final report

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Evaluation and Development of High Moisture Extruded Red Meat Trim Products (Stage 2)

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Abstract

Through effective ‘pre-process design’ and ‘formulation investigation’ an effective high moisture extrusion cooking (HMEC) trial process was assembled utilising Proform foods extrusion facilities. Development of this process enabled high levels of fat standardised meat to be processed aiding in a better understanding of texture and flavour impacts of the process. It has been observed that key to forming good texture is a balance of material viscosity and die flow velocity, which have been modified through both formulation and screw configuration while die design was keep constant.

Through a panel review process, a range of HMEC product concepts have been developed. This enabled a Food Service customer assessment of a minced pizza topping cluster style product, finding that ‘the flavour profile was right’ in comparison with typical pizza topping minced beef. Shelf life assessment shows that HMEC product should be frozen as soon as possible to ensure a 12 month storage life and that anti-oxidant addition is required.

An ex-ante cost benefits analysis has been completed for Australian beef supply chains of a new enzyme hydrolysis process which incorporating the HMEC process enables a potentially significant return to the red meat industry.

This work has enabled both MLA and Proform Foods to advance to an MDC commercialisation project (P.PSH.0673) which has now been approved and is under way.

The HMEC technology platform puts the red meat industry in a position to not only grow its markets through better price competitiveness, especially in the Food Service sector, but through leveraging enzyme hydrolysis to improve utilisation markedly, which will result in returns directly back to the producers.

Contents

Project objectives

Overall
This stage will: quantify consumer response to concept products in terms of sensory and willingness to purchase, engage with potential adopters in order to address all relevant needs in an ex ante cost benefit analysis of the HMEC technology and products, and demonstrate a range of red meat derived products possible with HMEC technology, undertake a detailed cost benefit analysis (CBA) and supply chain analysis including export opportunities and product classifications/categorization.

Milestone 4

Final Report

Success in achieving milestone

This milestone has been achieved with acceptance of this final report. The success of this project body of work is confirmed through the enabling of both MLA and Proform Foods to advance to an MDC commercialisation project (P.PSH.0673) which has now been approved and is under way.

The HMEC technology platform puts the red meat industry in a position to not only grow its markets through better price competitiveness, especially in the Food Service sector, but through leveraging enzyme hydrolysis to improve utilisation markedly, which will result in returns directly back to the producers.

Methodology

As a partner to commercialise this technology has been found and an MDC project has been raised, approved and started, the remaining aspects for focus of this final report have been on the supply chain aspects and opportunities.

A brief review of project achievements meeting outcome and objective requirements for the overall project is covered first.

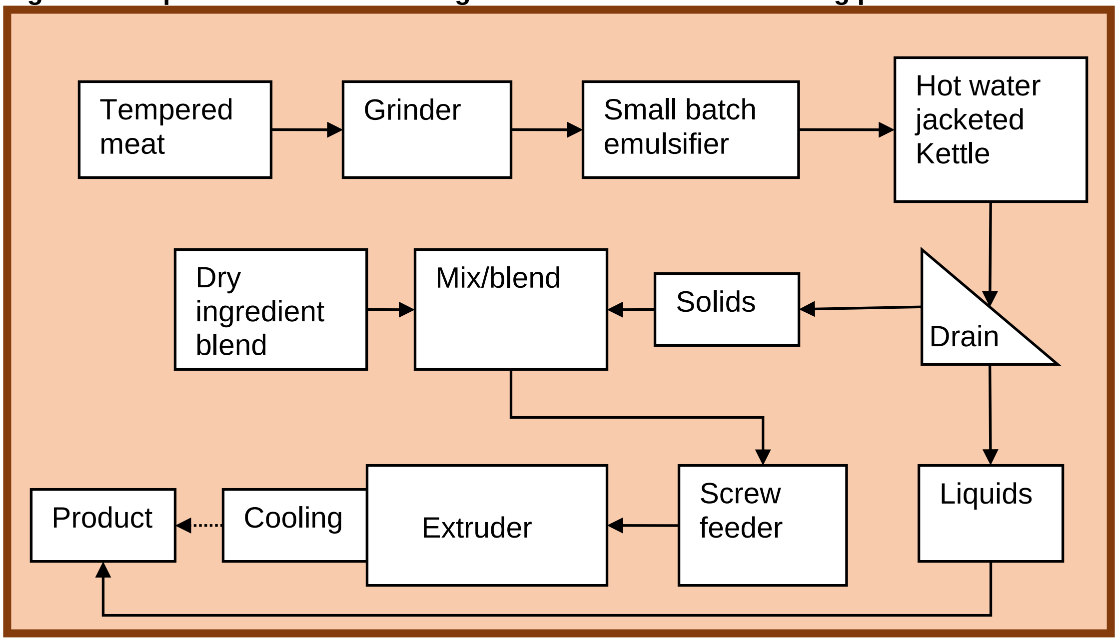
This is followed by a review of the potential issues highlighted in the CBA review completed for the Proform MDC project and an exploration and analysis of opportunities which may mitigate these issues, including hydrolysis, powdered meat and fat standardisation.

Discussion

<u>Review of project achievements</u>

This brief review will respond to questions posed in the project A.MPT.0049 variation deed. To assist in being brief, more details and other findings are included in each of the individual milestone reports. A summary overview of the process assembled is given in Figure 1.

Figure 1 Simple overview of MLA High Moisture Extrusion Cooking process

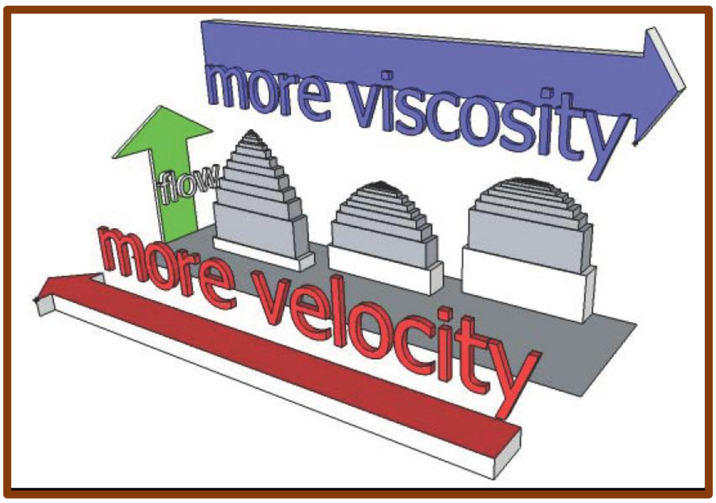


Q1. What range of textures (fibre thickness, mouth feel), colours and dimensions (steak, roast, cubes, thin slice, pulled fibres, shapes) can be achieved with red meat HIMEC?

A1.

i. A range of textures is available (fine fibres, ribbons to sheets). These are impacted by both ingredients/formulation (salt, protein, moisture and fat) and processing conditions (screw profile, melt temperatures, die design and cooling). The key 'process attributes' these impact are viscosity and die velocity which directly impact laminar flow profiles in the die. The flow profile impacts observed have been summarised in Figure 2, which clearly shows that both velocity and viscosity interact to produce specific profiles. Hence a balance is found through manipulating the variable groups above, the most effective being formulation which impacts viscosity, and die design and cooling which impacts velocity.

Figure 2 Effect of viscosity and velocity on material flow in the cooling die

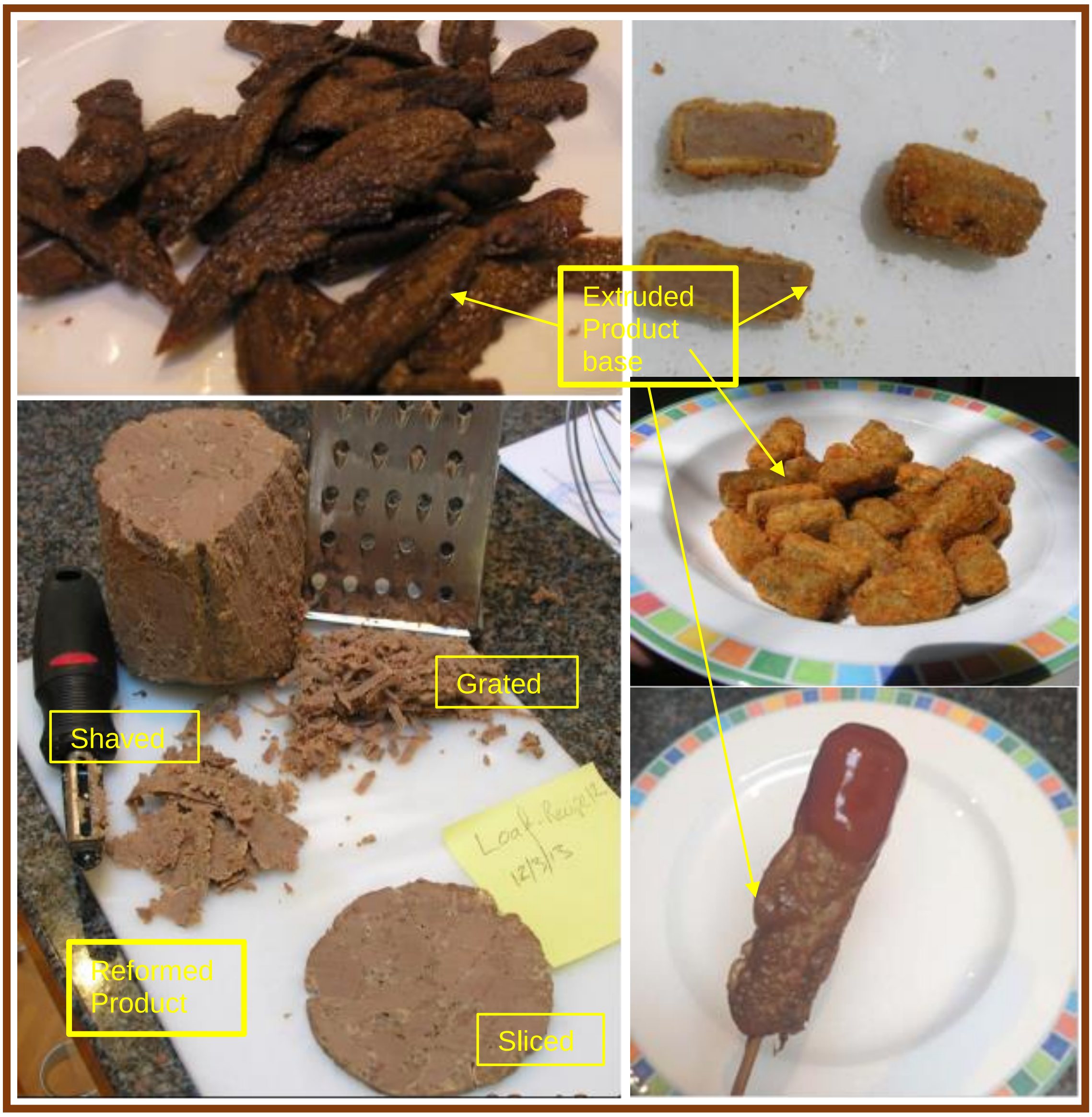


ii. Most colours can be achieved, the challenge is finding those which can survive the processing temperatures especially when requiring natural or nature identical colourings. With meat products, most colour requirements have been resolved with this work covering grey/brown cooked meat through to pink processed meat colours (see Figure 3)

Figure 3 Meat product colours ranging from (a) light pink/brown as a sausage through (b) grey/brown as cooked meat to (c) a strong red/brown colour

iii. The size and shape of the extruded product is limited to the die design, but this can be designed to achieve many different products such as sausages, steakettes, nuggets, shredded or pulled styled product. Additionally the extruded product can be shredded and reformed to make larger loaf products which can be sliced or diced the same as roast or other loaf products (see Figure 4).

Figure 4. Some product shape options using both extruded and reformed extruded product.



Q2. What do consumers think of the product?

A2.
Initially product panels with Marketing and technical reviewers were held to review product development, ensuring customer assessment would be on product that met a high standard. As the meat content was increased to a point where products containing more than 67% w/w meat could be presented, it was identified that external assistance was required to help improve the product flavour and presentation further.

To assist with this a consultant chef (Glenn Austin from X-treme Chef Consulting Pty Ltd) was recruited to assist with flavour and concept development. After reviewing all concepts the following changes were recommended: Colour change back to natural cooked meat style, flavour addition of some specialty culinary flavours, and presentation forms.

A summary of the product presentations is shown in Figure 5. Following panel acceptance of most of the new products, the product selected for assesment was pizza clusters. The opportunity to evaluate HMEC products as a crumble on pizza toppings was proposed by chef Glenn Austin as part of the Global Pizzas Pasta Challenge (GPPC). This was seen as an effective way to evaluate food service customers' assessment of a HMEC based product.

The outcome showed that the GPPC finalists significantly found the flavour profile is right. It was also noted that the finalists believed this to be more a commercial pizzas product than a boutique one.

Figure 5. Chef concepts a) Beef fingers, beef schnitzel and sandwich. b) Healthy meat loaf sandwich and c) Meat loaf parmagiana style d) Beef pizzas clusters e) Beef medallions Recipe

The recipe used for beef fingers, beef medallions and base mortadella loaf	
Recipe 12 component	% w/w
Shredded 60% w/w meat solids HMEC (1.5% NaCl + spices)	47
Beef fat (from separation)	9.4
Beef aqueous (from separation)	13.1
Minced 85 CL trim	23.5
Versagel	3.8
Flavour base: 75 beef/25 roast veg. culinary flavours	3.4
TOTAL INPUT	**100**
Total meat content	**67.1**

Q3. What range of applications of the extruded products is possible? E.g. impingement ovens; crumbing/schnitzel; kebabs; ragout; pie; microwave.

A3. As seen above the product is flexible, however each application does require some formulation development. The following aspects need to be considered for each application.

- With reformed products, a wide range of binders work effectively, but if the heat setting is over 70℃, then allowance for degrading of culinary flavour additive should be considered, especially in large loaf products which may be heated for over an hour. Additions of 20 to 30% may be required. For small products this is not an issue.
- All products have been freeze/thaw stable, however moisture is not tightly held in the extruded product and must be vacuum packed to minimise ice formation and water loss if frozen without further processing
- The extruded product requires flavouring, which can be done through reforming and using culinary flavour additives or a sauce/gravy/coating added to finely torn product.

As a reformed product all processing options investigated and listed in Q3 above have been found possible.

Q4. What is the shelf-life from a food safety point of view; flavour point of view; flavour and colour stability point of view?

A4. In summary all product off the extruder should be frozen as soon as possible with antioxidant added to ensure a 12 month storage life unless it is further processed and packaged (e.g. in retorted pouches). Further work should be completed to assess the correct level of antioxidants to be included as part of any formulation.

While only minor flavour changes were perceived, the rise in both TBARS and Peroxide Values (PV) indicated oxidation, although after 12 months PV's of 1.6 to 2.2 without any anti-oxidants is very manageable. It is likely that this has been minimised through vacuum packing[1]. Colour variation through aging has not been observed with the colourants used for meat products, however with formulation variation this may be expected.

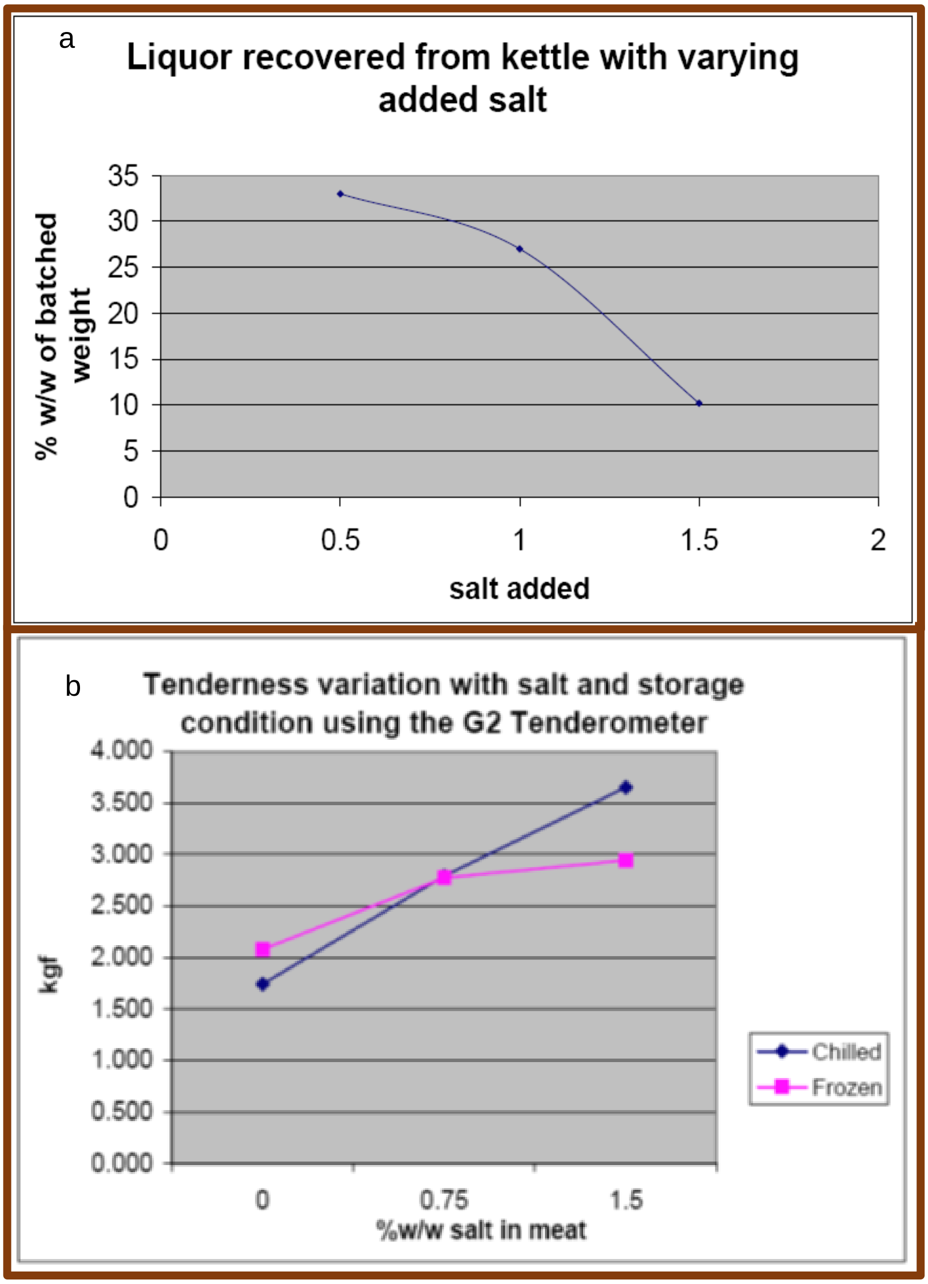
Q5. What flavours can be added and with what impact on texture (e.g. salt)

A5. While flavours can be added to the extruder with the meat and other raw materials, most flavours do not survive the severe extrusion conditions of temperatures up to 140℃ even though the retention time is only around 3 minutes. To ensure cost efficient use of flavours most are preferably utilised post extrusion.

Salt however, is a low cost flavour and is not severely impacted by the extrusion process. Three levels of salt (0.5, 1.0, 1.5) %w/w were assessed both for impact on water holding (during the fat standardisation process) and on tenderness of finished product. With water holding, salt reduced the amount of liquor recovered from the kettle as can be seen in Figure 6a. This had an impact on fat removal which is aided by the water draining through the cooked meat.

[1] Kulkarni, P. R. (1997). Handbook of Indices of Food Quality and Authenticity. Cambridge, England, Woodhead Publishing Ltd.

Figure 6. Impact of salt on water holding and tenderness



Product tenderness was assessed using the G2 Tenderometer, which has been found to provide results proportional to other tenderness measurements. The relationship between salt level and tenderness for both chilled and frozen stored product can be clearly seen in Figure 6b.

Over these levels of salt, increasing salt content increases product firmness, an effect which appears to be dampened slightly when product has been frozen. It should be considered that these results are only applicable for the formulation trialled (50% w/w meat solids), although the effect is significant and consistent with the well accepted effects of salt on water holding capacity and meat binding.

The formulation level of salt for initial concepts was selected to be 1% w/w of the batched meat as a compromise of flavour versus separation efficiency.

Supply chain analysis and cost benefit analysis (CBA)

A CBA has been completed separately from this project for the Proform HMEC (PHMC) MDC project (P.PSH.0673). This analysis highlighted the constraint of raw material supply to PHMC forecasted market volumes into Asia.

It is not desirable for PHMC to compete for the higher (>85 CL) grade meat trim products, as this reduces their competitive price into these markets. To this end a focus has been taken to source lower grade materials that can be upgraded cost effectively for PHMC to meet future sales.

Currently PHMC is looking to utilise mechanically separated meat and upgrade it through in-house fat standardisation. There is a wide variation in the standard of mechanically separated meat and few processors that utilise in-line fat monitoring, as this can be expensive.

While fat standardisation will go part of the way to meeting forecasted supply chain requirements, over the longer term this is projected to be insufficient. This and two other options (see Table 1) have been identified through this project to better utilise carcass components for both improved returns to stakeholders and meeting the potential shortfall in future PHMC raw material supply.

Table 1 Options to meet the potential shortfall in future PHMC raw material supply

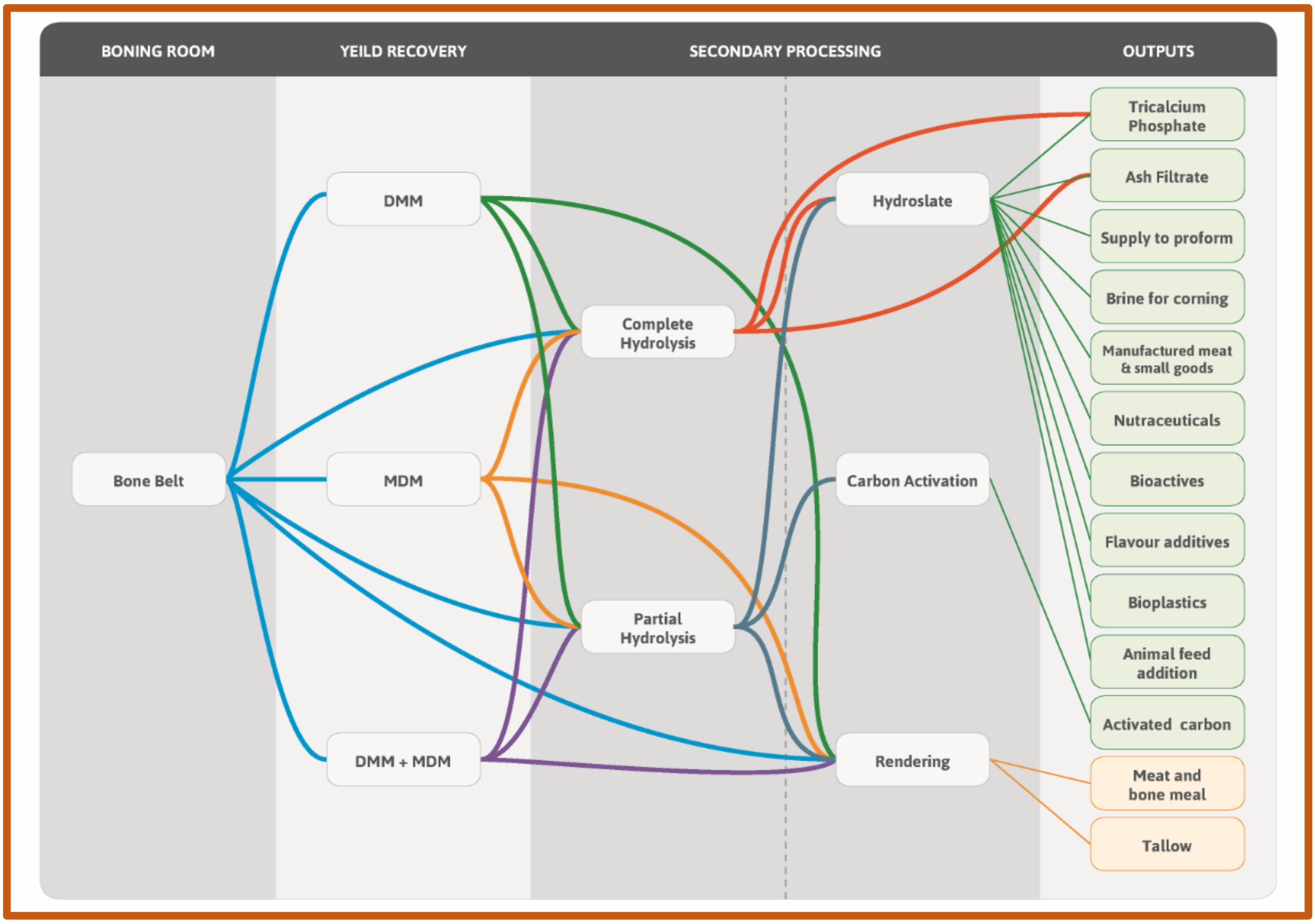
Aspect	Option		
	Meat standardisation	**Enzyme hydrolysis**	**Powdered meat**
Description	The process type is dependent on the PHMC processing rate. If the rate is over 1 Tonne/hr a commercial process (AlfaCold) is viable. At lower rates an in-house solution is required, Counter Current Extraction (CCE)	A new process which has two options, ‘partial’ and ‘complete’ enzyme hydrolysis of bones. Partial removes all meat from bones and Complete breaks the bones down also, leaving tricalcium phosphate and an emulsion.	An adaptation of an existing process using a high speed mill with high air throughput to dry meat products in less than 1 second. This has been developed under MLA projects A.MPT.00(27, 35 and 36)
General benefits	Enables a wider range of existing mechanically separated meat products to be utilised in the PHMC process.	Enables the recovery of meat and bone materials for human consumption instead of rendering, potentially replacing rendering.	Enables recovery of any meat materials for human consumption which do not justify freezing, storage and transport.
Limitations	AlfaCold is an expensive process, while CCE has a reduced yield.	A new process that will need production development from the pilot stage to mitigate risk.	While equipment has been commercialised, this application will still require production development also

Of these three options, meat standardisation is seen as a short term solution, until either of the other two become sufficiently developed. Of the other two the most beneficial to the red meat industry will be the hydrolysis process as this ensures a large part of the carcass is not only utilised, but done so without a significant loss in water, because the emulsion can be utilised directly into the PHMC process.

Enzyme hydrolysis CBA

This project has had a CBA completed on the viability of enzymatic hydrolysis for Australian beef supply chains, the complete CBA is included in Appendix 1. This process is simply using enzymes under controlled conditions to either partially or completely hydrolyse offal and by-products, especially bones. The enzymes target specific peptide bonds resulting in a product called enzymatically separated meat (ESM) which is suitable for food grade use with a protein content around 10%. The opportunity this process presents for market options, both existing and new, and how it can be integrated is summarised in Figure 7[2].

Figure 7 Potential options through utilisation of enzyme hydrolysis



[2] Green. P, Beker. S, & Bryan. K, (2014). Ex-ante viability of enzymatic hydrolysis for Australian beef supply chains. MLA, North Sydney.

With adoption of the enzyme hydrolysis process the Australian red-meat industry gets the opportunity to substantially increase the value generated per head through the following:

- Increase the value of product currently being converted to render and tallow
- Increase the volume and value of low value meat trim
- Increase the volume and value of MDM, DMM and Hydrolysate produced
- Increase the value of by-products suitable for human nutrition & high value pet treat products
- Utilisation of low value meat products in value-added foods
- Additional market options to give confidence to replace rendering plants
- Additional market opportunities other than meat proteins (such as bio plastics, animal feed additives etc.)
- Reduce rendering plant energy costs through more efficient hydrolysis process
- Increased energy savings as a result of the activated carbon system being energy positive**.**

These opportunities are covered in more detail in Appendix 1.

The value proposition for industry over the next 25 years is summarised in Table 2[3]. Each of the 6 period scenarios, assumes a percentage of the industry that has converted to hydrolysis and is in isolation to each of the other period scenarios.

[3] Green. P, Beker. S, & Bryan. K, (2014). Ex-ante viability of enzymatic hydrolysis for Australian beef supply chains. MLA, North Sydney.

Table 2: Opportunity for industry over the next 25 years[3]

SUMMARY PERFORMANCE MEASURES - INDUSTRY	Current	Year 5	Year 10	Year 15	Year 20	Year 25
Hd / annum	8,353,472	8,353,472	8,353,472	8,353,472	8,353,472	8,353,472
	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.
Capital cost (pmt option, upfront)	$140,000	$3,114,501	$6,782,658	$40,695,949	$48,478,607	$88,174,555
Gross return Per head	$0.02	$0.86	$4.16	$17.47	$24.10	$43.62
Total costs Per head	$0.00	$0.12	$0.64	$2.74	$2.96	$5.69
Net Benefit Per head	$0.02	$0.74	$3.52	$14.73	$21.14	$37.93
Annual Net Benefit for industry	$161,287	$6,179,689	$29,419,093	$123,054,778	$176,585,683	$316,856,247
Annual Net Benefit for the ex cap	$175,287	$5,057,040	$20,844,473	$89,444,674	$141,632,744	$248,256,430
Pay back (years)	0.80	0.62	0.33	0.45	0.34	0.36
Net Present Value of investment	$1,091,146	$37,440,287	$172,114,396	$719,849,232	$1,086,062,599	$1,927,347,987

Appendix 1 includes the assumptions used in the model to progressively convert from the current 99.7% of product being rendered down to 11% over the next 25 years as industry converts to meat extraction and hydrolysis. Hydrolysis options however see an increase from 0% to a total of 84%.

As can be seen the potential in improved return to the Red Meat Industry is substantial. The CBA recommends the following: **"**It is recommended to proceed with investment for the application of hydrolysis in red-meat value chain. Initial research indicates it is a viable business proposition and that value well beyond the initial investment will be created for the Australian red-meat industry. In light of these findings, the following recommendations have been made:

- It is proposed to supply PHMC with 30% of the low value meat products used to make HMEC with hydrolysate as the substitute.
- Invest in the installation of a pilot hydrolysis system at a medium or large processing plant. Meatco (Inventors of the process) could either process the product themselves or sell the enzymatically separated meat (ESM) back to the system or alternatively the processor could purchase the system and operate it independently. Note this option would require the inclusion of consultancy fees and patent costs. This would provide further evaluation and justification for larger scale commercialisation of hydrolysis in the red-meat industry in the future".

Meat Standardisation

Meat Standardisation is in essence similar to milk standardisation, which is simply reducing fat content to a level where it is always consistent and hence further processing can be conducted with a level of confidence.

To do this with meat there are a number of commercial processes that can be adopted, but there are two which are properly designed for the purpose, that being the AlfaCold process and Westfalia small capacity plants for the fish industry. A summary of both these processes is included in Appendix 2.

Unfortunately, these processes are generally designed for high capacity through-puts, in the order of 20 tonnes per day, which is appropriate for the full scale implementation of PHMC, but not the pilot production unit. While these processes can be sized appropriately, the costs do not scale down proportionally (still being over $500,000 for around 5 T/d).

Alternative options have been explored, which have included the following:

i. Batch cooking (kettle/tank) and screening
ii. Continuous steam injection and screening or pressing
iii. Continuous cooking (SSHE/screw cooker) and screening or pressing
iv. Counter current extraction (CCE).

i. Batch Cooking and screening

All of the MLA trials for this project have been conducted using a batch kettle and tilted draining (with the lid on) to separate the meat solids from the liquor (water and fat) as shown in Figure 1. This process was fine for trials but does not fit well for a larger scale continuous process as the footprint is large and the variation batch to batch is likely to impact the continuous process. The cost of these processes varied widely and contained added labour costs in operation also, but remains a fall back.

ii. Continuous steam injection and screening or pressing

This was a favoured option as it is continuous and requires a very small footprint. While a range of manufacturers were sourced for supply of steam injection equipment, all but one identified that their injectors were unsuitable for either this product or the low rates. A summary of requirements is included in Appendix 3.

The unit which claims to be suitable is a 'Pick direct steam injector', which is suitable for soups and sauces. However, there may be a potential problem with ground meat blocking the steam outlets, which are fine holes. This unit will be maintained as a fall back to trial.

iii. Continuous cooking (SSHE/screw cooker) and screening or pressing

This option was considered favourably also, as the scrapped surface heat exchangers (SSHE) are very effective, occupy a small foot-print and like the steam injectors are fully enclosed. However if they are used with a screening or pressing process instead of a centrifuge, very little liquor is likely to be recovered, as the trials shown in Appendix 4 indicate.

It is likely that the mixing/shearing emulsifies the fat within the matrix even at this lowest speed (120 rpm) of the Kenwood mixer. Without centrifuge separation the SSHE is not likely to work.

Screening or pressing

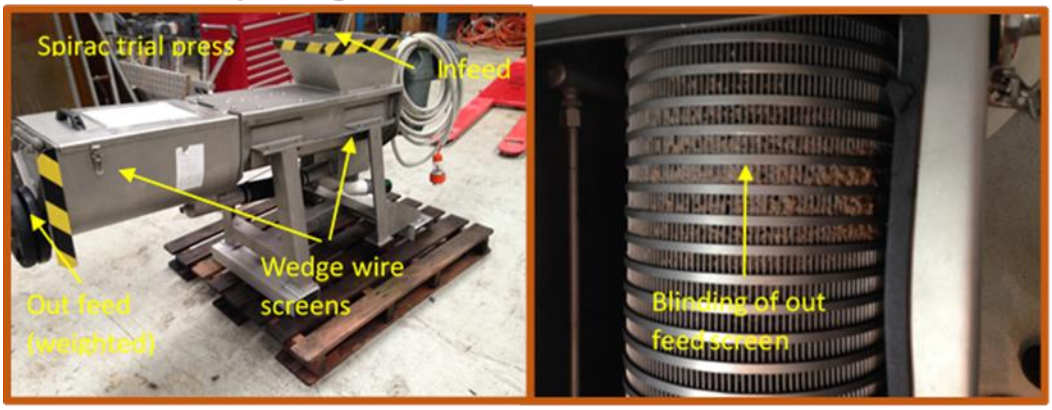
This process step is the actual separation of the liquor (water and fat) from the cooked meat solids. Screens do function on cooked ground meat, but tend to blind and hence require a cleaning spray of hot water to be pulsed to clear on a frequent basis, which adds to the liquor volume.

Rotating screens like the Contra Shear or Aquadrum – ACT from Aquatec Maxcon that have wedge wire screens require less cleaning flow. However it is essential that they are enclosed to minimise heat and moisture loss (to prevent fat solidification).

These units are designed to handle low solids inflows of 1.5 to 15% w/w, however cooked meat solids tend to be granular (if not agitated severely), so should still drain satisfactorily if a slow rotational speed is used and a reasonable volume of material is maintained in the screen, for pressing effect[4].

Screw presses are the next step in applying force to the material, resulting in squeezing more liquor through the screens. With these units, trials to date do indicate that wedge wire screens are preferable to mesh. However, with the additional force it is observed that both wedge wire and mesh still blind quickly (see Figure 8). This is possibly due to the weak structure of the meat granules and the pressing force squeezing them into the screens. The yield over the trial with the Spirac dewatering screw (wedge wire screens) showed a poor yield of meat solids but with an excellent separation result (see Table 3)

Figure 8 Spirac screw press showing indications of screen blinding after less than 5 minutes pressing



iv. Counter Current Extraction

This option was considered a fall back as it required considerable investment, and experience in using them for fat standardisation was not generally known. However the availability of a Jacmor jacketed screw conveyor changed this status, and trials were organised to evaluate CCE performance. CCE pot trial tests were run using a 100 g sample of 65 CL trim starting at fridge temperature (4 – 7℃) and adding 50 ml of 75℃ water, extracting with 2 to 3 gentle shakes, draining and repeating 10 times. The principle is to determine what could be possible with an efficient CCE process.

[4] 2002 Solids Separation Systems for the Pig Industry, Ch 5 Rotating Screens, FSA Environmental,

As can be seen in Table 3 the fat reduction is so significant that this style of process could provide a very effective and adaptable standardisation means.

The first trials with the Jacmor screw without modification (see Figure 9 – proposed screw change from solid to a twin ribbon) to assist in leaching through 'beach washing' (a process similar to sifting for gold), has shown considerable promise. As can be seen it has already far surpassed the MLA kettle process used for the HMEC Stage 2 trials (see Table 3). A quote has been provided for the proposed screw changes.

During trials with the solid screw, an evaluation was carried out with the use of no additional seperant (solvent/water) being added. This was projected to perform with a mass balance similar (in ratio) to that in Figure 10, however the extraction performance reduced significantly. It was determined that the heat carrying capacity of water plays an important role in the heating of the meat to cook temperature. Further trials will continue with this process as part of the Proform MDC project.

Figure 9 Proposed twin ribbon for replacing solid screw to further improve CCE trial

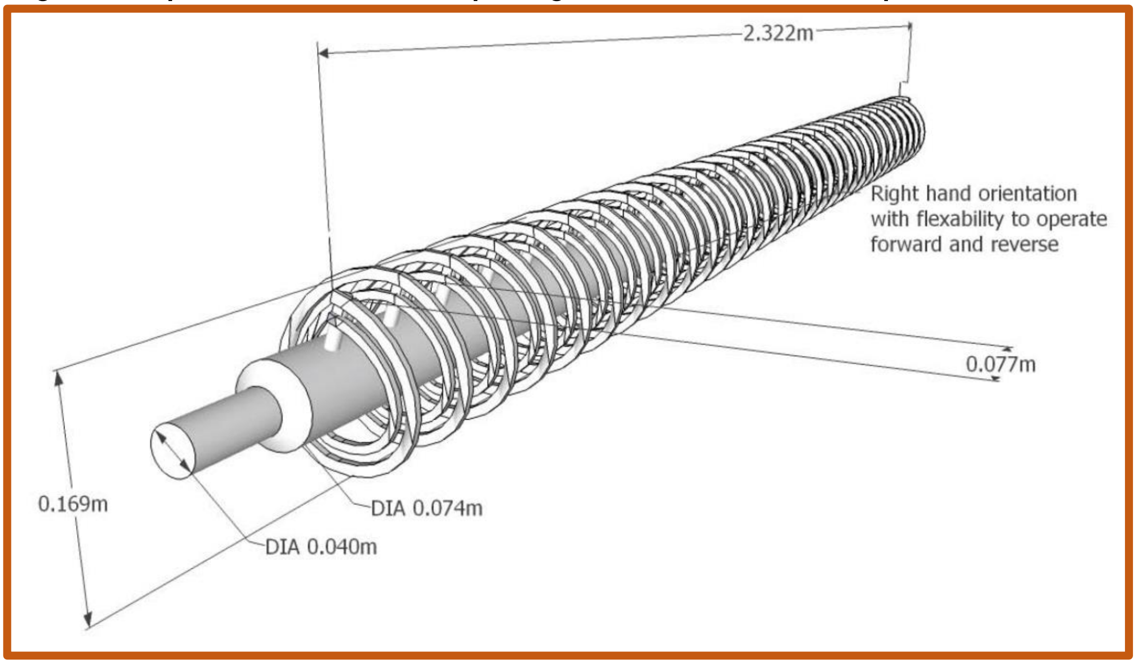


Figure 10 Proposed mass balance using no additional seperant (solvent/water)

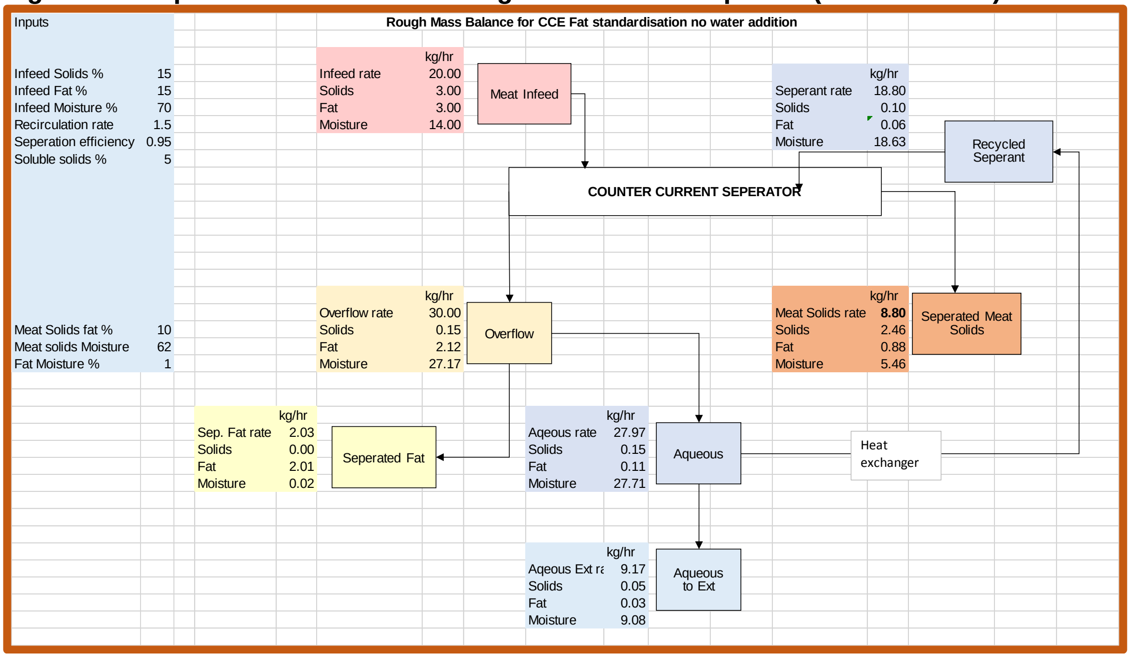


Table 3 Assessment of fat standardisation process options

	MLA Kettle (ave)		CCE Pot test		CCE		Spirac	
Component	Raw in	Meat Solids	Raw in	Meat Solids	Raw in	Meat Solids	Raw in	Meat Solids
% w/w								
Moisture	65.1	60.4	50.5	76.3	52.5	61.9	50.5	63.2
Protein	18.2	25.8	13.5	21.03	16.4	20.5	13.5	20.5
Fat	15.3	12.7	35	2.68	31.2	18.3	35	6.9
Fat reduction		2.6		32.32		12.9		28.1

While the Spirac unit is a viable option, especially if the yield issues can be resolved and a suitable means found for cooking the meat continuously, the potential indicated in the CCE pot tests favours this option. There is still some necessary work to be completed to resolve fat standardisation but significant progress has been achieved.

Conclusions

The principal objectives of this project have been achieved in that a new technology platform has been adopted for commercialisation on behalf of the red meat industry, answering the posed question “Is it worth a processor or value adder investing in an extruder to add value to the carcass by extending the use of trim beyond mince?”

As reviewed, all questions posed have been investigated and resolved with additional potential opportunities being incorporated to leverage the benefits of this new technology platform, namely enzyme hydrolysis and powdered meat.

This technology platform puts the red meat industry in a position to not only grow its markets through better price competitiveness, especially in the Food Service sector, but through leveraging enzyme hydrolysis to improve utilisation markedly, which will result in returns directly back to the producers.

Overall progress of the project

This project has completed an evaluation and development of the HMEC process for red meat trim products, showing that this process can be used as a value adding platform.

While a range of products have been investigated and developed, commercialisation of the process has overtaken the project with a commercial investor taking up an MDC project with MLA to advance a pilot production process. The products developed will become part of this commercialisation, for other investors, as spin off products as PHMC product comes available.

This project has additionally shown that this HMEC process can be leveraged to exploit a new enzyme hydrolysis process substantially improving utilisation and returns to MLA stakeholders.

Recommendations

While commercialisation is key among the recommendations of this work, this has been initiated through this project already.

Additional to commercialisation of the HMEC process it is strongly recommended that the enzyme hydrolysis process be commercialised also, through a similar but smaller MDC process as recommended by the cost benefit analysis.

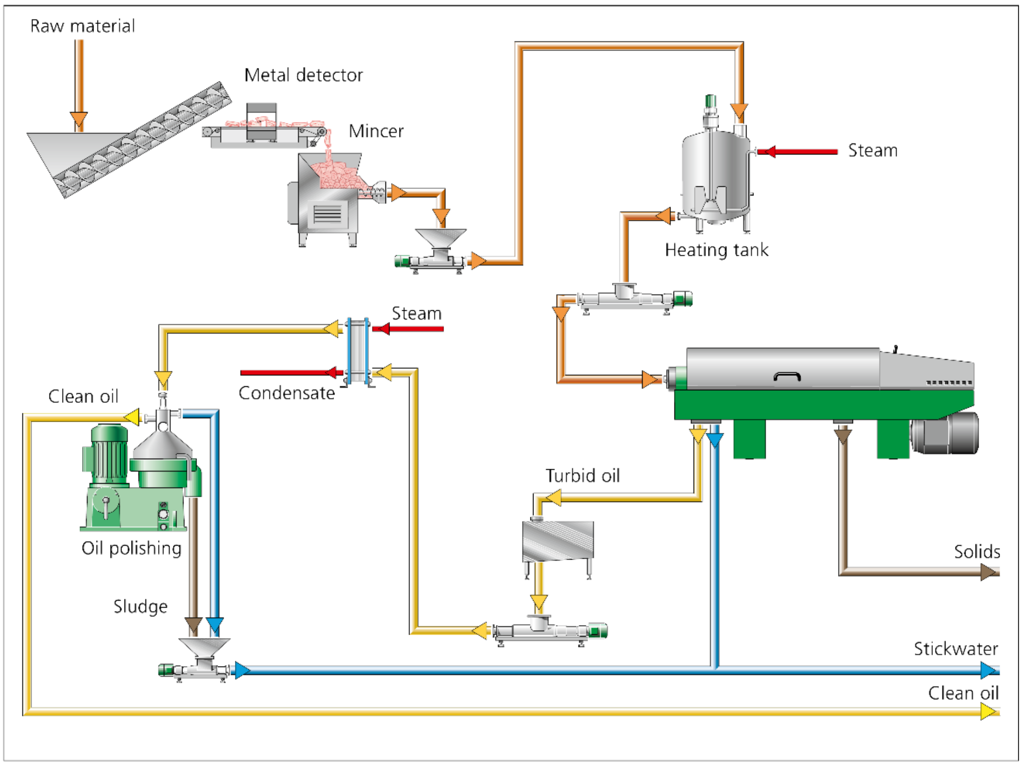
Appendices

<u>Appendix 1. Ex-ante viability of enzymatic hydrolysis for Australian beef supply chains</u>

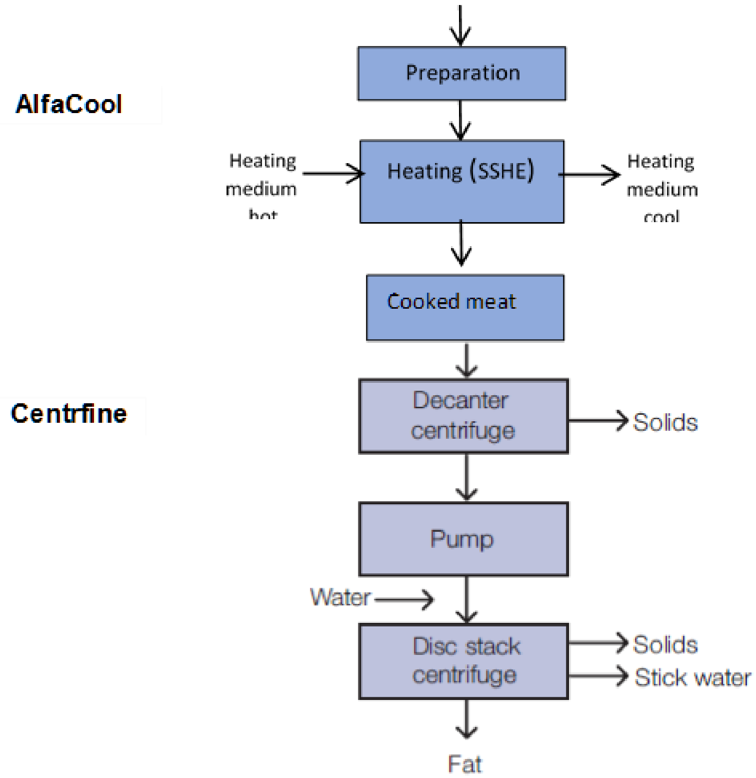
(Double click on following page to open CBA document

<u>Appendix 2. Available commercial meat standardisation processes</u>

a. Westfalia small capacity fish oil processing



b. AlfaCold process combining AlfaCool and Centrifine



Appendix 3. Process requirements for Steam injection option

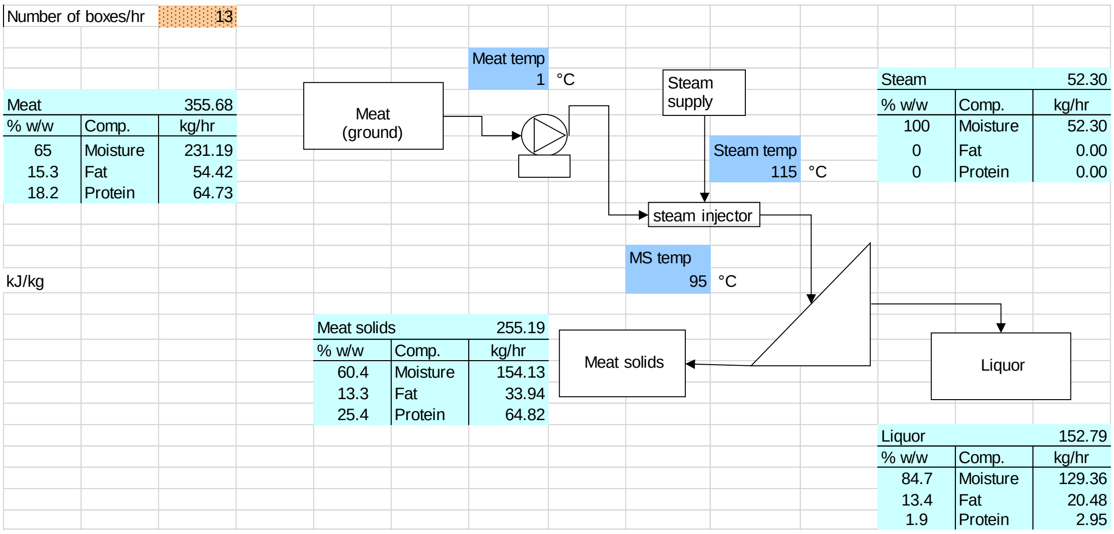
For direct steam injection use:

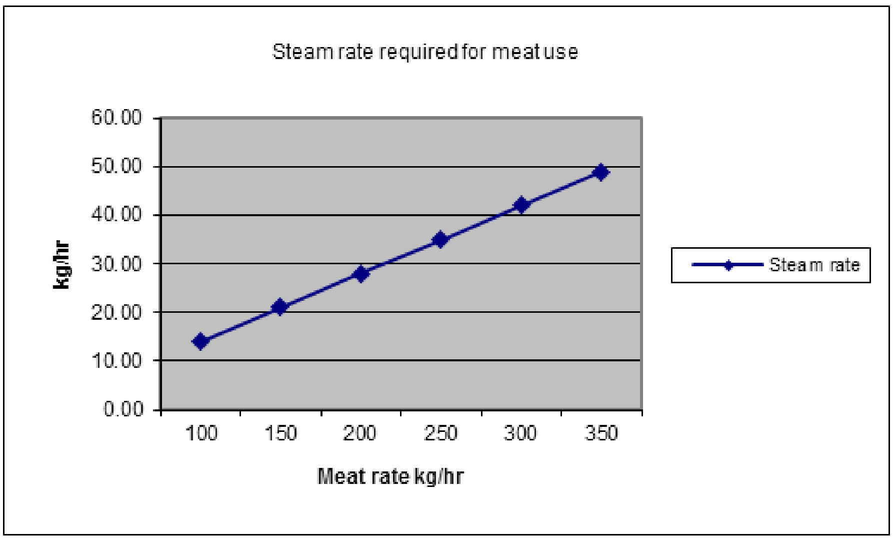
$$\dot{m} = \frac{Q}{h_g - T*C_p}$$

where:

$\dot{m}$ = Mass flow rate of steam kg/hr
Q = Heat transfer rate required kJ/s
h_g = the total enthalpy of steam prior to control valve kJ/kg
T = Final mix temperature °C
C_p = Specific heat capacity for mix kJ/kg°C

Assumptions:	
1. Steam injection just increases the liquor volume,	
2. Meatsolids remain as measured in kettle trials	
3. No steam sensible heat loss included in demand req.	
Variable reference	
Meat specific heat capacity kJ/kg°C	3.5
Steam heat of vapourisation kJ/kg 115 °C	2698.85
Steam heat of vapourisation kJ/kg 121 °C	2707.7





Appendix 4. Meat separation trials

Meat Separation trials

Two separate batches of Meat Solids were prepared using the following process:
1. 1kg of 85CL mince @-1.4˚C was heated to 35˚C stirring continuously in a pot on high heat.
2. This was further heated to over 90˚C on low heat with the lid on, stirring approxiamately once every minute .
3. The first of the batches was drained directly using the lid, the second was stirred in a mixer at 120 rpm for 30 seconds and drained similarly.
4. Both the meat solids and the liquor was weighed and the later allowed to cool, so the fat could be recovered and weighed seperately.
5. These weights and the known 85CL composition were used to estimate the mass balances across the processing. (Note: Protein content has been estimated as 1% from an average of 5 extraction analysis results)

2. Standard batch

Trim 85CL	Measured	1035
% w/w	Component	g
65.1	Moisture	674
15.3	Fat	158
18.2	Protein	188

Evaporation (g)	
Moisture	73

Kettle

draining

Meat solids	Calculated	730
% w/w	Component	g
63.99	Moisture	467
13.3	Fat	578
25.4	Protein	671

Liquor	Measured	232
% w/w	Component	g
57.6	Moisture	134
41.4	Fat	96
1.0	Protein	2

1. 120 rpm batch

Trim 85CL	Measured	1008
% w/w	Component	g
65.1	Moisture	656
15.3	Fat	154
18.2	Protein	183

Evaporation (g)	
Moisture	76

Kettle

Mixing @ 120 rpm

Meat solids	Calculated	925
% w/w	Component	g
63.98	Moisture	592
13.3	Fat	673
25.4	Protein	674

Liquor	Measured	7
% w/w	Component	g
85.0	Moisture	6.0
15.0	Fat	1.1
1.0	Protein	0.1

This trial indicates very clearly that the speed of mixing/shearing is likely resulting in emulsification of the fats within the matrix. While some cooling occurred during the mixing at 120 rpm, the temperature did not fall below 70℃ before separation. The meat solids were suspended within a plastic bag for a further 20 minutes and less than 1 g was recovered over the 7 g initially.

Figure A4.1 Summary of separation trial with and without mixing post cooking.

Appendix 5. Analysis results

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MELBOURNE LABORATORY
20 King Street
Blackburn, Vic 3130
03-8878-2100 Fax 03-9877-8444

CERTIFICATE OF ANALYSIS

COA No:	MEL-50677765-0
Supersedes:	None
COA Date:	12/12/2014
Page 1 of 4	

TO:
Chris Dahm
Thricor Pty Ltd
13 Holding St
Beaumaris, VIC 3193

Received From:	Beaumaris, VIC
Received Date:	04/12/2014
P.O.#:	Thricor Pty Ltd
Location of Test: (except where noted) Blackburn, Vic	

Analytical Results

Desc. 1: Beef Solids 1st Extraction
Sample Number: 452740756
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1

Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.7	g/100g	FAB 14	11/12/2014	SYD
Fat	12.5	g/100g	FAB 13.3	10/12/2014	SYD
Moisture	70.1	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	22.1	g/100g	FAB 93	10/12/2014	SYD

Desc. 1: Beef Solids 2nd Extraction
Sample Number: 452740760
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1

Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.4	g/100g	FAB 14	11/12/2014	SYD
Fat	9.2	g/100g	FAB 13.3	10/12/2014	SYD
Moisture	70.6	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	15.8	g/100g	FAB 93	10/12/2014	SYD

Desc. 1: Beef Solids 3rd Extraction
Sample Number: 452740762
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1

Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.4	g/100g	FAB 14	11/12/2014	SYD
Fat	10.1	g/100g	FAB 13.3	10/12/2014	SYD
Moisture	70.5	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	15.6	g/100g	FAB 93	10/12/2014	SYD

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Analytical Results

Desc. 1: Beef Solids 4th Extraction

Sample Number: 452740764
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1

Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.3	g/100g	FAB 14	11/12/2014	SYD
Fat	7.8	g/100g	FAB 13.3	10/12/2014	SYD
Moisture	69.7	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	16.4	g/100g	FAB 93	10/12/2014	SYD

Desc. 1: Beef Solids 5th Extraction

Sample Number: 452740765
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1

Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.3	g/100g	FAB 14	11/12/2014	SYD
Fat	6.9	g/100g	FAB 13.3	10/12/2014	SYD
Moisture	71.6	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	22.0	g/100g	FAB 93	10/12/2014	SYD

Desc. 1: Beef Extract 1

Sample Number: 452740767
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1

Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.4	g/100g	FAB 14	11/12/2014	SYD
Fat	3.1	g/100g	FAB 13.1A	12/12/2014	SYD
Moisture	93.0	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	1.9	g/100g	FAB 93	10/12/2014	SYD

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Location of Test: (except where noted)
Blackburn, Vic

Analytical Results

Desc. 1: Beef Extract 2
Sample Number: 452740768
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1
Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.3	g/100g	FAB 14	11/12/2014	SYD
Fat	1.2	g/100g	FAB 13.1A	12/12/2014	SYD
Moisture	95.7	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	1.8	g/100g	FAB 93	10/12/2014	SYD

Desc. 1: Beef Extract 3
Sample Number: 452740769
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1
Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.3	g/100g	FAB 14	11/12/2014	SYD
Fat	1.9	g/100g	FAB 13.1A	12/12/2014	SYD
Moisture	94.5	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	1.8	g/100g	FAB 93	10/12/2014	SYD

Desc. 1: Beef Extract 4
Sample Number: 452740770
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1
Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.2	g/100g	FAB 14	11/12/2014	SYD
Fat	0.3	g/100g	FAB 13.1A	12/12/2014	SYD
Moisture	97.8	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	1.1	g/100g	FAB 93	10/12/2014	SYD

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Analytical Results

Desc. 1: Beef Extract 5

Sample Number: 452740771
Condition Rec'd: NORMAL
Temp Rec'd (°C): 1

Condition Comment: 0.0

Analyte	Result	Units	Method Reference	Result Date	Loc.
Ash	0.1	g/100g	FAB 14	11/12/2014	SYD
Fat	1.1	g/100g	FAB 13.1A	12/12/2014	SYD
Moisture	96.0	g/100g	FAB 6.1A	10/12/2014	SYD
Protein	0.5	g/100g	FAB 93	10/12/2014	SYD

SHANE DICKS
ACTING LABORATORY MANAGER

Noted Test Locations: SYD-Silliker Australia Sydney Laboratory, Unit C2, 391 Park Road, Regents Park, NSW 2143

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