The use of kiwifruit for tenderising meat

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FIET Meat Tenderisation Project

The FIET programme, funded by MBIE, is a significant inter-organisational programme aimed at bringing new and emerging technologies to the food industry if New Zealand. The FIET meat tenderisation project was developed with a view to adding value to tough meat cuts by use of combinations of new and emerging technologies, particularly combinations of pulsed electric field (PEF), high pressure processing (HPP), enzyme processing and sous vide cooking as an industrial process.

The Size of the Prize

New Zealand exports around 400,000 tonnes of beef and a similar amount of lamb each year (source NZ Dept. of Statistics Infoshare). Only about 10% of the carcass weight is prime tender meat. Most of the rest would be more valuable if tenderised. It has been estimated that 85,000 Tonnes of low-value beef cuts are produced each year, and if the margin on half of this could be increased by just $1 a kg on average, this would equate to $42M in added revenue for the industry.

In this project, we have initially focused on beef brisket, which is made up of the pectoralis profundus and pectoralis superficialis muscles. These muscles, which account for more than 5% of the total muscle mass on a beef carcass, support 60% of the weight of the standing or walking animal, and are particularly tough, with high levels of connective tissue. In fact, the term "brisket" is believed to derive from the Middle English brusket which comes in turn from the earlier Old Norse brjósk, meaning cartilage. Brisket normally requires long cooking times, and is regarded as a low-value, poor quality meat cut.

Enzyme Processing of meat with Kiwifruit

The ability of kiwifruit juice to break down food proteins has been known anecdotally for many decades, and was first published nearly 60 years ago by A.C. Arcus, then working in the Nutrition Research Department of the University of Otago Medical School (Arcus, 1959). Arcus noted its ability to break down gelatin, preventing jellies from setting, and coined the name actinidin for the enzyme responsible, as Actinidia is the genus that produces it (in line with papain from Papaya and ficin from Ficus species). The idea that actinidin might be used to tenderise meat has also been around for a long time, the earliest published report coming from Lewis and Luh (Lewis & Luh, 1988). The application of actinidin to tenderise meat in the domestic kitchen has been around a long time, too, with use of kiwifruit marinades popular as early as the 1970s and recipes for kiwifruit marinades to be found in more recent Edmonds Cookery books.

The Problem: How to inactivate Actinidin?

The use of kiwifruit or actinidin to tenderise meat industrially has not yet been successfully realised. This has been because although the enzyme tenderises meat very effectively, it will continue to break down the meat structure over time, until it becomes a sludge: the problem is stopping the enzyme action at just the right point – and actinidin is hard to stop.

Jessie Zhu whose work described in this article formed her M. Tech thesis

An early attempt by our team to inactivate actinidin using HPP (as reported earlier in the literature) proved unsuccessful. In another approach, we hypothesised that actinidin-catalysed tenderisation might be stopped by an appropriate heat treatment, applied as a following sous vide cooking process. At the time, we were fortunate that a suitable

student, Xiaojie (Jessie) Zhu came along wanting to do a Masterate. Over subsequent weeks, Jessie ran many trials and developed a clear picture of the conditions needed to completely inactivate actinidin. The process was not simple because:

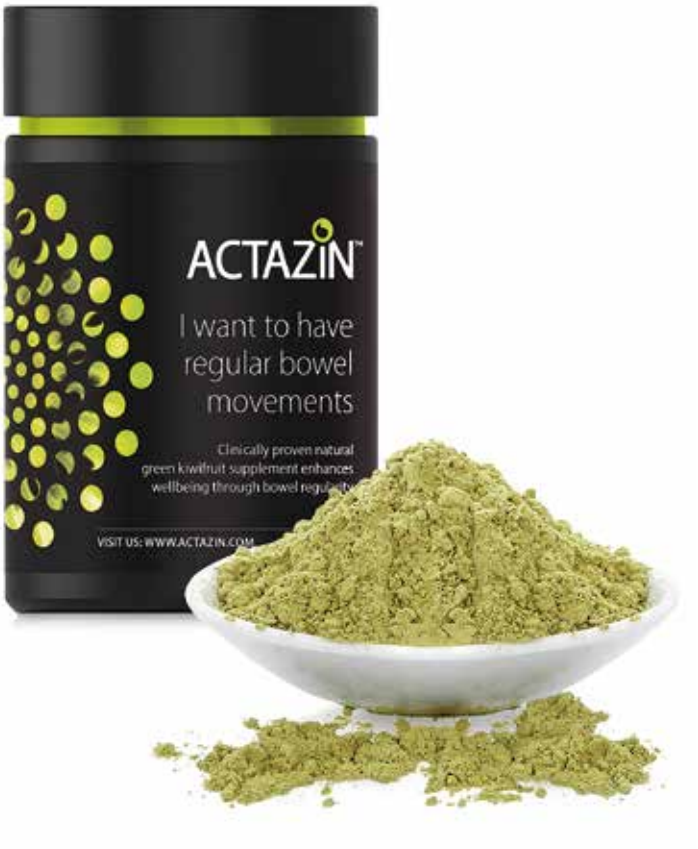
- Actinidin also exists as a precursor (proenzyme) that becomes activated by hydrolysis. This meant that in some heat treatments, the activity of the enzyme actually increased.
- Actinidin self-hydrolyses, and will self-destruct when incubated by itself, but in the presence of other proteins will preferentially hydrolyse those other proteins.
- There appears to be an additional effect of meat proteins that protects actinidin against heat inactivation – possibly through viscosity or control of water activity. It is important to recall that proteolytic enzymes require two substrates – one is protein and the other is water!

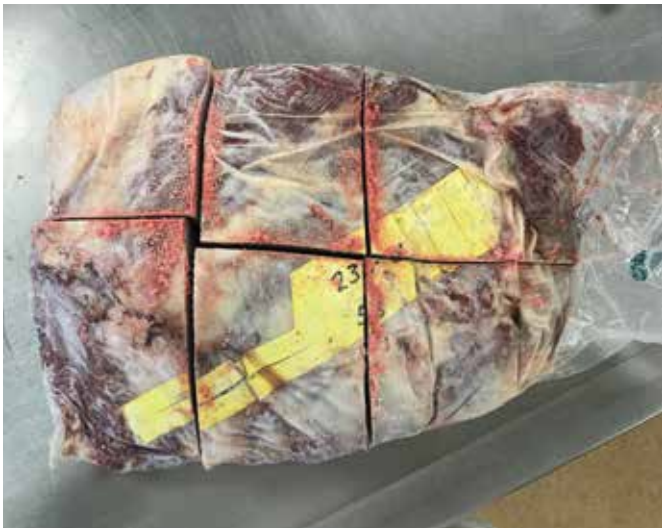
Jessie was able to develop a model for actinidin inactivation in the absence and presence of meat, and to identify an optimal sous vide process to minimally cook the meat while fully inactivating the enzyme.

Combined process development

It was then necessary to develop suitable techniques to treat meat with actinidin to properly tenderise it, and then to stop the reaction with a suitable heat treatment. We used steaks made from brisket from dairy beef cows – not the most tender of cuts! For the enzyme process, we used a commercial preparation: Actazin™ from Anagenix.

It was quickly established that a simple marination process was not ideal, as it selectively tenderised the surface of the meat, giving a rather unpleasant surface texture and less tenderisation deeper in the meat. The final process involved multiple site injection of a very low level of enzyme, followed by vacuum tumbling (a process similar to that used for hams). Brisket steaks prepared in this way were cooked sous vide at 70°C for 30 minutes, which was enough to inactivate the enzyme. Steaks prepared from brisket using this process could be used immediately, stored overnight at 4°C, or stored frozen for several weeks. We anticipate that meat from other cuts, and from other animals (such as sheep meat) could be similarly processed, possibly with some fine-tuning needed.





Brisket cut into steaks

And the proof of the pudding...

Brisket steaks prepared in this way were tested against control steaks in a series of instrumental tests, and also tested using a sensory panel by Maryanne Staincliffe at AgResearch in Ruakura. For the sensory panel tests, the steaks were given a final sous vide cook at 60°C for 55 min, to finish cooking the meat and to ensure microbiological safety.

The actinidin-treated meat had no change in pH, colour and cook loss, but showed a lower instrumental shear force and improved sensory scores for tenderness, juiciness and flavour compared with the untreated meat samples.

Overall, the injection of enzyme solution made the meat more tender with "just right" tenderness. The enzyme-treated meat was juicier than normal untreated meat. The flavour of the meat was somewhat enhanced by the addition of actinidin. Three weeks of frozen storage increased the tenderness even more (probably due to freeze-thaw effects), but had no significant effect on the juiciness and flavour.

Future directions

Jessie has now completed her M. Tech. and the full details have been submitted for publication in the international scientific literature. Her thesis has been lodged in the Massey library and should be available online soon. Over the next two years, we plan to take the process to pilot scale with beef, and to extend the process to sheep meat, in both cases working with major industry partners.

We will continue to investigate other technologies for tenderising meat, including PEF, which we hope to take to pilot scale, and work on the development of more sophisticated processing models for sous vide cooking. We will also explore the potential of shockwave processing of meat, which is now being carried out at pilot scale in Germany and in Australia.

Acknowledgements

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Food Industry Enabling Technologies

Food Industry Enabling Technologies (FIET) is funded by the Ministry for Business, Innovation and Employment and its purpose is to support new process developments that have the potential to add significant value to our national economy. The programme has six partners, Massey University (the host), Riddet Institute, University of Auckland, University of Otago, Plant and Food and AgResearch. Funding is $18m over six years (2015-2021) and targets pre-commercialisation activities. If you are interested in more information, then please contact either Dr Jo Kerslake, FIET Programme Director, (j.i.kerslake@massey.ac.nz) or Professor Richard Archer, Chief Technologist, (R.H.Archer@massey.ac.nz).