final report

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Meat Powder and Hydrolysis

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Executive summary

The opportunity

Secondary by-products (bone, fat trimmings) are a significant proportion of the carcass and mostly deliver a minor return while impacting muscle meat yield. Two technologies that have been investigated (powdering and hydrolysis) which not only significantly improve yield recovery, but importantly the quality and value of meat that then remains fit for human consumption, have been further assessed through to product concepts and an ex-ante business case analysis.

The process

This assessment has involved engaging equipment manufacturers, modifying and building processes and producing product concepts for inclusion in existing commercial products for assessment. This has been followed up by engaging the equipment manufacturers to provide budget quotations for these processes to process at 1 tonne/hr.

The outcomes

Powdering

The modifications to the powdering process have made it capable of processing a wide range of secondary products where it was previously limited due to fat content. The product concept developed with this process is the milling of a mixture of 30% bones and 70% fat trimmings called DM70. Two product types can be manufactured; 1. Meat extender and edible fat or 2. Undenatured meat extender. DM70 type 2 (rehydrated) has been shown to substitute 30% of 90 CL trim one for one in 100% beef sausages with good acceptance and no grittiness.

Hydrolysis

A small manufacturing process, including an imported reactor from Europe, was setup to produce sufficient bone hydrolysate to enable production trials substituting it for finely textured beef (FTB) in Proform Foods HMEC beef product. It was shown that 70 to 80% of the FTB could be replaced and excellent texture maintained while providing cost savings to the manufacturer.

The conclusions

Pay-back for both processes was found to be within the 2 year time frame while maintaining an IRR of 20%.

The stand-out option was definitely the DM70 type 2 product, which could be used in a wide range of meat products that currently use 90 CL trim, such as sausages and burgers. This product is produced in around 1 second from bone and trim to finished product.

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1 Background

Secondary by-products (bone, offal and rendering) are a significant proportion of the carcass and mostly deliver a minor return, additionally yield loss of muscle meat after primal deboning is expensive. This has driven the investigation of innovative harvesting technologies, which not only significantly improve yield recovery, but importantly the quality and value of meat that then becomes fit for human consumption.

Two of the technologies being investigated are Powdering and Hydrolysis, both have shown technical potential, but need to be assessed for their value adding benefits as separate business cases for the red meat industry.

2 Project objectives

The objectives of this project are summarised as;

- Organise and complete trials to produce red meat bone hydrolysate that can be used in Australia as a functional ingredient.
- Organise and test trial product cyclone concept to expand application of powdering (milling/drying of meat products) recommended in stage 1 (A.MPT.0036)
- Prove (quantify and qualify) value adding benefits of both platforms through product concepts – including seeking market feedback for potential next stage adoption
- Seek industry feedback and review supporting value propositions for inclusion of powdered/hydrolysate meat from previous research to build next stage adoption plans
- Report findings

3 Methodology

3.1 Materials

3.1.1 Powdering Raw material preparation

Raw materials both Bone (leg, shoulder and rib) and Trim (70CL) were prepared at MeatCo and transported chilled to Jäckering for the trials. Three days of trials (**Day 1, Day 2 and Day 3)** were completed over a 3 month period.

Day 1 trial batches of material were prepared being; Trial 1 (30% Bone:70% Trim), Trial 2 (15% Bone:85% Trim) and Trial 3 (100% Trim). These levels were chosen as they would assist in maximising the opportunity to utilise bone material while its presence also tends to assist transport through the mill and this would enable fine tuning to ensure the best result. The bone was size reduced using a bone breaker (shredder style, 5 cm max.) while the meat was ground using a 5mm plate (Fig 1).

Figure 1 Size reduced bone (a) and ground 70 CL trim (b)

Day 2 trials utilised just trial 1 material from Day 1.

Day 3 trials utilised trial 1 material from Day 1 and 100% size reduced bone.

3.1.2 Hydrolysis Raw material preparation

Food grade beef leg and shoulder bone was to be supplied ground to 10 mm ensuring a maximum bone dimension and hence effective time control for enzyme hydrolysis. This was found to be not possible as bone breakers and crushers are now predominately used and whole bone was supplied instead. This constrained what could be achieved in the time frame that all resources were contracted for. Assistance was sort from all avenues, the bones could not be returned as they were supplied domestically (without a Meat Transfer Certificate). Alternative suppliers were sort along with processors which may be able to grind leg bones.

To achieve a workable solution a small older style hogger was sourced and hired (Fig 2a) which had a single drum with 10 mm teeth notching into a 10 mm spacer grate. While this machine was capable, it was very slow as the belt was quite worn and slipped easily, jamming frequently.

Figure 2 Older style hogger (a) and hogger size reduced bone (b)

The size reduction was not ideal but was deemed satisfactory (Fig 2b), with pieces measuring up to 50 mm in the longest dimension and averaging 15 to 25 mm for 1 standard deviation. The consequence being that the enzymatic hydrolysis would be less efficient and yields of hydrolysate protein lower.

Increasing hydrolysis time substantially (2 to 3 times) to enable maximum hydrolysis was not considered a best option, as this could result in much lower Daltons (molecular size of protein products), making the hydrolysate less applicable for the desired use. Additionally there may be some unknown flavour outcomes (experience of MeatCo for hydrolysis time has been predominantly less than 90 minutes and usually 45 minutes). A reduction in yield was accepted as this would give at least a reflection of the yield expected in industry utilising bone breakers/hoggers/shredders for rendering as a more cost effective bone size reduction to grinders.

3.2 Methods

3.2.1 Powdering

Previous work has shown that product produced from this technology is functional (A.MPT.0036), however its application was limited by its inability to handle higher fat contents. Proposed modifications (A.MPT.0036) were manufactured and trialled to assess if this could be resolved. These trials were run in Germany in absentia.

The information generated to date (A.MPT.0036, A.MPT.0035, A.MPT.0027 and A.MPT.0049) and collected from these trials; product assay for market assessment, equipment costs, operational requirements have been utilised to construct a business case for the red meat industry.

3.2.2 Hydrolysis

This technology does not currently exist in Australia, so a trial unit was imported for these trials and then returned to the Netherlands. While trials could have been conducted in the Netherlands, the cost of completing these there and to import product back to Australia was prohibitive. The hydrolysate produced was added as flavour and additional namer substituting Fine Textured Beef (FTB) in a Proform HMEC product and assessed.

Using the business case data for the ProForm HMEC MDC project P.PSH.0673, equipment costs, and operational requirements a business case for hydrolysis was developed.

4 Results and Discussion

4.1 Powdering

4.1.1 Process concept

These trials were to determine if the use of a trial cyclone with specific design attributes can enable the rotor milling process to dry material with fat contents higher than 15% w/w (this appears to have been set as a maximum limit by equipment manufactures). The key aspects of the process are;

- Gas heated air at a set temperature is sucked through a turbo rotor mill which is being fed with product from the bottom of the mill
- As the product is milled its surface area increases and the drying rate is accelerated
- At the outlet of the mill (top) product exits via a method which ensures minimal cooling occurs to the product leaving the mill, and hence fat deposition in the duct is reduced.
- This is maintained through the ductwork to the trial cyclone so that fat does not accumulate.
- At the trial cyclone the velocity is substantially slowed, enabling substantial flash cooling and settling out of the product into the trial cyclone.
- The air exits the trial cyclone by accelerating again ensuring what remains entrained transfers to the main cyclone.

4.1.2 Day 1 Trial observations

A report of the Day 1 trials carried out at Jäckering GmbH in Germany prepared by MeatCo was completed and is available as part of the in-house report, a summary of these outcomes and analysis follows:

Contact was maintained throughout the trials via phone, Skype and email so that outcomes could be discussed and key decisions resolved. From the results of the Day 1 trials it is clear, that the rotor mill using the trial cyclone, easily dried all three products, each ending up around 2/3 content of fat and less than 2 % moisture. The mill owners were surprised at the effectiveness of the system and agreed to explore this further with us.

The initial design of the trial cyclone was modified by Jäckering by raising the product entry to match normal cyclones, this while logical, may be why more material appeared to end up in the main cyclone when bone was being milled (difficult to confirm). After the first trial Jäckering also extended the outlet duct to reduce product carry-over, it was difficult to determine if this was impactful also, as too many other variables were also changed (this being the necessity of time constrained development). The second trial with 15% bones: 85% trim resulted in substantially larger carry-over, but this may have been the result of other changes like lower product temperature.

The first trial was a useful learning exercise in that the screw feeder could not handle the larger bone pieces and these had to be removed by hand during that run, so the bone percentage was much lower than 30% and consequently the ash content also much lower (Trial 2 bones were double size reduced to avoid trial 1 issues). Also the temperature needed to be subsequently reduced as the moisture was extremely low (<0.1%) such that the product was quite dark indicating some heat damage

Both of the products from trials 2 and 3 were also well over dried but damage was much less both still having a lighter colouration hinting at pink compared with trial 1 (30% bone and 70% trim). Immediately after collection the powdered product appears liquid due to the high fat content which is in its liquid state over 50̊ C.

The key result that can be taken from these trials is that the trial cyclone enables the mills to perform as if there was little or no fat in the process. Previously the outlet ducts from the mills rapidly blocked up with fat and the whole system became clogged and had to be stopped within a short time.

Following discussions with the mill owners it was agreed the product temperature may be able to be reduced further through further design changes.

These modifications were prepared and run again on 21/9/16 ('Day 2' Trials). As there was very limited time, we could only run one of the three 'Day 1' options. Trial 1 (30% bone with 70% trim) was chosen, as this has potentially the greatest strategic benefit short term. However longer term the ability to immediately stabilise any material that is food grade instantly (bones/offal/trim) in a form that can be blended and added to many food products will provide a very useful means to increase return to stakeholders.

An option that presents itself from these trial results is to process food grade material that would have gone to rendering. As the material has been milled down in size, it is most likely all of the fat cells have disintegrated, which will led to very efficient separation and potentially very good control of the fat content in the protein powder. With the moisture contents achieved in these trials, there would likely be no water in the fat stream, as these moistures are way below where we usually expect 'bound water' levels to be, which ends up in the solids stream.

Overall the Day 1 trials have proven the capability of rotor mill drying, with a trial cyclone, to stabilise high fat products effectively. The capacity of the machines that Jäckering provide are based on kilograms of moisture they can remove (see Appendix 1), these capacities should be met now with high fat meat products, using the trial cyclone concept.

4.1.3 Day 2 Trial observations

The objective of the Day 2 trials was to modify the trial cyclone to enable more air flow lowering required temperature settings in the mill to dry product.

The trial set-up of the new trial cyclone was designed to allow continuous running with the liquefied product draining into the sample pots. Unfortunately heat loss from the unit was such that the milled product solidified inside, especially as temperatures were lowered.

A total of 7 runs were carried out using 70CL trim in a ratio of 70:30 with bones. The outcomes were extremely successful with product temperature reductions from 80 C to 70 C and then 60 C, the last two achieving moisture contents of 5.0 and 5.2% respectively. Spin test results confirm that the fat was still separable with centrifugation, but it must be kept over 50̊ C.

The heated air temperature minimum was determined using high temperature psychrometric charts to calculate the water carrying capacity required to achieve the desired stabilised moisture content, which was determined to be 60˚C for the air flow and the product rate being run. While the ambient air moisture does matter, it amounts to only a small portion of the carrying capacity once the air is heated. What is more important is the ambient air temperature, as this increases (35̊ C plus) then humidity becomes important and the heated air temperature would need to be increased.

The system was then modified to increase the residence time in the mill and use little or no external heating, as the bones provided significant friction. These runs produced product temperatures of 40 to 60 degrees C and product moistures of 14 to 13% respectively. These moistures were a little high resulting in a water activity of 0.93 (require a maximum of 0.86 for stability). However these trials using no external heat did provide product with minimal heat damage having a distinctly pink colouration.

This product was processed into sausages using the following recipe; 50% Milled meat (DM70), 35%

Figure 3 Trial 2 set-up for continuous operation Available in confidential report

water, 5% fresh onions 5% potato starch, 2% nitrite salt, 3% spices/additives. The sausages were well formed (cooked at 82̊ C to a centre temperature of 68̊ C) with little fat loss. They were light pink in colour and tasty, but the presence of grit was very noticeable (unacceptably so).

4.1.4 Day 3 Trial observations

Jäckering have designed a new rotor system independent of this work, with other design changes which make it similar to Mill 27 (the proposed optimal mill designed discussed in A.MPT.0035 and A.MPT.0049). Use of this rotor for our applications was agreed to for these trials with the potential for implementation.

Following discussions with MLA project managers, it was agreed that this further exploration should be completed at an agreed cost, as being able to utilise bone material could have significant rewards.

These trials were to decrease mean particle size so material could be incorporated directly into products without the need to process in a colloid mill (to remove grit). Additionally this new rotor design could assist in reducing the final moisture content using just ambient air for drying.

Two products were run in the Day 3 trials; *1. 70 CL trim:bone at 70:30* ***(DM70)*** *and 2. 100% bone*.

The analysis results for the milled products are given in Table 1. As can be seen both products had very low moistures, with water activities down around 0.2. These water activities are equivalent to coffee or milk powder indicating the potential for an excellent shelf-life, especially if vacuum packed with anti-oxidant.

Sausages have been produced with the first product which showed a very good functional replacement (30%) of 100% 90 CL beef trim sausages, providing good firmness and flavour with no indications of grittiness or off-notes. There is some paleness and blending issues, when the DM70 is cold (<10˚C) it is very firm and needs to be mechanically mixed in

In summary a range of options exist for this technology, the option chosen at this stage is the DM70 from Day 3, trial 1 to be used as a general beef protein functional meat replacement alternative. Mechanically mixed it only has a slight impact on the colour, additional sausage trials have proven this to be correct. It should be noted that the fat content is very high in this milled product, nearly 60% w/w, however its functionality is very high.

The option to separate the fat exists with the Day 1 or Day 2 milled product using heated air at 70 or 60˚C This option does not exist with Day 3 product which is far more stably emulsified, heating to 50˚ C results in no fat separation, while heating to over 80˚ C is needed to start releasing the fats (hence denaturing the proteins).

Note: While the final bone containing products in Day 1 and 2 trials were gritty, the modifications utilised in Day 3 are most likely to be as effective in eliminating grit perception for these products also.

The potential for this technology is significant as it enables the opportunity to recover most non 'specific risk material' protein without significant heat denaturation. The ex-ante business case in section **4.3** considers a number of options.

4.2 Hydrolysis

These trials were primarily to enable production of up to 1 Tonne of beef bone hydrolysate for production scale trials substituting trim or fine textured beef in Proform HMEC product, enabling a business case assessment. Additional to this, the opportunity to investigate the hydrolysis process first hand and assess its potential for red meat products was also important.

The hydrolysis trials were initially planned for late June, but as identified in Milestone 1, a delay of 4 weeks due to shipping delays resulted in trials being re-scheduled for 18th July 2016. While a week was planned for installation and commissioning of the hydrolysis plant, the reactor was unfortunately held up in customs due to incomplete accompanying documentation, leaving 1 day for installation and commissioning (see 8.2.1 in Appendix 2). It should be noted here that CSIRO Food Innovation Centre helped make the impossible possible in that one day.

The operational process flow with hazard and safety review (see Appendix 3) was completed and constructively assessed with CSIRO Food Innovation Centre team. Several areas were highlighted correctly (see 8.2.2 in Appendix 2) as needing correction and were adopted.

Figure 3 Hydrolysis trial equipment layout

The process as put together (Fig 3) was laid out in a straight run, so that services were available where needed and access down either side was available. This also was the most practical for levelling equipment, as all the flooring was slopped to central drains.

As identified earlier the necessity of having to size reduce the bones, resulted in a significant reduction in what could be accomplished within the one week for which resources were contracted. The hogger took a day to locate, hire, transport, rewire (switches, cables and plug), clean and test, leaving 4 days for processing.

The processing rate of the hogger was dependant on jamming, without jamming the 1.2 tonne of bone could have been processed in one day at around 150 to 200 kg/hr. Instead the hogging rate was around 50 kg/hr with the bones being dipped in hot water prior to hogging as this reduced the jamming, which initially was continuous.

The first batch prepared for hydrolysis was prepared as planned (see Table 2), these levels were found to perform similar to MeatCo's Netherland based results. Hence these were continued with throughout as time for experimenting was minimal. The rest of the batches were increased to maximise the reactor volume only.

It was obvious that we would not be able to process the desired 1 Tonne of hydrolysate, so plans to at least achieve close to 400 to 500 kg (enough to make product at low rates or to utilise Proform Foods pilot process to make product) were put in place.

The preservative chosen was 'Opti.Form SD4' from Corbion, which is lactate based and works well with the anti-oxidant chosen, which was 'Rapsolution AO OS' from CBS Foodtech which is rosemary based . Together the two work well with meat products. In discussions with the suppliers we may have used both at the lower end of what is recommended; the most crucial will be the rosemary extract since while the finished product is frozen, it is still needed to perform its function.

4.2.1 Trial observations – bone hydrolysis at CSIRO

The first batch, while being excellent, had to be held over-night as it was not sufficient to run through the 3 phase separator. To ensure this would not spoil, the temperature of the holding tank was set on 70̊ C (Note: the jacket temperature was set up with an automatic temperature controller, controlling direct steam injection into the circulating water supply see Fig 4(a)). In the morning the batch was found to have an undesirable smell (not spoilt, but unacceptable). The temperature of the jacket circulating water indicated correctly but the contents of the tank were only at 44.5̊ C.

It was determined that either the boiler had gone down over night (no record of this happening) or that the volume in the tank was too small to be effectively heated by the jacket (which did not appear to heat the bottom of the tank). It was decided to dump this batch by running it through the separator to remove the fat and send the hydrolysate to waste.

As time was getting tighter, a crisis plan was put in place. This involved ensuring we had enough bone size-reduced to run 3 batches in one day. Additionally we lost our GEA centrifuge expert who was called away on an emergency support job. The bone was size reduced and stored in liner bags in cardboard boxes stacked 5 high in the freezer to minimise refreezing over-night.

A first batch was prepared on Thursday night as we were constrained to finish at 5 pm on Friday night (allowing time for wash-down). This batch was held with a jacket temperature set at 95˚C, and actually heated up to 90˚C prior to finishing that night. In the morning the circulation temperature was again reading correctly at 95˚C but the product had cooled to 65˚C (this conundrum remains unsolved) but the batch was still in a good condition from an odour assessment.

The remaining two batches were processed on the Friday and the GEA expert returned to assess how to best separate the emulsion. While the 3 phase decanter was the same as MeatCo's its operating parameters were significantly different.

Figure 4 Equipment challenges (a) Holding tank heating (b) Kason screen blinding

As a 1mm screen had been used in the Kason sieve, there were very few solids in the emulsion, this was then exploited to see if clean fat could be separated at this stage. The benefit of this is only a polishing centrifuge would be needed, which handles low levels of solids but gives a polished fat stream, reducing the required asset investment. This was found to be the case and could be considered, provided a reliable 1mm screening system can be sourced (the Kason screen was a multilayered screen and became contaminated with fine bone which could not be removed, see Fig 4 (b)).

The spin test of the samples collected, while evaluating the centrifuge, clearly indicate that with a 1 mm screen very few solids remain (around 1 to 2 % in the hydrolysate when run to minimise fat, see

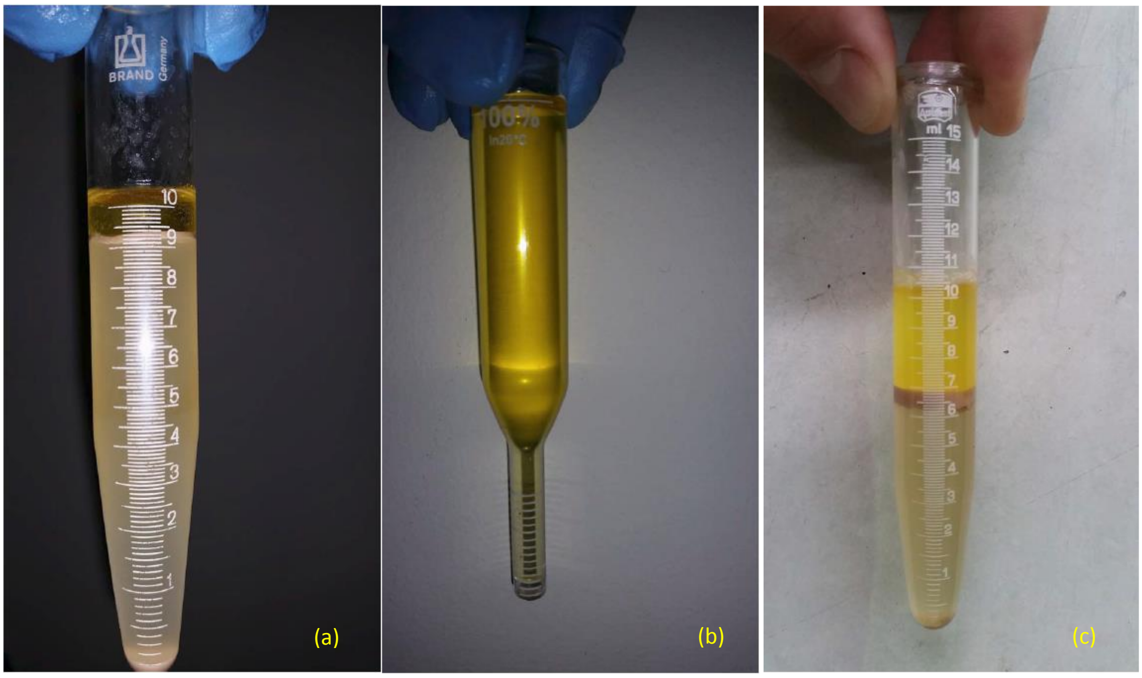


Figure 54 Fat split test results (a) Hydrolysate run to minimise fat (b) Quality of fat when run to produce clean fat (c) Hydrolysate resulting from 3 phase separator trials

Fig 5 (a)). The fat that can be produced when targeting clean fat showed no presence of water (see Fig 5 (b)). Unfortunately the result of making these assessments meant we ended up with too much fat in the hydrolysate (see Fig 5(c)). GEA offered to provide assistance, when we were ready, to spin this back to whatever fat was required (below 10 %). It was planned to do this just before transferring the material to Sydney, so we could add additional anti-oxidant at the same time.

4.2.2 Trial observations – Hydrolysate in Proform Foods HMEC

It was noted that each of the 200 l drums collected (3 in total) varied in fat content between 20 and 30%. It is believed this was the result of separation while transferring, as the liquid height was below the stirrer during the last 1.5 drums.

In discussions and planning with Proform Foods, formulations were modelled looking at replacing 30%, 50%, 70% and 100% of FTB in their textured meat product (Proform HMEC), using both the full fat hydrolysate (~ 24% w/w fat) and reduced fat hydrolysate (<10% w/w). These results indicated that it was feasible to run full fat hydrolysate at 70 % replacement of FTB and maybe 100% with minor increases of the cereal component to maintain protein levels.

The trial replacing FTB in Proform HMEC with hydrolysate was a challenge, as we were replacing a solid product (fine textured beef) with a liquid (hydrolysate). The hydrolysate drums were first thawed and then combined and mixed to provide a uniform material supply see Fig 6(a). Batches of hydrolysate were combined with some of the cereal supply replacing 100% of the FTB, these were blended and tested to see if they had the elasticity needed for the feed pump to handle, see Fig 6(b).

To get the elasticity correct some of the water content (22%) was reduced from the pump feed and made up for in the cooker, see Fig 6(c). While this was still at the limits of what the pump could handle, a consistent feed could be maintained see Fig 6(d).

To reduce the complexity the flavour and colour additives were left out of the mix as these were not essential and would only hinder the assessment of the texture able to be achieved.

Figure 6 ProForm HMEC trial preparation (a) Blending hydrolysate (b) testing mix elasticity (c) Preparing batches for pumping (d) Pump feed with single batch

It was decided that we would run just the one production trial at 100% replacement of FTB, as time was constraining and this would enable sufficient investigation time should things prove difficult while maximising the outcome. The trial result was a success with excellent product texture being achieved.

It is noted here that while this texture is excellent it does not exactly match Proform HMEC, in that the FTB meat content provides a texture that appears a little more particulate. It was generally agreed that 75 to 80 % replacement could enable sufficient FTB (20 to 25%) to satisfy product appearance requirements.

These trials utilised high fat content hydrolysate (~24% w/w) and provided stable running conditions with good textured product. This simplifies the hydrolysate production process by requiring only a decanter centrifuge to ensure no bone fines. During the trials at CSIRO it was noted that there was also very few fines (1 to 2% w/w) as most were removed with the 1 mm screen. Hence the workload of the decanter centrifuge will be low, minimising operator involvement, noise, energy and capital cost.

While the fats extracted from the bones are likely to be of high quality, the hydrolysate has been valued at $1,200/tonne in its high fat form (~ 24% w/w), negating any benefit of separating the fat out. The low fat hydrolysate has been valued at $1,500/tonne as it has superior processing benefits, but requires fat separation and polishing. The high fat value has been used in the hydrolysis ex-ante business case assessment see section 4.3.2.

4.3 Ex-ante business case analysis

4.3.1 Powdered Meat

The raw material for powdered meat is that material that is still food grade but is sent to rendering as it is not valuable enough to justify freezing/storage or sales costs, this material is often high fat trim, bone and offal.

As identified during the trials, there is a possibility of two *product types*, being;

1. Milled material processed at over 60 C, where the fat is separated and the protein and ash is collected as a cake,

And

2. Milled material processed at around 40˚C, where the fat cannot be easily separated but the proteins are highly functional (undenatured).

In both cases the DM70 product (70% CL70 trim and 30% bone) will be considered, recognising that product type 1 could easily be any CL trim while product type 2 will be constrained by the application in which it is utilised.

It is proposed that 'type 2' products may suit offal raw material sources as well as bone and fat trim which can be utilised as meat content in sausages, salami, or other processed products requiring water binding, flavour enhancement or valuable meat extension (replacement).

The value of the DM70 'raw material feed' becomes very low (cents/kg) as soon as it is directed to rendering. This competitive value must be considered, it is what the material is worth as a rendering feed material given most processors have these assets already.

4.3.1.1 DM70 raw material value

The two main products produced through rendering are tallow and meat and bone meal (MBM), these were respectively $1045/tonne (Damian Evans, 2017) and $600/tonne (George Schinard, 2017) in March 2017, the estimated average over the last 2 years being $842 and $614 respectively (Cheetham, 2017). Using the average moisture and fat contents of MBM at 5%w/w and 10%w/w for beef respectively, the contribution of the raw materials to tallow and MBM has been estimated (MLA, 1997) giving:

Boning room bones yield - 19% tallow and 45% MBM, and

Boning room fats (trim) yield - 60% tallow and 12% MBM (MLA, 1997)

This gives a current rendering competitive value using DM70 raw materials (30% bone, 70% trim fats) of;

(0.3 x 0.19 x $1045) + (0.7 x 0.6 x $1045) = $499 for tallow

(0.3 x 0.45 x $600) + (0.7 x 0.12 x $600) = $131 for MBM

Total *current* rendering value of DM70 raw materials = $630/tonne

And an average value over the last 2 years of;

(0.3 x 0.19 x $842) + (0.7 x 0.6 x $842) = $402 for tallow

(0.3 x 0.45 x $614) + (0.7 x 0.12 x $614) = $134 for MBM

Total 2 year *average* rendering value of DM70 raw materials **= $536/tonne**

The value of the rendering raw materials has been previously estimated at 34 cents per kg overall, (48 cents for boning room trim fats and 36 cents for bones, per kg) (A.MQA.0018, 2014), based on revenue minus costs. It is not clear if these figures include margin or not, it has been assumed here that it does not.

Using this, the raw material value for DM70 feed materials has been estimated as;

((0.3 x 0.36) + (0.7 x 0.48)) x 1000 kg/tonne = $444/tonne of raw material

Based on process moisture loss we require 1.92 tonne of raw material to make 1 tonne of DM70 product.

Hence cost of raw material to make 1 tonne of DM70 is **$852/tonne**

This is a very high value for a mix of raw material that currently goes into rendering to generate a reduced total volume of tallow and MBM product worth $842 and $614 per tonne respectively.

4.3.1.2 DM70 product values

4.3.1.2.1 DM70 product type 1

Product type 1 milled at over 60°C, fat is separated and the protein and ash is collected as a powdered cake stable at room temperature

Type 1 product produces both a meat extender and high quality edible tallow, it can utilise low CL trim, with the meat extender maintaining good functionality due to the very short processing time (less than 1 second).

However the extender is slightly darker than fresh meat as can be seen in Fig 10 and depending on how much fat is removed, will have an ash content between 10 and 30% w/w which may limit its application. The ash content can be reduced through reducing bone addition, but used at moderate levels this is unlikely to be concerning as it will be rehydrated in use. This product will benefit from the modification in Day 3 trials in that there should be no grittiness.

It is proposed to use it to improve water holding capability of meat products (maintaining namer status) at use levels of 20 to 30% w/w (rehydrated equivalent), as previously shown with powdered 90 CL trim in A.MPT.0036 (Dahm, 2014). This could effectively substitute for the equivalent amount of 90 CL trim.

While the product can be vacuum packed and stored at room temperature, the obvious benefit of this product would be its inclusion directly into products produced locally in association with the abattoirs processing it.

To determine the product type 1 value, it is necessary to estimate the cost of goods (COG). To this end the following are evaluated; a) Energy cost, b) Labour cost, c) Repairs & maintenance cost and d) Financial cost.

Energy cost

Using the total milling plant power demand possible, at 'non time of use' (nToU) power rates for small business, 11.0892 ¢/kWhr (Ausgrid, 2017).

Total kW demand possible = `1,090. kW (motors, see Appendix 8) + 288 kW (Energy required heating to 70 C, this will be via an indirect gas burner if required – but costed electrically to reduce risk)

Total hourly cost/tonne = 1378. kW x 11.0892 ¢/kWhr

= **$153 $/tonne**

While this appears considerably more expensive than rendering which was estimated at $68/tonne in 2006 (A.MQA.0018, 2014), allowing for the change in the energy price index for Australia (excluding SA as the last 2 years have been extreme) this becomes;

August 2006 index average was 4.7077 ¢/kWhr and May 2017 index average was 11.825 ¢/kWhr (Energyaction, 2017), which is an increase of 2.5 times. Hence scaling Rendering costs to today's dollars makes it $170/tonne.

The powdering process will require regular CIP operation which will incur some additional hot water costs, but it is not expected to exceed an hourly cost of $10/tonne, making the process energy competitive with rendering

Labour

This process will require a single skilled operator, while semi-automated, blockages and breakdowns will occur, these being expected in the ancillary operations of; initial size reduction, transfer pumps and fat separation.

Labour is costed at the high end at **$54/tonne** of product as skills are essential. This compares to the average rendering labour cost of $32 in 2006 (A.MQA.0018, 2014) adjusted to 2017 using the wage price index (ABS2, 2017) giving $45/tonne.

Repairs and Maintenance(R&M)

Repairs and maintenance on the mill and air ducts are unknown as this is the first application of this technology to powdering meat. The process has considerably less moving parts than a rendering operation, but those that move, move fast. General mill wear is well understood and will be managed under weekly and monthly surveillance. For simplicity Repairs and Maintenance will be equated with rendering which in 2006 the average was $48/tonne of product (A.MQA.0018, 2014) which can be indexed to 2017 using the manufacturing index change for food manufacturing 123/85.2 (ABS1, 2017) giving **$69/tonne**.

Totalling the cost of goods (COG) above, see Table 1

Table 1 Total cost of goods excluding finance for DM70 product type 1

	Raw material	Energy	Labour	Repairs & maintenance	Total COG
$/tonne	852	153	54	69	**1128**

With product type1 it will be easy to manage the final moisture content, ensuring an optimal 6% w/w. This will be done at the exit of the mill prior to fat separation and will modify the results in Table 2.

While more tallow could be taken, it is worth more in the extender. So for each tonne of product produced we get 0.5 tonne of tallow and 0.5 tonne of extender.

Substituting 90CL trim directly with DM70 meat extender would provide the following revenue:

(Note: DM70 needs to be rehydrated which would mean effectively reducing the amount required to match 90 CL trim. It will have the capacity to hold at least 3 times its own weight of water which would quadruple the amount produced). For this exercise we will just *double* the amount, recognising there is the potential for further earnings.

Value of 90 CL replaced = 1.0 tonne/hr extender x $6,496/tonne 90 CL trim (MLA market report - May 18th, 2017) = $6,496/hr

Value of tallow recovered = 0.5 tonne tallow x $842/tonne tallow (Cheetham, 2017)
= $421/hr

Total earning value of DM70 product type 1 = **$6,917/tonne (1 tonne/hr)**

(Note: It is recommended replacing just 20% of 90 CL trim in a product with DM70 product type 1 extender initially, until confidence of its full impact is better understood for each product)

This value compares very favourably to the value for rendering these materials.

Financial costs

The financial costs is based on financing the entire process plus the addition of a polishing centrifuge process. This gives a total asset investment of

Total asset investment = €confidential + €57,640 = €confidential = AU**$confidential**

To cover the cost of financing/investment a 20% internal rate of return (IRR) has been applied. Additionally a 1 year lag phase has been added for purchasing and installation. A summary of the key inputs for the net present value (NPV) calculation are given in Table 2 and a plot of discounted cumulative cash flow is presented in Figure 7.

Table 2 Cost benefit analysis for powdered red meat product type 1

Product value ($/tonne)	$6917.00
Plant cost ($millions)	$CONFIDENTIAL
Maximum output units (tonnes/yr)	1,920.00
COGs $/tonne base	$1128.00
Req. rate of return %	20

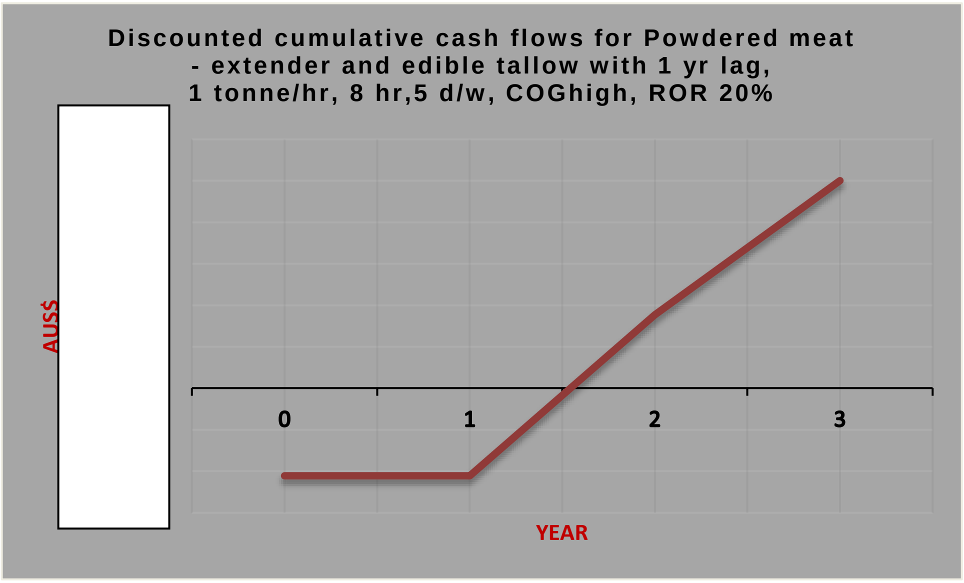


Figure 7 DM70 product type 1 discounted cumulative cash flows

This is an extremely profitable proposition with a potential to extend the applications of the extender product type 1, while also providing a means to potentially recover other rendered materials that may be leveraged similarly.

4.3.1.2.2 DM70 product type 2

Milled material processed at around 40 C, where the fat cannot be easily separated but the proteins are highly functional (undenatured).

As indicated 'Day 3 Trial observations' DM70 product type 2 extender (rehydrated) was perfectly able to substitute 30 % of CL90 trim, one for one, in 100% beef sausages, maintaining product acceptance (limited only by a lightening of colour). The fat content is very high, which may also limit its use, however as it is rehydrated this drops significantly.

It should be noted here that these are being used as extenders not replacing protein content, these products are about cost reduction while maintaining product form, product namer and taste.

This product utilises the same raw materials and process as DM70 product type 1 but there is no tallow separated, maximising the production of extender. The main difference is that the water has been removed with the fat mostly solid under shear, which has resulted in a stabilised emulsion of fat and protein. The fat cannot be separated by centrifuge until it is heated to over 80̊C. A number of emulsion breakers were trialled with no success. The outcome is similar to that achieved with an emulsifier where when heated the proteins start to denature before the fat is released.

The COG will be left the same as for DM70 product type 1, see Table 1. Although the process does not need a centrifuge, reducing hot water demand and possibly less labour and repairs & maintenance also.

The difference is that this product is much more functional as the meat proteins have not been thermally damaged and can easily replace up to 30% of 90 CL in 100% beef sausages.

The value of DM70 product type 2, allowing for only double the amount of extender due to rehydration is;

Value of 90 CL replaced = 2.0 tonne/hr rehydrated extender x $6,496/tonne 90 CL trim (MLA market report - May 18th, 2017) = **$12,992/hr**

The asset investment does not require centrifuging for polishing so is;

Total asset investment = €confidential = AU**$confidential**

Again allowing a 20% IRR and a one year lag phase for purchase and installation, the discounted cumulative cash flow shows this option is at least 2.5 times better than product type 1 and only requires one 8 hr shift per day.

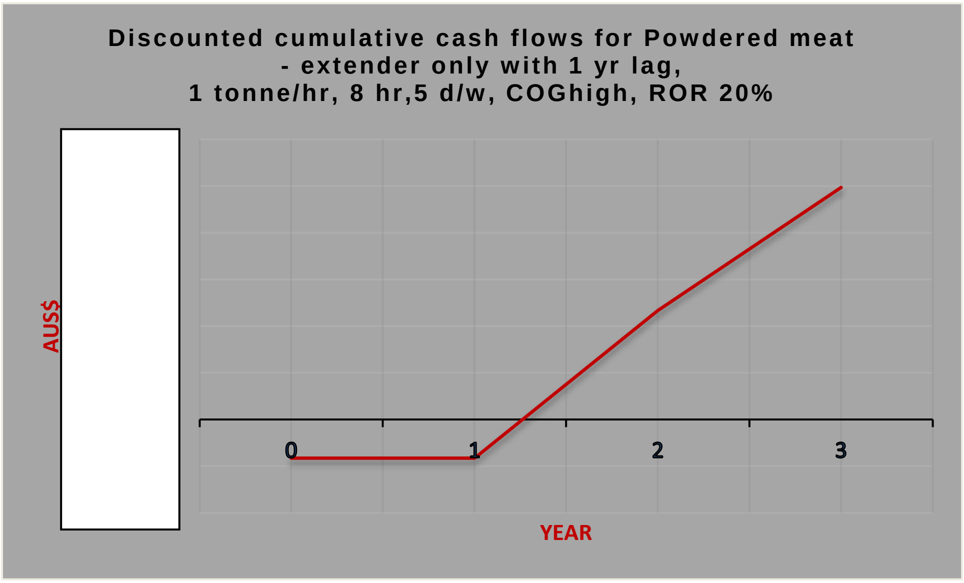


Figure 8 DM70 product type 2 discounted cumulative cash flows

In summary the potential of these products exceeds the treatment evaluated here, being meat based food products they may have a much wider array of applications which better utilise their; undenatured status, taste, water holding ability, namer claim and shelf stability.

This process is currently limited to 500 kg/hr per mill as it utilises a very new rotor design which it appears is not yet available in the larger mills. The trial cyclone concept developed has proven successful and Jäckering has added considerably to this. It is expected that the process cost may become much more competitive as further advances are achieved.

As this new process stands, it is simple, safe and commercially available for MLA. This is a very attractive opportunity and should be commercialised as the returns to both processors and producers will be considerable. Risks created include the significant change it may have on the rendering process and the products produced which have become global commodities. The main aspect of concern will be removing a significant part of the protein and fat from rendering (low value trimmings) which may result in a lot higher ash levels in MBM. It is most likely that a balance will be found where the returns are maximised without over stripping raw materials for rendering.

This process is not a replacement for rendering, as it does not process non-food grade or specific risk material, what it does is provide an opportunity to recover food grade material that would otherwise be too expensive to recover.

Other than some work for MeatCo it appears Jäckering mills have not been used for meat products at all. Jäckering is a flour milling company that started making their own mills in 1955 and now manufacture mills for a wide range of materials including, plastics, metals, chemicals and foods. They see their future in mills.

4.3.2 Bone hydrolysis

The product produced from this process 'Beef product hydrolysate' is made from the digestion of beef bones with some meat still attached. The process just as easily can process bones that have been through a meat recovery process, in which case the product would be 'beef bone hydrolysate'.

These bones come from those food grade bones that currently get directed to rendering because they are too difficult/expensive to freeze quickly. The process specified by GEA/MeatCo is included in Appendices 5 and 9.

The value of the product has been set by targeting the customer as it will be used to substitute for Finely Textured Beef (FTB). The full fat hydrolysate is costed at **$1,200/tonne** as it has a significant lower protein content and must be balanced with additional protein sources.

As with the powdered meat these bones have been priced at 36 ¢/kg. Unlike the powdered process the raw material infeed rate sets the capacity of this process (product output of hydrolysate plus fat is the same) which is 1 tonne/hr of bone cake. Bone cake is ground/chip bone to dimensions of less than 12 mm.

This gives a total raw material cost = **$360/tonne**

The energy cost is estimated similar to the powdered meat, with total kW of the process being; Bone preparation kW + Screening kW + GEA process kW

165 kW + 10 kW + 116 kW = 291 kW

Additionally we will need at least 105 kW of steam energy per hour to heat the reactor contents to 50 then 90˚C. Assuming we use electrical generation to supply steam (worst case) then;

Total energy cost = 396 kW x 11.0892 ¢/kWhr

= **$44/tonne** (i.e. at 1 tonne/hr)

While the process is semi-batch, this is mostly automated, although cleaning will require additional labour. Overall a single skilled operator will be required similar to the powdered meat process.

Labour required for bone hydrolysis = **$54/tonne**

Repairs & maintenance will be simple to medium, estimated at 4% of fixed capital investment annually (Sari, 2017). Using total asset cost below of $confidential and total production output being the same as the powdered meat at 1,920 tonnes/year, this gives;

Repairs and maintenance for bone hydrolysis = **$72/tonne**

This gives the total COG as shown in Table 3

Table 3 Total cost of goods for Bone hydrolysis

	Raw material	Energy	Labour	Repairs & maintenance	Total COG
$/tonne	360	44	54	72	**530**

Financial cost

The size reduction to the spec of 12 mm is not part of the GEA specification, it will likely be a locally sourced shredder, if this can meet requirements. For now, a Titan prebreaker and grinder has been specified and priced in stainless steel at AU$confidential to eliminate an unknown, see Appendix 11. Added to this will be a small live bottom stainless steel feed bin to accumulate the bones prior to grinding at $50,000. The screening process will also be separate to the GEA quote as this needs to be continuous, such as the Kason centri-sifter price 2002 US$60,000 (Peters, 2017) converted to 2017 using 240.8/181.9 (Anon, 2017), then US$ to AU$ (multiply by 1.32) gives $0.11m

The proposed delivery to the end users at this stage is as frozen blocks produced utilising existing blast/plate freezer facilities.

As the tallow will not be separated at this stage the total cost of the process proposed is;

Bone cake prep. + Kason screen +GEA quote = $confidential + $0.11m + $confidential

Bone hydrolysis total asset cost = AU**$confidential**

Again, assuming an internal rate of return of 20% to cover financing. No lag phase has been added for purchasing and installation as the equipment is standard. A summary of the key inputs for the net present value calculation are given in Table 8 and a plot of discounted cumulative cash flow is presented in Figure 27.

Table 4 Cost benefit analysis for bone hydrolysis process

Product value ($/tonne)		$1200
Plant cost ($millions)		$confidential
Maximum output units (tonnes/yr)		3840.00
COGs $/tonne base		$530.00
Req. rate of return %	20	

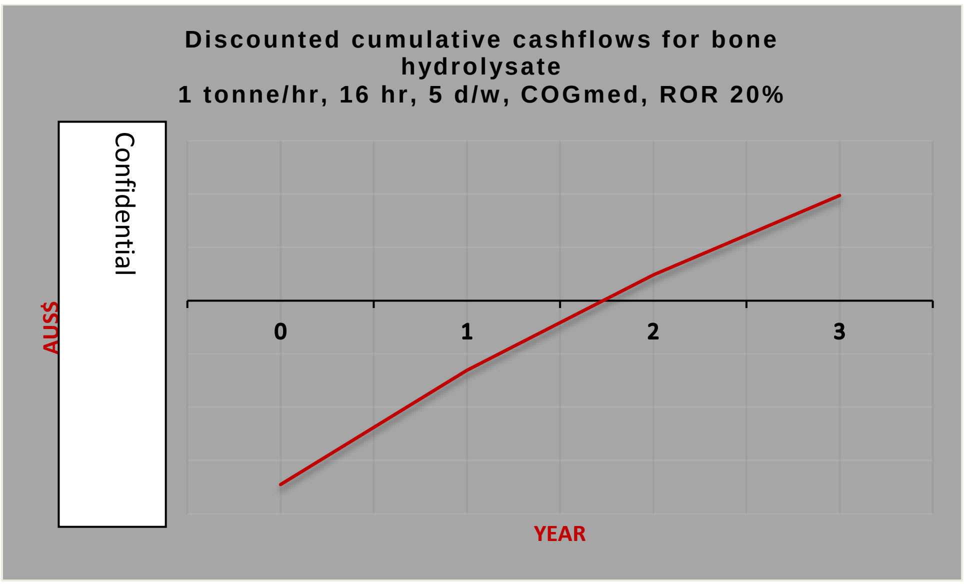


Figure 95 Bone hydrolysate discounted cumulative cash flows

It is worth noting that this process while generating positive earnings at 1 tonne/hr does require at least 2 shifts per day to pay back in a reasonable period. However it does scale-up very well if the raw material supply is large enough.

Obviously the smaller the bones are size reduced the more efficient and faster the process becomes, it is proposed that a shredder style size reduction process may be adapted to achieve this at a substantially reduced asset cost to the pre-breaker and grinder and should be considered in the future, but will need development.

5 Conclusions/recommendations

5.1 Powdering

The results from the powdering trials are very rewarding, opening up a wide range of options for this process, especially a potential process for human food grade rendering in an instant.

Both product concepts proposed based on DM70, present as positive investments with breakeven positions being achieved within two years, even allowing one of these years for purchase and installation. The option to produce just the powdered meat extender with no tallow was the best performer generating income at 2.5 times the extender and tallow option.

It is recommended that this process be adopted first as a pilot, possibly through an MDC project, to increase our knowledge base on how best to utilise the products proposed and provide a means to explore the other potential opportunities including offal stabilisation.

Any processor considering a new rendering investment, especially those with local further meat processing facilities, should seriously consider this powdered meat opportunity.

To reduce the risk of this process not being utilised it is recommended that a review of this projects findings be undertaken by processors, as a more practical and informed assessment.

5.2 Hydrolysis

Production of sufficient bone hydrolysate for full scale product inclusion trials was successfully achieved in essentially a ‘pop-up style’ mini manufacturing process set-up at CSIRO Werribee.

The preservative and anti-oxidant trialled were successful although it is recommended their rate be increased by 50% (confirmed by suppliers) as 6 months frozen storage was near the limit based on product shelf life after thawing (less than one day at 10˚C).

The inclusion trials successfully showed that bone hydrolysate can be used to substitute finely textured beef (FTB) at 70 to 80% in Proform Foods HMEC, maintaining excellent texture with no disadvantages. However the product would have to be frozen for handling considerations, which simplifies delivery also.

The ex-ante business case assessment has shown this opportunity to be a positive investment option with a breakeven occurring within two years, but would require a two shifts/day operation at 1 tonne/hr processing rate. This process does scale very well and it is proposed that this would be the best method of adoption, as it is a semi-batch process and the constraining process is the separator which could be doubled for a minor increase in project cost.

6 Key messages

Any processor considering a new rendering investment, especially those with local further meat processing facilities, should seriously consider this powdered meat opportunity.

Any material that is food grade before it is sent to rendering should be converted into powdered meat extender using this powdered meat milling process as the returns, present as significant.

7 Bibliography

A.MQA.0018. (2014). *New products, Co-product and Value adding Innovation Training.* North Sydney: Meat and Livestock Australia Limited.

ABS1. (2017, May 22). *Input to the Manufacturing industries, subdivision index numbers*. Retrieved from Australian Bureau of Statistics: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6427.0Mar%202017?OpenDocument

ABS2. (2017, May 23rd). *Australian Bureau of Statistics*. Retrieved from 6345.0 - Wage Price Index, private Australia, Mar 2017: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6345.0Mar%202017?OpenDocument#Time

Anon. (2017, May 28th). *Producer price index - Food product machinery*. Retrieved from Federal Reserve Economic Data (FRED): https://fred.stlouisfed.org/series/PCU3332413332411

Ausgrid. (2017, May 22nd). Network Price List 2017-2018. Sydney, NSW, Australia.

Cheetham, A. (2017). *MLA Co-product market report - April 2017.* North Sydney: Meat and Livestock Australia.

Dahm, C. (2014). *Powdered Meat.* North Sydney: Meat and Livestock Australia.

Damian Evans, C. F. (2017, May). Renders Circle 37. Australia.

Energyaction. (2017, May 22). Retrieved from Energy Action Price Index: http://www.energyaction.com.au/energy-procurement/energy-action-price-index

George Schinard, W. G. (2017, May). Rendering Circle 37. Australia: www.ausrenderers.com.au. Retrieved from www.ausrenderers.com.au

MLA. (1997). Rendering yields - 1997. North Sydney, NSW, Australia.

(2017). *MLA market report - May 18th.* North Sydney: Meat and Livestock Australia.

Peters, M. S. (2017, May 28th). *Plant Design and Economics for Chemical Engineers - Cost Estimator*. Retrieved from McGrawHill Online Learning Center: http://www.mhhe.com/engcs/chemical/peters/data/ce.html

Sari, R. M. (2017, May 22). *General process plant cost estimating*. Retrieved from KLM Technology Group: http://kolmetz.com/pdf/EDG/ENGINEERING_DESIGN_GUILDLINE_General_Plant_Cost_Estimating_Rev01web.pdf

8 Appendices

8.1 Appendix 1 Jäckering rotor mill models and capacities

Modell *Model*	Antrieb *Drive* (kW)	Gewicht *Weight* (t)	Maße *Size* (mm)	Leistung *Capacity* (kg/h)	Verdampfungsleistung *Evaporation Capacity* (kg/h)
ULTRA-ROTOR I	7,5/11/15	0,43	1400 x 1000 x 920	10-100	10-25
ULTRA-ROTOR II	11/22/30	2,0	1590 x 990 x 1480	20-200	50-100
ULTRA-ROTOR III	45/55/75	3,0	2610 x 1360 x 1740	50-1200	200-230
ULTRA-ROTOR V	110/132/160	8,0	3110 x 1610 x 2200	200-5000	500-750
ULTRA-ROTOR VI	200/240/315	13,0	3650 x 2150 x 2300	500-10000	1000-1500
ULTRA-ROTOR VII	315/400/500/900	23,0	4200 x 2360 x 3700	1000-18000	2000-3500
SUPER-ROTOR 25	11	0,42	1300 x 800 x 850	10-100	-
SUPER-ROTOR 75	55	4,0	2610 x 1360 x 1620	100-1000	-
ULTRA-ROTOR CS	18,5-400	4-15,0	-	1000-10000	-

Sondermodelle auf Anfrage – *Special models on request*

8.2 Appendix 2 Lessons learnt

Ensure exporting agent is fully aware of Australian import documentation requirements.

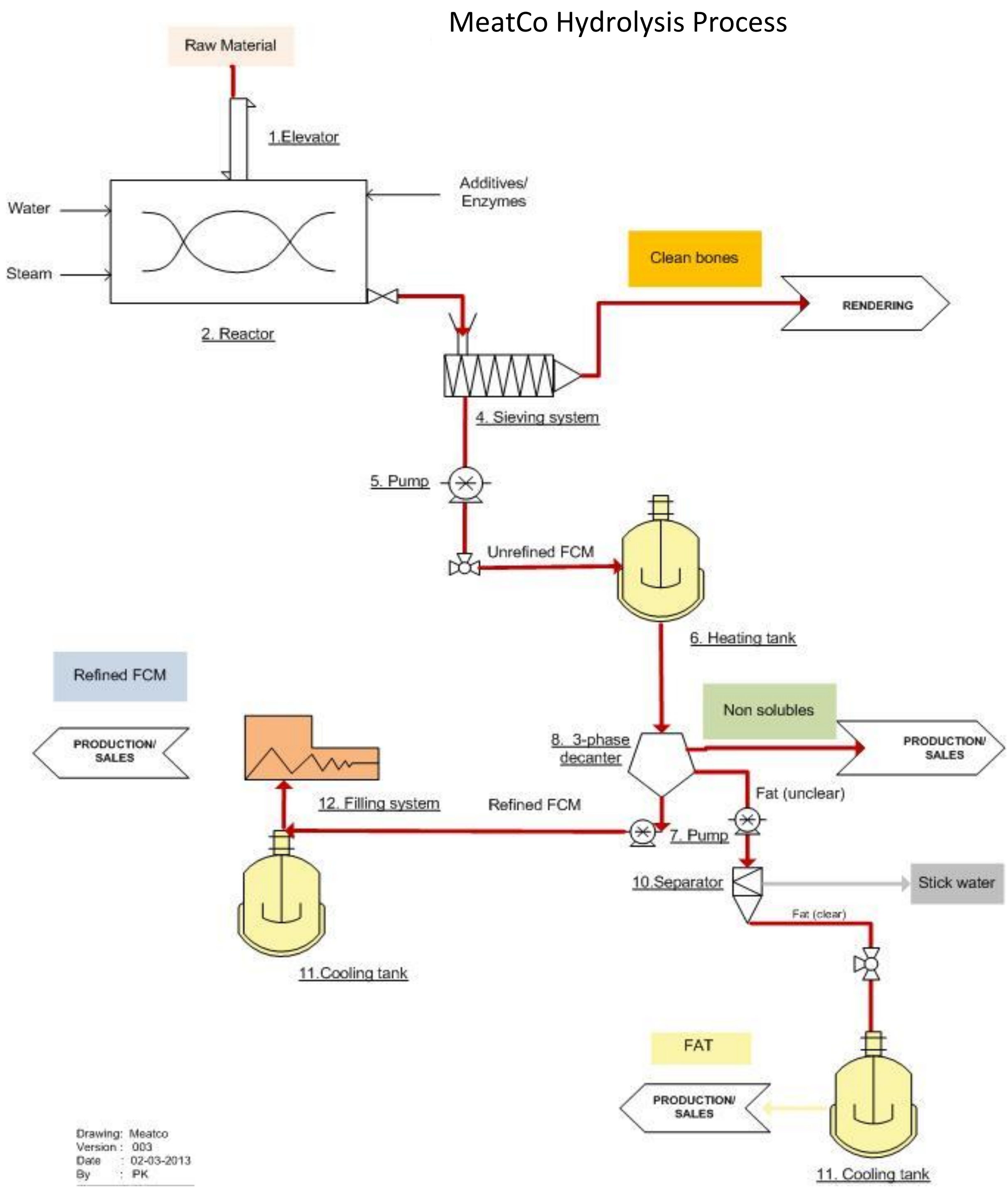
The unit was scheduled to be fumigated (a precaution taken to speed clearance) and all use of correct packing materials were planned. Unfortunately communication of exact documentation requirements were not clearly understood between local agents and the Netherlands agent with; letterheads being correct, dates being in a set time frame and information needing to be on one official page. Communication was very difficult as emails were exchanged with day time differences (9.00 am in the Netherlands being 5 pm here), this resulted in minor matters taking days.

In the end the reactor was charged storage costs as it had over stayed the allocated time permitted for clearance. In all, 4 days were lost, which proved critical for commissioning.

Ensure all hired equipment has been electrically assessed.

Assumptions of hired equipment being regularly serviced does not make it so. In all 3 pieces of equipment hired each had to be inspected as no inspection tags were attached and two of these had to be rewired to add stop start control.

8.3 Appendix 3 MeatCo Hydrolysis Process



8.4 Appendix 4 Operational process flow with hazard and safety review

General note: This is a food process and as such Australian food handling procedures must be followed

Operational process flow for hydrolysing ground beef bone	**Hazard and Safety options**
500 - 600 kg/day conditioned ground beef bones @ 2 degrees C	Temperature critical - Frozen product requires at least 3 days to thaw @ 4˚C
Boxes manually loaded into reactor using step-up platform*, total 200 kg	Boxes 18 kgs, boxes unpacked at ground level into tubs, 2 people carry tubs
50 to 100 kg of water added and mixed, being heated up to 45 – 55˚C, then 200 g of enzyme added*. Digest 45 – 90 min	Temperature critical, - steam pressure low, heating slow. Enzyme addition – rubber gloves, eye protection and mask.
Inactivate by heating up to 80 – 90˚C. Hold for 5 min, then start screening	Temperature critical – holding time variable but > 5 mins
Screen reactor contents through 1 mm Kason vibrating screen manually using buckets, gloves and eye protection essential. As emulsion collected pour into pump hopper and transfer to holding tank at 60˚C.	Burn hazard – safety gloves face shield and apron. Jacketed pump, temperature safe piping. Possible buffer tank?
When 300 to 500 litres collected run through 3 phase centrifuge by gravity feed.	Hot lines - gravity feed reduces risk Centrifuge – precision machine, trained operators only
Collect fat and solids in rubbish bag lined drums (150 kg total, in 6 rubbish bags) when solidified transfer to skip. Direct hydrolysate to cooling tank (pump assist if necessary) and cool to 2˚C before draining into drums (approx. 1.5 hrs).	Hot fat and solids (50˚C), two people to transfer 25 kg rubbish bags to skip.
Transfer drums to freezer, ensure lids loose for expansion (drums must have at least 10% head space). Secure lids 12 hours later.	Transfer drums on pellets with lids fixed closed, when settled, loosen lids.