able to dramatically improve on what

we have and further increase the efficiencies. It is very easy to recover costs spent on recovering energy that is going to waste.

Finally I would like to acknowledge the significant contribution MLA has made to the development of this process. I would also like to acknowledge the support from Dennis King, David Kassulke, Bill Spooncer, Craig Palmer and especially Andy Bennett for his assistance and help.