Final report

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Powdered meat concept – product trials

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Abstract

A stable and functional powdered red meat product has been developed using Gorgens Turbo Rotormill on 90 CL beef trim, providing a water holding capacity of 5:1, even with some denaturation having being produced at a minimum of 72 °C. Further improvements are projected with processing down to 60 °C, and proposed simple modifications to enable handling most red meat co-products.

Substitution of fresh beef 1:1 with rehydrated powder (based on protein with no additives) has been found acceptable in a sensory assessment with up to 40% replacement in beef burgers and salami. The high levels of substitution do result in a more brown appearance.

A simple cost benefits analysis indicates this opportunity to be interesting and robust. This showed a 40% of rated production volume, providing breakeven in less than 3 years, at half the current retail sales price for a competing product.

Contents

Project objectives

To develop powdered meat prototypes derived from food grade by-products typically produced in Australian abattoirs (trimmings and bone destined for pet food and/or rendering). Thereby assessing various milling equipment previously identified in A.MPT.0035.

The project will generate information on powdered meat in terms of composition (protein/particle size) and functionality (hydration, blend ability, shelf life stability) and an understanding of milling technology capability. It is envisaged this proof of concept research and preliminary feasibility will facilitate future processor and retailer engagement in the application of the technology to enable provisions for market development and increased revenue to low value cuts/by-products in a commercial mode.

Background

Previous projects A.MPT.0027 and A.MPT.0049 have led to this trial work, the first being an evaluation of a new concept mill, the second a review of alternative milling technologies for stabilising red meat co-products.

The Goergens (Gorgens) milling drying process is in essence a turbo rotor milling process which has the ability to handle high volumes of air throughput, heated or not. The turbo rotor can be modified depending on key product aspects required, such as drying or size reduction. The process can be provided in food and pharmaceutical design and with all necessary safety requirements. The trials conducted were carried out on standard equipment (size G 55) which was fitted with an indirect gas air heater and the necessary instrumentation to provide design data for scale-up (Figure 1).

Figure 1. Gorgens Turborotor Mill Pilot Plant[1]

[1] (2014). Gorgens. TurboRotor-System Micronising•Mixing•Drying, Mahltechnik Gorgens GMBH.

Methodology

Importing raw materials from Australia was seen as high risk, so raw materials were sourced through a meat service provider (MeatCo) in the region, who had provided material to Gorgens previously. Through negotiations with both the service provider and Gorgens, it was agreed to trial the following three materials, as previous experience had resulted in failure due to fat levels higher than 14 % w/w.

1. 90 CL Trim diced
2. Bones hydrolysed* to reduce fat
3. 50:50 mix of crushed bone (un-hydrolysed) and 90 CL Trim

** The hydrolysis process is patented and owned by MeatCo, this process involves mixing bones (crushed or uncrushed depending whether fat reduction is required) with enzymes (e.g. papain) holding for a period of time at 55 °C then heating to 85 °C to inactivate. Following this the bones can be separated cleanly from the mix in a mechanical deboning machine with little to no pressure exerted, resulting in no calcium being removed from the bones. Figure 2 shows the effectiveness of this process on small poultry bones.*

Fig 2. Poultry bones following enzyme hydrolysis and deboning.

While initially it was planned to evaluate the powdered meat products here in Australia, the conditions of the import permit granted were not achieved in full and following unsuccessful attempts to fulfil them, the samples needed to be returned to Europe for analysis.

As agreed with MLA project manager, negotiations with both the Mill owners and a third party consultant enabled a suitable means for the analysis and evaluations to be completed effectively in Europe. The brief specified was:

A. Analyse Powdered Beef ("PB 90/10") on specific criteria including; water binding capacity, solubility, fatty acid profile, FFA, peroxide value and Total Viable Count. Proximate analyses on fat, water, protein, ash.

B. Implementation through replacement of fresh beef meat with rehydrated powdered beef in processed meat products. Trials to be done on 20% and 40% replacement of fresh beef in beefburgers and in cooked salami cotto (a non fermented manufactured cured product). Product to also undergo a freeze/thawing cycle to assess its influence on the product quality.

Discussion

Trial summaries

A summary of each of the trials with observations, conditions and outcomes is outlined below.

a) Trial 1. 90 CL Trim diced or ground

The 90 CL trim provided was assessed as very good product with a clean smell. The product was transported the morning of the trials and arrived at - 2 °C ground in a semi frozen state. The mill was assembled with the standard rotor design, with blades staggered to assist conveying up through the mill (Figure 3).

Initial assessment of the feeding system was tested and found that the vibratory feeder was ineffective, so material feeding was done by hand feeding from a weigh scale. Feeding rate was varied from 60 to 30 kg/hr to obtain a rate where moisture content was low enough for stabilisation. The temperature of the inlet air was also varied from 240 to 200 °C to reduce over heating of the product, which subsequently reduced from 85 °C to 72 °C. The drying was instantaneous, occurring in less than 1 second and material collected was vacuum packed for later analysis.

It is proposed that the temperature could be further reduced through additional air flow and/or a lower in-feed air temperature, as an ideal maximum of 60 to 65 °C would be required to maintain some pink colour of the meat as was achieved in project A.MPT.0027, where temperatures as low as 35 to 40 °C were achieved.

Problems with product build up were apparent as can be seen in Figure 3. The mill manufacturers believe this is due to fat which is limiting in the process. From our previous trials in A.MPT.0027 this was also observed and modifications downstream of the mill were made through positioning an intermediate cyclone *below* the out feed from the mill. This assisted in fat removal from the ducts where it tends to collect at any elevation change, trapping material and flooding back into the mill. As can be seen in Figure 1 the cyclone is located above the mill, with elevation over the entire length from the mill to the cyclone. Further to this, from Figure 3 it can be seen that fat has built up at the top of the rotor level (on the inside of the door) but not further up, indicating that this is likely draining back into the mill from the outlet duct piping.

These trials could not be exhaustive as the process set-up would need to be modified to optimise processing meat and the mill owners were reticent to do this for this trial. However a relationship is being developed through discussions and more flexibility has been indicated. Heat loss in the duct work was the main issue resulting in fat solidification, either insulation or use of an intermediate cyclone for product collection nearer to the mill may be required.

The trial produced a fibrous dry powder of which 6 kg was collected for evaluation, the mill ran for approximately 2 hours and processed all 100 kg of 90 CL trim. While concern over the build-up is yet to be resolved for higher fat content products, these are potentially just simple design changes which may include;

1. Use of an intermediate cyclone (batch, semi-batch or continuous screw out-feed) located below the mill outlet.
2. Insulation of ducts and cyclone to prevent fat solidifying.
3. Use of surface coatings to minimise adherence if absolutely necessary.

4. Use of an air hammer on vessel walls where hang-up may occur, such as the Niro pneumatic hammer[2].

Note that keeping the material being processed above 50 ºC will prevent fat solidifying and negate any fat issues.

Figure 3. Product build up inside the Turbo-rotor mill processing 90 CL trim

In summary the trial was seen as very successful.

b) Trial 2 Bones hydrolysed to reduce fat

The hydrolysed bones were found to be over hydrolysed in that nearly all fat and protein had been extracted, leaving principally Calcium phosphate (most likely as tricalcium phosphate $Ca_3(PO_4)_2$, even though in bone it exists as hydroxyapatite $Ca_5(PO_4)_3(OH)$, this is yet to be confirmed). An example of over extracted bone when air dried is given in Figure 4, while this is more extracted than the material used, this was prepared using the same process (Patent: WO2011108920 (A1))[3]

As can be seen in Figure 4, only the structural mineral network remains. It should be noted here that this may be a potential source of phosphate for fertilizer production, which may be recovered by solubilisation and ion exchange removal of the calcium. If

[2] GEA Powder Technology (2013). "Niro pneumatic hammer." from http://www.niro.com/niro/cmsresources.nsf/filenames/pneumatic-hammer.pdf/$file/pneumatic-hammer.pdf.

[3] Koehorst, P. W. (2011). METHOD FOR PREPARING A PROTEIN EMULSION. Espacenet. WPO. Netherlands.

the bone does remain as hydroxyapatite, then its potential use as a coating for metal implants may be an option[4].

Figure 4. Extracted bone fragment dried

This extracted material required no heat addition for milling and drying and was produced as a fine off-white powder having a size range down to 72 microns. A second pass of this material using a fine grinding rotor design (see Figure 5), produced a very white powder with a size range down to 42 microns(see Figure 6). It is preferred to have the size down to 10 microns, as at this size the human mouth cannot perceive it as grit. However these results were very encouraging as the material was easily dried, indicating the milling/drying system could have the capacity to remove the moisture from the average abattoir bone production (approximately 1,500 kg/hr based on an average abattoir processing 425 cattle per day[5] and bone being around 15% [6] of the average carcass weight of 325 kg[7]).

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[4] G. S. JOHNSON M. R. MUCALO M. A. LORIER U. GIELAND, H. M., * (2000). "The processing and characterization of animal derived bone to yield materials with biomedical applications. Part II: milled bone powders, reprecipitated hydroxyapatite and the potential uses of these materials." JOURNAL OF MATERIALS SCIENCE: MATERIALS IN MEDICINE **11**: 725 ..741.

[5] D.T. Quinn and S.U. Fabiansson (2001). Risk assessment of abattoir effluent should BSE be found in cattle in Australia. DAFF, Commonwealth of Australia**:** pg 3.

[6] Chichester, C. O., Ed. (1981). ADVANCES IN FOOD RESEARCH, . Mechanically Deboned Red Meat. New York, Academic Press Inc.

[7] Anonymous (June 2006). A REVIEW OF THE STRUCTURE AND DYNAMICS OF THE AUSTRALIAN BEEF CATTLE INDUSTRY. DAFF, AUSVET ANIMAL HEALTH SERVICES**:** pg 33.

Figure 5. Fine grinding rotor design

Figure 6. Extracted bone powder following a first pass with the standard rotor (left) and a second pass with a fine rotor (right)

c) Trial 3 50:50 mix of crushed bone (un-hydrolysed) and 90 CL Trim

Given the problems with the 10% fat level in the trim, it was expected that the 50:50 mix of crushed whole bone and trim (estimated fat content of around 15 % w/w) would cause more problems, especially as it was necessary to use the fine grinding rotor so that bone particles would be as fine as possible. This proved to be the situation, with material initially processing then gradually decreasing until no product was exiting (Figure 7). Around 1 kg of clean material was recovered. On inspection of the cyclone and mill, most material had coated the duct work and the cyclone, clogging the rotary valve at the product outlet.

The trial was halted at this point as it was clear that without modification 10 % w/w fat content was likely to be the maximum manageable through this system. However as can be seen in Figure 8, the process can remove the moisture and stabilise this material with the moisture at 8 % w/w prior to the system blocking up.

Figure 7.50:50 crushed bone and 90 CL trim feeding

Figure 8. 50:50 crushed bone and 90 CL trim before and after 1 pass of the mill

Equipment cost

An estimate was requested to assess the equipment cost for a system to handle around 300 kg/hr plus, in stainless steel with the necessary safety interlocks and commissioning in Australia. This was provided verbally at €300,000 for a G90 and €5,000 for commissioning. The machine sizes go up to a G200, which has 10 times the capacity output of a G90, indicating that whatever the abattoir size in Australia, there will be a machine to handle the volume.

Analysis results

With strict import permit conditions applied to the powdered beef samples, a contingency was implemented to leave identical product samples in the Netherlands with Meatco so that at a minimum proximate analysis could be completed should the returning samples be confiscated/destroyed. While destruction of the samples was avoided they were confiscated and the back-up samples used for proximate analysis which are presented in Table 1.

Table 1 Proximate analysis of trial samples

No.	Description	Moisture	Protein	Fat	Ash
0	90 CL Trim typical analysis (averaged)	69.7	21.3	8.9	0.9
1	90 CL Trim milled at 89° C	9.7	70.8	17.8	3.7
2	90 CL Trim milled at 72° C	11	65.6	21.5	3.41
3	Hang-up in cyclone	5.3	54.4	36.3	2.78
4	Hydrolysed bone with 1 pass (standard)	7.1	25.5	5.7	60.6
5	Hydrolysed bone with 2nd pass (fine)	3.4	26.9	5.7	63.23
6	50:50 90 CL Trim : Unhydrolysed bone	8	34.4	13.1	43.39
7	Bone typical analysis (averaged)	41.9	20.3	18.1	19.9
8	50:50 Trim:Bone typical (calculated)	55.8	20.8	13.5	10.4

Extending the analysis so that a comparison can be made with the previous trials using the Aximill equipment[8], analyte concentration factors and water removal efficiencies have been calculated and are presented in Table 2. The previous trials had achieved only 0.34 kg water removed/kg feed with a single pass and required two passes to achieve 0.60 kg water removed/kg feed, hence the Gorgens mill was more than twice as effective. The moisture reduction percentage is considerably better also, the previous trials only achieving 23% on the first pass and 54 % after the second pass.

Table 2 Concentration factors and water removal efficiency

No.	Description	Analyte concentration factors					Water removal efficiency	
		Moisture	Protein	Fat	Ash	Mean	kg water removed /kg feed	% Moist. Red.
1	90 CL Trim milled at 89° C	3.0	3.3	2.0	4.1	3.1	0.68	86
2	90 CL Trim milled at 72° C	2.9	3.1	2.4	3.8	3.1	0.67	84
6	50:50 90 CL Trim : Unhydro -lysed bone	2.1	1.7	1.0	4.2	2.2	0.55	86

[8] C. Dahm (2010). Powdered meat technology feasibility trials. A.MPT.0027, Meat & Livestock Australia.

It should be noted that higher temperatures were used with these trials (85° C and 72° C), which resulted in some denaturing of the meat proteins, the previous trials ran at around 40° C for Trim. However reducing the temperature lower should be possible especially if the process is modified to better handle the fat, which appeared to be accumulating in the mill process. This appears to be supported by both the low analyte concentration factors for fat in the samples (Table 2) and the high fat result from the duct and cyclone (Table 1, sample 3).

As can be seen in the Gorgens pilot plant layout (Figure 1) the steep incline, may mean that any solidified product (i.e. fat setting on the uninsulated duct wall) has to be driven up the duct to the cyclone rather than being carried in the air flow. This was observed most severely in the duct following the 50:50 trim:bone trial. The duct, cyclone and mill were all thickly coated in fatty milled material.

To avoid this, and potentially enable the ability to handle high fat materials, it was previously suggested that an intermediate cyclone be utilised[9]. A batch cyclone was designed as economically as possible (Figure 9) below and has been cost estimated at up to €3,000, which includes; drum, ducts, hoses and machining for the proposed changes (Figure 10).

Figure 9.New trial product cyclone design

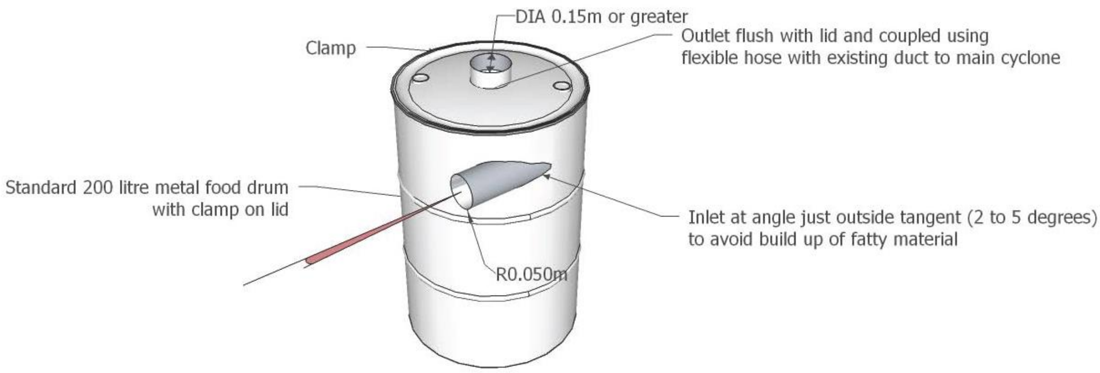
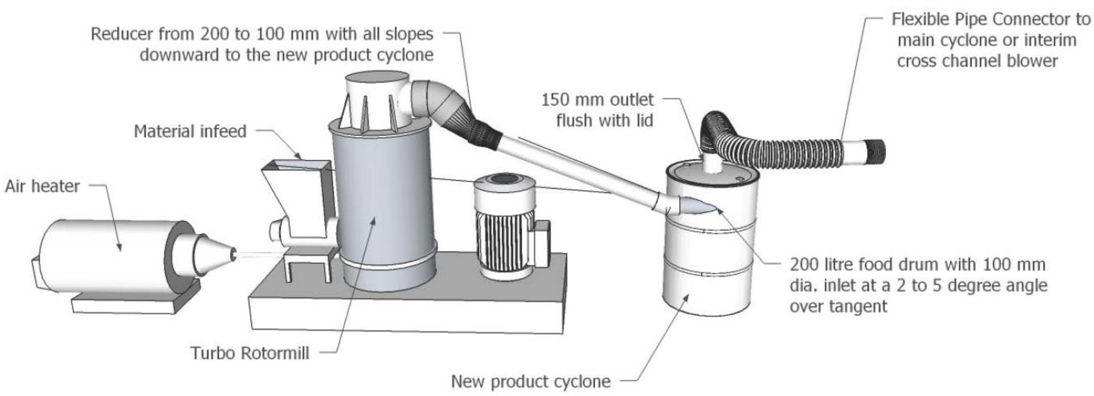


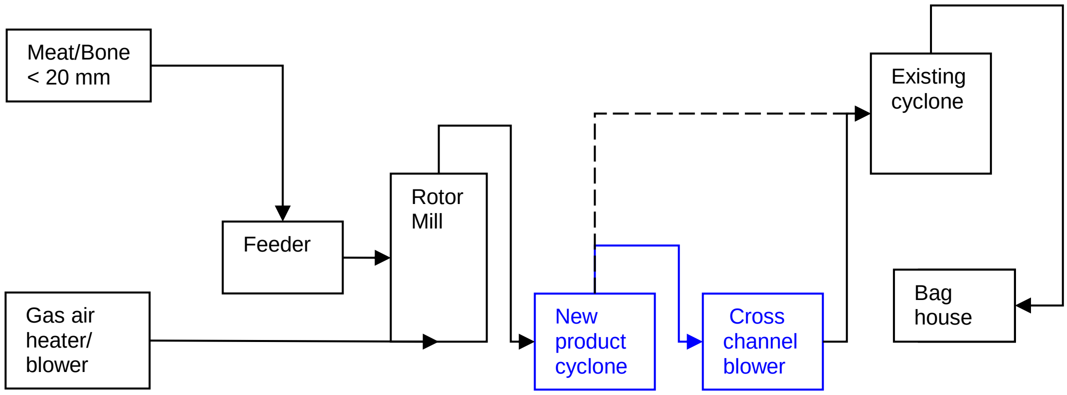
Figure 10 Schematic process diagram of proposed trial changes (elevation)



9 C. Dahm (2013). Interim Report Powdered meat concept – product trials. Project A.MPT.0036, Meat & Livestock Australia.

A simple process flow of this set-up, indicating the potential to utilise an additional cross channel blower should constriction be a concern for air flow, is shown in Figure 11.

Figure 11. Simple process flow diagram with changes to handle high fat



Product functionality assessments

The samples prepared in Germany are shown in Figure12, after one year in holding at ambient conditions at Melbourne airport, these appeared exactly as they had when first produced.

Figure 12. Powdered 90 CL meat trim samples before return to Germany

Initially it had been thought the samples would be deteriorated and preparations were being made to have the trials re-run on our behalf by the Mill owners and analyses completed in Europe through a third party. Being provided access to the samples for assessment by AQIS, had enabled the project to resume under the same budget with only a time delay.

The largest block of samples collected were for the 90 CL trim trials, so these samples were used for all product performance assessments. The product review as specified was conducted by MeatCo in the Netherlands, a complete report, including recipes used and procedures followed, is included in Appendix 1. Following is a summary of these findings.

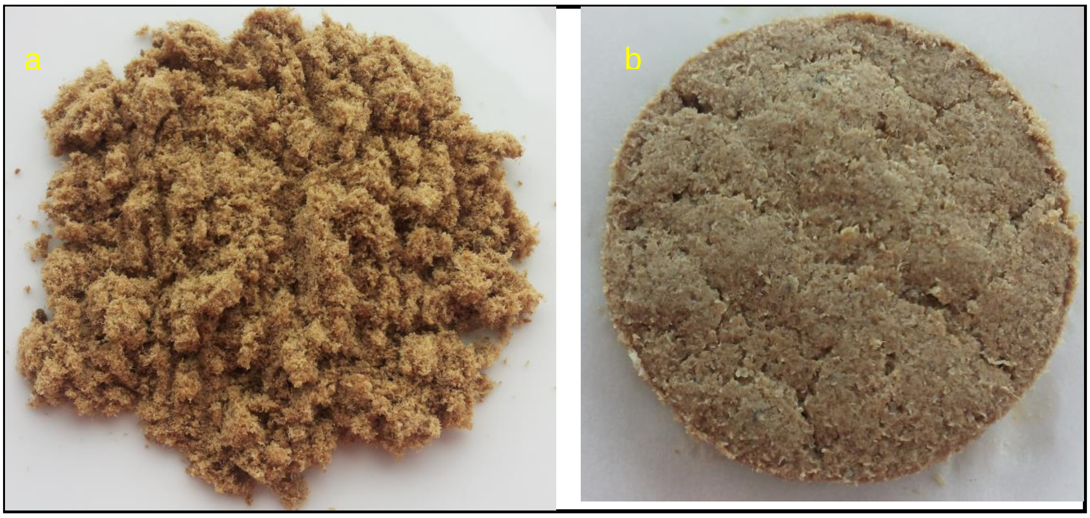
a) Functional analysis of powdered meat

The rehydration to saturation has showed that the powdered meat can rehydrate, and hold, five times its own weight of water (i.e. 50g of powder held 250g of water). The powder also was observed to clearly show the formation of extended fibres on rehydration (Figure 13)

Figure 13.Reconstituted powdered meat fibres

Reconstituting the powder to provide a meat protein equivalent to that of 90 CL beef trim, the powdered meat was combined with twice its weight of water, taking the protein content from 65.6 % w/w to 21.8% w/w (Figure 14).

Figure 14 Reconstituting powdered meat a) to equivalent protein fresh meat product b)



A summary of the powdered meat analyses results (Table 3) also indicates that there was some denaturation occurring in processing, as the solubility of meat protein has dropped from around 43% in a fresh state[10] to around 14% of total protein content. The high hydration result is therefore a surprise and may be due to the high shear rate within the mill, opening up the tertiary structure of the meat fibres allowing more hydrophilic bonding. A more detailed investigation of this observation is warranted in future work.

Table 3. Summary of powdered meat analyses results for 90 CL beef trim

Analyte	Units	Results	Observations
Water binding	g/g	5	Very high, suspect protein structure more open (other comparable products 2 – 3 g/g)
Solubility	g/100g protein	14	Normally soluble protein of fresh meat is around 43% of protein*, this result indicates denaturation, which may be the result of malliard products and being stored at a medium a_w[11]
Fatty acid profile			
sat	%	43.1	The Fatty acid profile is very similar to fresh meat[12]
mono	%	50.7	
poly unsat.	%	3.7	
omega 3	%	0.6	
omega 6	%	2.6	
Free Fatty Acids	%	4.2	Slightly up but low for having been dried and held at ambient temperature for 12 months
Peroxide Value	meq/kg	1.6	Slightly up but low for having been dried and held at ambient temperature for 12 months

[10] Tadeusz Karamucki, J. K., et al (2004). "CORRELATION BETWEEN MEAT WATER-SOLUBLE PROTEIN CONTENT AND CARCASS AND MEAT QUALITY TRAITS IN FATTENERS DIFFERING IN MEATINESS." Pol. J. Food Nutr. Sci. **13/54**(2): 185-190.

[11] Sun, Q., A. Senecal, et al. (2002). "Effect of Water Activity on Lipid Oxidation and Protein Solubility in Freeze-dried Beef during Storage." Journal of Food Science **67**(7): 2512-2516.

[12] C. Dahm (2010). Powdered meat technology feasibility trials. A.MPT.0027, Meat & Livestock Australia.

Total Plate Count	CFU/g	<40	Very low indicating material has likely been pasteurised and hygienically handled
Moisture	% w/w	11	Slightly higher than targeted but is equivalent to an $\mathbf{a_w}$ of 0.5 to 0.6[13]
Fat	% w/w	21.5	Reconstituted this will drop below 10% w/w, so is lower than expected
Protein	% w/w	65.6	As expected
Ash	% w/w	3.4	As expected

The water activity estimate[14] of 0.5 to 0.6 indicates that the powdered meat is stable from a microbiological view point. However the very low Total Plate Count was not expected, as the processing conditions were average. This indicates that the process must be providing some pasteurising and this along with vacuum packing and low residual oxygen levels during storage in dark, has ensured a microbiologically stable product, this is a significant finding.

b) Performance of powdered meat in products

It was critical that this project assess the performance of powdered meats, in product applications, to ensure that functionality was maintained. Processing at temperatures above 65 °C was a concern for denaturation and this has been shown to be occurring. However, as summarised below the powdered meat has performed exceptionally well.

In the following two products types; beef burgers and cooked salami, fresh beef was substituted at both 20% and 40% w/w with reconstituted powdered meat unit for unit. The beef burgers (Figure 15) were slightly browner but performed equivalently to the 100% beef burgers as shown in Table 4. They were found to be juicier, tasty and to have better bite.

[13] Sun, Q., A. Senecal, et al. (2002). "Effect of Water Activity on Lipid Oxidation and Protein Solubility in Freeze-dried Beef during Storage." Journal of Food Science **67**(7): 2512-2516.

[14] (2014). "MEAT DRYING." Retrieved 25 June, 2014, from http://www.fao.org/docrep/010/ai407e/ai407e18.htm.

Figure 15. Reconstituted powdered meat in; a) beef burgers before and b) beef burgers after cooking, c) salami before and d) salami after cooking (Note: 1 = 0%, 2 = 20% and 3 = 40% substitution of beef)

The salami cotto products like the burgers were browner in the raw and cooked state (Figure 15), it may be possible that some Maillard products from the milling/drying process are impacting this, but it is most likely the result of some heat denaturation. However, with the product cured and smoked, this did not significantly impact overall appearance.

Generally the powdered meat products were found to perform very well in sensory attributes, with the colour and rigidity being the only results not matching the 100% beef products, but still performing well.

The only area of concern is with thawing of the salami containing 40% w/w reconstituted powdered meat. This product shows an increase in weight loss, which appears from observations to be partly due to the formation of gel pockets.

In summary, these results show that even processing products at temperatures of 72 to 85 °C, a significantly high degree of functionality has been maintained.

Table 4. Weight loss and sensory assessment of 20 and 40% powdered meat substitution of fresh beef against 100% fresh beef

Product	Assessment	1. 100% beef	2. 80% beef	3. 60% beef
Beef burger				
	Weight loss frying (%)	36	35	35
	Juicyness	6	7	7
	Flavour/Taste	6	6	7
	Smell	7	7	6
	Bite	5	7	7
	Rigidity	8	7	6
	Colour	6	6	8
Cooked Salami cotto	Weight loss freezing / thawing (%)	0	0	12
	Weight loss cooking (%)	4	13	8
	Juicyness	8	7	7
	Flavour/Taste	8	8	8
	Smell	8	8	8
	Bite	8	7	7
	Rigidity	8	7	6
	Colour	8	7	6

This work shows it is possible to convert fresh meat to a powdered form and then utilize it reconstituted, unit for unit (without additional additives) replacing up to 40% w/w of fresh product in a range of formulations while maintaining acceptance. This performs far better than any of the comparative products sourced (Appendix 2) which are utilized at up to 8 % w/w replacement with water holding capacities of up to 3:1.

It is proposed that this should be possible also, for higher fat trim products (with the simple modifications recommended).

Commercialisation assessment

The stability and functionality of this '90 CL powdered trim' product warrants commercialisation, a similar product (Appendix 2) is selling for $58/kg here in Australia and this along with most others does not match the water holding or functional performance of this product.

An FOB estimation of a commercial food grade Gorgens Tuborotor milling process (not including installation) has been provided at just over €300,000 for a 1T/hr feed rate. Applying a simplified but conservative estimation of the total capital investment for a flash dryer[15] which includes the cost of piping, instrumentation, electrical

[15] Tadeusz, K. and T. S. Zbigniew (2006). Cost-Estimation Methods for Drying. Handbook of Industrial Drying, Third Edition, CRC Press.

connections, insulation, building space, and engineering all in stainless steel, this totals at around AU$1 million.

Allowing for a single shift situation, where this equipment is operated for only 8hrs/day, 240 d/yr, basing energy costs on peak electrical supply (not gas) the following cost of goods (COG) is estimated (Note that energy costs are changing significantly, so electrical has been used to be conservative).

Table 5. Powdered red meat cost of goods estimation

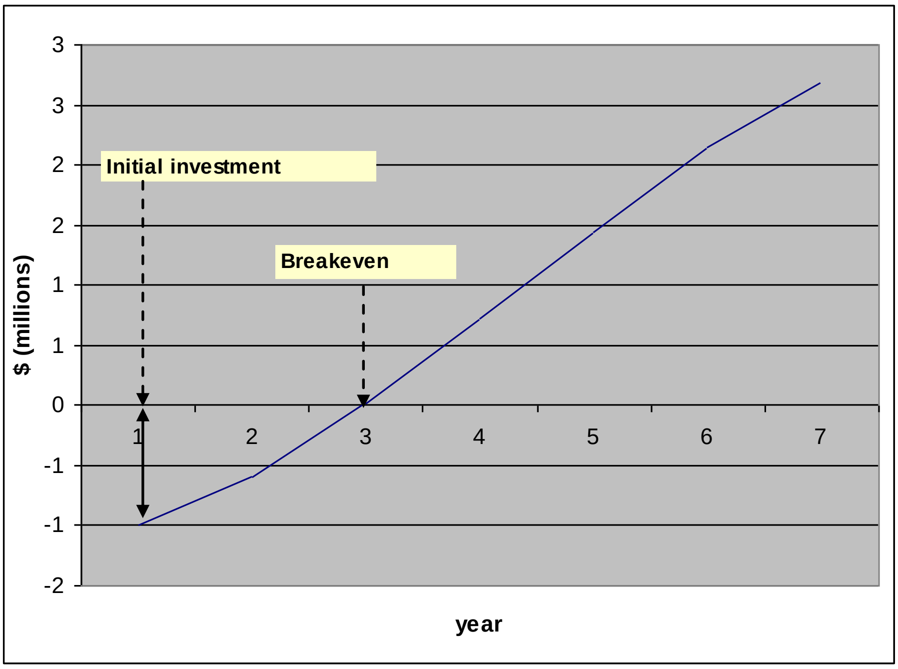
Element	Cost $/kg	Notes
Ingredient Cost	$17.50	90 CL Trim purchased @ $5/kg being concentrated 3.5 times
Packaging	$0.35	FFS 4 x 1.5kg in a 6kg nett cardboard box (a middle option)
Labour + oncost	$0.40	(Based on total Vol 576 T/yr & 2 crew @ $100,000/yr each)
Operating overheads	$2.00	Energy ($1.66/kg), Engineering, spares, overheads, QA, planning….
Cost of sales	$0.25	processed meat average
Depreciation	$0.00	to give an IRR of 30% for $1M investment see Table 4
Total COG	**$20.50**	

A plot of discounted cash flow has been calculated based on incremental (proportional) sales growth (20 %/yr) to equipment capacity over 5 years following installation. In this example a product sales price less than one half that of the existing product in the market place has been used.

Table 6. Cost benefit analysis inputs for powdered red meat product at half market price

Sales price ($/kg)	$25.00
Plant cost ($millions)	$1.00
Maximum output units (kg millions)	0.58
COGs $/kg base	$20.50
Req. rate of return %	30

Figure 16. Discounted cumulative cashflows for powdered red meat product-less than half sales price



As can be seen this is an interesting opportunity, of course no consideration of market demand has been assessed, however for an existing product to survive which retails for $58/kg with minimum order quantities, there appears to be a market.

Conclusions

This process utilising Gorgens Turbo Rotormill is definitely capable of drying the materials investigate within a few seconds but requires development modification to handle fat contents over 10% w/w. Further investigation will be required to get meat materials dried with minimum temperature impact (that is, 60 to 65 °C),

It should be noted that the MeatCo hydrolysis process offers some interesting opportunities for low cost meat recovery for food products. This may have a potential application for the HMEC process as a low cost raw material supply with low calcium levels.

The powdered meat samples prepared in Germany on 90 CL beef trim, have shown to be microbiologically safe with a moisture content of 11% w/w (a_w ~ 0.5 to 0.6) and with very little deterioration over 12 months storage under ambient conditions in Melbourne.

The powder has shown a propensity for hydration, holding water to powder of up to 5:1. When reconstituted for equivalent protein content to fresh trim, significant fibre content is apparent, although some denaturation has been indicated in reduced soluble protein content, which was expected operating the mill at 72 to 85 °C.

It has been shown that it is possible to convert fresh meat to a powdered form and then utilize it reconstituted, unit for unit (without additional additives) replacing up to 40% w/w of fresh product in both cooked burger and salami cotto formulations with good acceptance results.

A simple but robust cost benefits assessment indicates an opportunity exists, but will require market direction for a detailed assessment.

Overall progress of the project

This is the final report for this project, commercialisation discussions have been initiated with an Australian flavour manufacturer with exchange of confidentiality documents signed and initial sharing of information. It is recommended that these discussions be progressed to a point where an MDC project may be scoped and proposed.

Recommendations

It is proposed that this milling process be commercialised commencing with a production prototype which can be utilised for additional concept development. The potential of this process crosses all co-products, providing an option to secure added value in food products that would otherwise be rendered through lack of economical options.

It is important that the modifications proposed in this report be explored, as this will enable both lower temperatures and a much wider range of products that can be stabilised, enabling maximum values to be returned to the producers.

Appendices

Appendix 1 MeatCo consultants report on MLA powdered meat

Survey of Powdered Beef 90/10

1. **Goal.**

   A. Analyse of Powdered Beef ("PB 90/10") on specific criteria like water binding capacity, solubility, fatty acid profile, FFA, peroxide value and Total Viable Count. Basic analysis is performed on fat, water, protein, ash.

   B. Implementation and replacement of fresh beef meat with powdered beef 90/10 in processed meat products.
   Trials will be done on 20% and 40% replacement of fresh beef in beefburgers and in cooked salami.
   The cooked salami will also undergo a freeze/thawing cycle to assess its influence on the product quality.

2. Description of the analyses / trials.

A. Water binding capacity.

50 gram of PB 90/10 was mixed with tap water untill maximum water retention was reached at room temperature. Water retention was evaluated by adding the PB90/10 – water mixture to a measuring glass and observe the release of free water during standing.

Solubility.

Two methods are being applied to judge the solubility of BP90/10.
First of all, 1 part of BP90/10 was mixed with 9 parts of water.
Then, the mixture was either filtered trough a paper filter or centrifuged in a Heraus table centrifuge (Labofuge 6000). From the dissolved fraction, the protein was estimated by measuring the Brix level and converting this to protein content.

Fatty acid profile.

According ISO 5508/12966-2

Free fatty acids.

According Basic ISO 660 2009

Peroxide value.

According ISO 3960 2007

Total Viable Count.

According ISO 4833 modified

Dry matter / Moisture.

4 hours at 103° Celsius

Fat.

Extraction after acidic hydrolysis.

Protein.

Dumas-N * 6.25

Ash.

Crude, 550° Celsius

B. Implementation in meat-recipes.

General:

Based on the results of the chemical chemical analyses, in which the PB 90/10 was analyzed with 65,6% of protein, it was decided that (in order to reconstitute the meat) 1 part of PB 90/10 was mixed with 2 parts of cold water.

This reconstituted meat ("RM 90/10") is being used to replace fresh beef in levels of 20% and 40%.

I. **Beefburgers.**

The meat was mixed with the RM 90/10 (where appropriate) and the onions, water and spices for about 3 minutes at low speed in a Camry Food Processor.
After forming the beefburgers, they were frozen down till -18° prior to frying.

1. Recipe: 100 parts minced beef (3 mm)
   10 parts water
   5 parts fresh onions
   1 part beefburges spices

2. Recipe: 80 parts minced beef (3 mm)
   20 parts RM 90/10
   10 parts water
   5 parts fresh onions
   1 part beefburges spices

3. Recipe: 60 parts minced beef (3 mm)
   40 parts RM 90/10
   10 parts water
   5 parts fresh onions
   1 part beefburges spices

II. **Cooked Salami.**

The meat was mixed at high speed with a bowl chopper with the RM 90/10 (where appropriate) the oil, water, nitritesalt and additive/spices for about 1 minute to max. temperature 8° Celsius. After vacuumizing the meat emulsion is filled into sterile casings. After filling the salami was rested for 6 hours at 4° Celsius and then cooked at 82° Celsius till 68° Celsius core temperature.

1. Recipe:
   75 parts minced beef (3 mm)
   25 parts minced porc (3 mm)
   5 parts sunflower oil
   5 parts water
   3 parts nitritesalt (0,6% NaNo2)
   2 parts cooked salami additives/ spices

2. Recipe:
   60 parts minced beef (3 mm)
   15 parts RM 90/10
   25 parts minced porc (3 mm)
   5 parts sunflower oil
   5 parts water
   3 parts nitritesalt (0,6% NaNo2)
   2 parts cooked salami additives/ spices

3. Recipe:
   45 parts minced beef (3 mm)
   30 parts RM 90/10
   25 parts minced porc (3 mm)
   5 parts sunflower oil
   5 parts water
   3 parts nitritesalt (0,6% NaNo2)
   2 parts cooked salami additives/ spices

3. **Results.**

A. Analytical results

Water binding capacity.

1 part of PB 90/10 showed to be capable of taking up 5 parts of water.
Mixing 50 grams PB 90/10 with 250 grams of water showed no release of free water.

Solubility.

50 grams of PB 90/10 was mixed with 450 grams of water.
After mixing the mass was filtered or centrifuged (10 minutes at 4200 rpm).
In both dissolved fractions, a protein content of about 0,9% was measured.
This equals 9% soluble protein in the original PB 90/10.
Taking in account an analyzed protein content of 65,6% in the PB 90/10, it can be estimated that the solubility of PB 90/10 is about 14% (~ 9% out of 65,6%).

Fatty acid profile.

Results

GC Analyses

Fatty Acid Composition (ISO 5508/12966-2)	001
C12:0 dodecanoic acid [lauric acid] (%)	<0,1
C14:0 tetradecanoic acid [myristic acid] (%)	2,7
C14:1 tetradecenoic acid (%)	0,9
C15:0 pentadecanoic acid (%)	0,4
C16:0 hexadecanoic acid [palmitic acid] (%)	25,6
C16:1 hexadecenoic acid (%)	4,6
C16:2 hexadecadienoic acid (%)	<0,1
C17:0 heptadecanoic acid [margaric acid] (%)	1,0
C17:1 heptadecenoic acid (%)	0,9
C18:0 octadecanoic acid [steraic acid] (%)	13,2
C18:1 octadecenoic acid [incl. oleic acid] (%)	43,7
C18:2 octadecadienoic acid [incl. linoleic acid] (%)	2,6
C18:3 octadecatrienoic acid [incl. linolenic acid] [omega 3+6] (%)	0,5
C19:1 nonadecenoic acid (%)	0,2
C20:0 eicosanoic acid [arachidic acid] (%)	0,1
C20:1 eicosenoic acid (%)	0,4
C20:3 eicosatrienoic acid (omega 3+6) (%)	<0,1
C20:4 eicosatetraenoic acid (omega 3+6) (%)	0,3
C22:5 docosapentaenoic acid (omega 3+6) (%)	0,1
Saturated Fatty Acids (%)	43,1
Mono unsaturated Fatty Acids (%)	50,7
Poly unsaturated Fatty Acids (%)	3,7
of which Omega 3 Fatty Acids (%)	0,6
of which Omega 6 Fatty Acids (%)	2,6
Unknown Fatty Acids (%)	2,4

Free fatty acids.

Free fatty acids (on the extracted oil) (Basic ISO 660 2009)	001
Free fatty acids (on the extracted oil) (%)	4,26
FFA molmassa	M=282
Free fatty acids for calculating (%)	4,26

Peroxide value.

Peroxide value (on the extracted oil) (ISO 3960 2007)	001
Peroxide value (on the extracted oil) (meq/kg)	1,6

Total Viable Count.

Microbiology Analyses

Sample no.: Analysis date:	NORM	001 16-6-2014 11:37:49
Total Plate Count 30°C (cfu/g) ISO 4833 modified		<40

Dry matter / Moisture.

89,0 % (w/w)

Fat.

21,5 % (w/w)

Protein.

65,6 % (/w)

Ash.

3,41 % (w/w)

B. Results on implementation in meat-recipes.

I. Beefburgers.

Weight loss after frying:

	Test 1 (100% beef)	Test 2 (80% beef)	Test 3 (60% beef)
Fresh weight (gr)	162	165	164
Fried weight (gr)	104	107	107
Weight loss (gr)	58	58	57
Weight loss (%)	36	35	35

Quality assessment:

	Test 1 (100% beef)	Test 2 (80% beef)	Test 3 (60% beef)
Juicyness	6	7	7
Flavour/Taste	6	6	7
Smell	7	7	6
Bite	5	7	7
Rigidity	8	7	6
Colour	6	6	8

0 = Very bad
5 = Acceptable
10 = Excellent

In general the addition of RM 90/10 loosens the structure of the beefburger after frying. Also the taste is improved, probably because of a Maillard reaction induced flavouring process.
Water binding is also improved, which is most clearly observed when pressing the beefburger after frying. Without added RM 90/10, the water is easily being squeezed out whilst the 60% beef shows no water release at all.

II. **Smoked salami.**

Weight loss after cooking:

	Test 1 (100% beef)	Test 2 (80% beef)	Test 3 (60% beef)
Fresh weight (gr)	423	443	426
Cooked weight (gr)	407	384	394
Weight loss (gr)	16	59	32
Weight loss (%)	4	13	8

Although a definite gel formation was observed after cooking in both test 2 & 3, part of this gel is being caused by air holes during filling.

Weight loss after freezing / thawing:

	Test 1 (100% beef)	Test 2 (80% beef)	Test 3 (60% beef)
Frozen weight (gr)	413	425	430
Thawed weight (gr)	413	425	380
Thawing loss (gr)	0	0	50
Thawing loss (%)	0	0	12

Quality assessment:

	Test 1 (100% beef)	Test 2 (80% beef)	Test 3 (60% beef)
Juicyness	8	7	7
Flavour/Taste	8	8	8
Smell	8	8	8
Bite	8	7	7
Rigidity	8	7	6
Colour	8	7	6

0 = Very bad
5 = Acceptable
10 = Excellent

In general the addition of RM 90/10 does not affect the firmness and taste of cooked salami too much. The structure tends to be a bit more brittle but this is not necessarily negative. The biggest effect is noticed at the somewhat more brownish colour after cooking. Replacing 40% of the beef meat with RM 90/10 is in general fully acceptable.

Freezing/thawing causes some weightloss but does not affect the product in a negative way.

<u>Appendix 2 Comparative powdered meat products</u>

nutradry
Dried Nutritional Technology
fresher. flavour. goodness.

28 Navigator Place,
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Queensland 4011
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PRODUCT SPECIFICATION

Product Name	**NutraDry Beef Powder**
Pack Size	15kg
Product Code	SBE01
Origin	Made in Australia from local and imported ingredients

<u>Description</u>
NutraDry Beef Powder is produced from Australian animals only. The meat is minced, cooked and then dried with added salt and starch, next the powder is milled and packed under a nitrogen atmosphere to aid storage.

<u>Physical Standards</u>

Flavour	Free from off flavours, typical of cooked beef
Appearance	Free flowing powder
Colour	Light Brown
Odour	Typical of cooked beef, free from off or objectionable odours
Size	Milled though a 2.3mm screen

<u>Microbiological Parameters</u>

Total plate count	<5,000 cfu/gram
E. Coli	Not detected /gram
Salmonella	Not detected / 25grams

<u>Nutritional Information</u> (Theoretical/100g)

Energy	2,290 kJ
Protein	51.7 g
Total fat	36.4 g
- saturated fat	19.4 g
Carbohydrate	3.2 g
- sugars	0.9 g
Dietary fibre	0.8 g
Sodium	850 mg

Ingredients	Beef, tapioca maltodextrin, salt, natural antioxidant (Rosemary Extract)
Moisture	< 6% w/w
Consumption	Food ingredient or food seasoning
GMO	NIL as per Food Standards, Australia & New Zealand Code

<u>Claims</u>

<u>Food Allergens & Sensitivities</u>

	Present in raw material
Cereals including wheat, rye, oats, barley, and spelt	No
Milk	No
Eggs	No
Soybeans	No
Fish	No
Crustaceans	No
Peanuts	No
Sesame Seeds	No
Tree Nuts	No

<u>Packaging details</u>

Packaging	Nitrogen flushed metallised LDPE bag in cardboard carton
Carton size (external)	385 x 250 x 480 mm (for large pack sizes)
Shelf life	3 years under ideal conditions (less than 20°C, dry, unopened).

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Henningsen Nederland bv

DEHYDRATED MILLED COOKED BEEF RS

This product is produced by air drying cooked beef in an approved factory (according to EC regulations 852/2004 and 853/2004). The approval number is EC NL 1120.

Ingredients
Cooked beef (98%) and salt (2%)

Physical standards

Appearance	Milled coarse powder: 100% to pass a 12 mesh sieve
Colour	Medium brown
Flavour and aroma	Characteristic of cooked beef

Chemical and nutritional standards

Moisture	5%	maximum	
Protein	57%	minimum	
Carbohydrates	0%	of which:	
		- sugars	0%
Salt	3%	maximum, of which:	
		- sodium	1,2%
Fibres	0%		
Fat	35%	maximum, of which:	
		- saturated fat	15%
		- mono-unsaturated fat	17%
		- poly-unsaturated fat	2%
		- trans fatty acids	1%
Energy		± 2300 kJ / ± 550 kcal	

Microbiological standards

Standard plate count	<25.000/g
Enterobacteriaceae	<100/g
Yeasts and moulds	<100/g
E-coli	<10/g
Salmonella	negative in 25 g

GMO Status
According to EC regulations 1829/2003 and 1830/2003 Dehydrated milled cooked beef RS can be declared as GMO free.

24002 Version 2.2

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Henningsen Nederland bv

POWDERED COOKED BEEF TYPE A

This product is produced by spray drying cooked beef in an approved factory (according to EC regulations 852/2004 and 853/2004). The approval number is EC NL 1120.

Ingredients
Cooked beef (100%)

Physical standards

Appearance	Fine powder, 100% to pass a 16 mesh sieve
Colour	Medium brown
Flavour and aroma	Characteristic of cooked beef

Chemical and nutritional standards

Moisture	5%	maximum	
Protein	58%	minimum	
Carbohydrates	0%	of which:	
		- sugars	0%
Salt*	2%	maximum, of which:	
		- sodium	0,8%
Fibres	0%		
Fat	35%	maximum, of which:	
		- saturated fat	15%
		- mono-unsaturated fat	17%
		- poly-unsaturated fat	2%
		- trans fatty acids	1%
Energy		± 2300 kJ / ± 550 kcal	

*Natural presence

Microbiological standards

Standard plate count	<25.000/g
Enterobacteriaceae	<100/g
Yeasts and moulds	<100/g
E-coli	<10/g
Salmonella	negative in 25 g

GMO Status
According to EC regulations 1829/2003 and 1830/2003 Powdered cooked beef type A can be declared as GMO free.

26403 Version 2.2

Bibliography

(2014). Gorgens. TurboRotor-System Micronising•Mixing•Drying, Mahltechnik Gorgens GMBH.

(2014). "MEAT DRYING." Retrieved 25 June, 2014, from http://www.fao.org/docrep/010/ai407e/ai407e18.htm.

Anonymous (June 2006). A REVIEW OF THE STRUCTURE AND DYNAMICS OF THE AUSTRALIAN BEEF CATTLE INDUSTRY. DAFF, AUSVET ANIMAL HEALTH SERVICES**:** pg 33.

C. Dahm (2010). Powdered meat technology feasibility trials. A.MPT.0027, Meat & Livestock Australia.

C. Dahm (2013). Interim Report Powdered meat concept – product trials. Project A.MPT.0036, Meat & Livestock Australia.

Chichester, C. O., Ed. (1981). ADVANCES IN FOOD RESEARCH, . Mechanically Deboned Red Meat. New York, Academic Press Inc.

D.T. Quinn and S.U. Fabiansson (2001). Risk assessment of abattoir effluent should BSE be found in cattle in Australia. DAFF, Commonwealth of Australia**:** pg 3.

G. S. JOHNSON M. R. MUCALO M. A. LORIER U. GIELAND, H. M., * (2000). "The processing and characterization of animal derived bone to yield materials with biomedical applications. Part II: milled bone powders, reprecipitated hydroxyapatite and the potential uses of these materials." JOURNAL OF MATERIALS SCIENCE: MATERIALS IN MEDICINE **11**: 725 ..741.

GEA Powder Technology (2013). "Niro pneumatic hammer." from http://www.niro.com/niro/cmsresources.nsf/filenames/pneumatic-hammer.pdf/$file/pneumatic-hammer.pdf.

Koehorst, P. W. (2011). METHOD FOR PREPARING A PROTEIN EMULSION. Espacenet. WPO. Netherlands.

Sun, Q., A. Senecal, et al. (2002). "Effect of Water Activity on Lipid Oxidation and Protein Solubility in Freeze-dried Beef during Storage." Journal of Food Science **67**(7): 2512-2516.

Tadeusz, K. and T. S. Zbigniew (2006). Cost-Estimation Methods for Drying. Handbook of Industrial Drying, Third Edition, CRC Press.

Tadeusz Karamucki, J. K., et al (2004). "CORRELATION BETWEEN MEAT WATER-SOLUBLE PROTEIN CONTENT AND CARCASS AND MEAT QUALITY TRAITS IN FATTENERS DIFFERING IN MEATINESS." Pol. J. Food Nutr. Sci. **13/54**(2): 185-190.