Final report

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Evaluation of the Supachill© technology

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Executive Summary

Supachill© is an immersion cooling system designed to rapidly cool food products for both chilled and frozen applications. The manufacturers claimed several product quality advantages for freezing meat including:

- Reduced ice crystal formation, tissue damage and drip loss
- Improved yield, tenderness, firmness, eating quality and shelf life.

These quality advantages potentially may translate into significant marketing advantages and as such Teys Bros and Meat and Livestock Australia entered into a partnership to investigate the potential of the Supachill technology.

The purpose of the project was to:

- Determine the value proposition
- Develop a research and development plan
- Validate the Supachill claims in portion control products as well as preliminary testing on other products
- Determine preliminary market feedback

A cost benefit analysis was conducted in order to quantify the value that could be created by this technology for Teys business. Benefits unique to the rapid freezing system included improvements in market access through alternative classification of product, reduction in airfreight rates, reduced drip loss resulting in improved retail presentation and extended shelf life, and raw material price reduction. Secondary benefits of using the Supachill freezing infrastructure to cool cooked products saves expenditure on blast freezing that would otherwise have been required. Supachill was expected to deliver a return on investment within 24 months of operation.

The following outcomes were achieved from product trials:

- The colour, drip loss and tenderness of aged beef steaks subjected to three temperature regimes (blast chiller, Supachill and blast freezer) were compared.
- Supachill reduced freezing time by nearly 2 days compared to blast freezing.
- Supachill resulted in meat that had less purge loss but tended to be lighter and browner in colour than blast frozen meat. The magnitude of these effects depended on the period of time steaks were displayed after thawing.
- Colour was more intense and colour change due to freezing treatment was more perceptible in the rump than cube and strip loin steaks.

- Further research work is recommended to assist with developing commercial applications for Supachill.

No significant regulatory issues were identified by Teys during the project. It was accepted on the advice of AQIS that product was to be labelled as frozen.

Over the past 2 years, Teys Food Services has established an export customer base for Supachill products. This customer base was initially built around existing and new customers predominantly in EU markets, however more recent times TFS has expanded the product range into the Asian market.

Customers have clearly indicated that they are achieving substantial savings to the degree where customers are achieving between 4-5% in yield gain due to reduce purge loss in the tempering process, which has also contributed to enhanced eating quality. Minor issues in product quality identified through extensive market development and evaluation has been resolved, and a full range of rapid frozen value-added products are being commercially produced for international orders.

The progression of the Supachill project was hampered by the difficulties faced by the equipment supplier, and a Liquidator was appointed for Supachill Technologies Pty Ltd in December 2010. Subsequently, the equipment manufacturer ceased to operate and unable to provide any ongoing technical support with Supachill. However, Teys has continued to operate the equipment and made some substantial modifications to improve the product quality and process efficiencies. An air-knife conveyor was installed to remove all the residual glycol from the external packaging. Also a return conveyor was installed to transport the Supachill racks from the exit end of the unit to the loading end, assisting with production efficiencies and reducing OHS hazards.

The technology continues to operate commercially for Teys Food Service; however Supachill is no longer manufactured.

Contents

1 Background

Supachill© is an immersion cooling system designed to rapidly cool food products for both chilled and frozen applications. The manufacturers claimed several product quality advantages for freezing meat including:

- Reduced ice crystal formation, tissue damage and drip loss
- Improved yield, tenderness, firmness, eating quality and shelf life.

These quality advantages potentially may translate into significant marketing advantages such as selling frozen product in a fresh product category. Teys wish to evaluate these claims for various applications beginning with the freezing of a portion controlled product. Application of the Supachill© technology to other products including primals, value added, cooked, and ultimately whole carcases is intended in the future in both domestic and export supply chain scenarios.

Meat starts to freeze at a temperature below 0°C. As the temperature reduces further, more of the water in the meat is converted into solid ice. Different countries have varying temperature benchmarks for frozen foods and meat, typically frozen foods should be stored below -15°C, and -18°C is often recommended. Since about 80% of the water in meat will have converted to ice when the temperature is -10°C, meat below this temperature can largely be considered frozen. The rate of freezing can affect the size and location of ice crystals and thereby the quality of meat frozen post rigor due to biophysical effects.

In support of the Supachill© claims, significant research has demonstrated that fast freezing rates cause ice formation to be intracellular and extracellular for slow freezing rates (Warriss 2000). An increased amount of extracellular ice formation leads to damage to the muscle fibres, decreased water holding capacity of muscle proteins and failure of fibres to reabsorb water on thawing (Van Moeseke *et al.* 2001).

Research has demonstrated that freezing and thawing rates can also affect drip loss, myofibrillar solubility, tenderness and influence retail colour display (Anon and Calvelo 1980; McGeehin *et al.* 2002; Ngapo *et al.* 1999a; b; Petrovic *et al.* 1993). Although not applicable to the current application, considerable research has also been done into the effect of freezing pre-rigor meat.

Teys has identified a unique business opportunity to develop a new range of rapid frozen value added meat products for existing and new local and export markets. Commercial immersion freezing technology known as Supachill technology and it used exclusively in seafood and fruit and vegetable rapid freezing applications (see Photo 1). While not previously demonstrated commercially in meat applications, it is anticipated that the benefits of premium quality is transferrable also to the meat products as it is with existing foods applications.

Photo 1 – Supachill technology planned to be installed at Teys Foodservice

Teys's strategy is to invest in the development of rapid chilling and freezing technology across its business. If the installation of the Supachill technology becomes commercial, it is expected that significant value can be added to meat carcases, primals and products, costs reduced and overall competitiveness enhanced in export and domestic markets. Should rapid freezing technology be able to freeze products which once thawed, exhibit similar characteristics to fresh product, there are significant advantages for Australian meat and meat products in both export and domestic markets.

The broad objective of this research is to determine whether or not this proposition is correct. This project will not just focus on rapid freezing but also on rapid chilling as this will also offer potential benefits. The expected outcome will be to produce a report that will verify the claims of the manufacturer.

2 Project Objectives

The purpose of this research is to:

- determine the value proposition of Supachill for very fast freezing and very fast chilling
- develop a detailed research and development plan for Supachill technology
- validate the Supachill claims in portion control products as well as preliminary testing on other products
- determine preliminary market feedback

3 Materials & Methods

The protocol for the trials to determine the benefits of Supachill versus fresh and conventionally frozen product was developed in conjunction with MLA, AgResearch and the Department of Food and Agriculture, WA.

3.1 Raw material

The raw material for this experiment was sourced from 10 Angus cattle slaughtered at Teys Establishment 294 (Beenleigh). These animals came from the one vendor consignment and met the *post mortem* pH temperature requirements for boning categories 1-8 (Meat Standards Australia).

Three primal cuts were collected from both sides of the 10 carcases 24h (cold boned) after slaughter and packed in a vacuum pack. Post collection all products were stored under refrigerated conditions (Chill Tunnel) temperature set point -1°C. The product met CCP4 requirements of < 3°C within 48hrs and was loaded out to Teys Food Services. Product temperature taken prior to dispatch was 1.2°C.

3.2 Experimental design

The experiment was a 3x3x3 factorial design and the treatment factors were:

1. Primal cut: cube roll, strip loin, rump
2. Cooling process (Table 1): Blast chiller (BC), Blast freezer (BF), Supachill© (SC)
3. Post thaw display time: 0, 4, and 7 days

Table 1 - Process treatment description.

Cooling process	Treatment method	Thawing method
Blast chiller	Chilled never frozen in a blast chiller 48h	Thawing not needed
Blast freezer	Slow freeze in a blast freezer 48h	48h at 0°C blast chiller
Supachill	Fast freeze in Supachill© 3h then blast freezer 45h	48h at 0°C blast chiller

With this design there were 27 treatment factor combinations; for each of which 10 steaks was allocated, one from each of 10 carcases giving a total (N) of 270 samples (Table 2).

Table 2 - Numbers of steaks for each primal, process and display time.

Primal	Display	Process	Total

	time	Blast chiller	Blast freezer	Supachill	
Cube roll Code 7705	0	10	10	10	30
	4	10	10	10	30
	7	10	10	10	30
Strip loin Code 7704	0	10	10	10	30
	4	10	10	10	30
	7	10	10	10	30
Rump Code 7703	0	10	10	10	30
	4	10	10	10	30
	7	10	10	10	30
Total		90	90	90	270

3.3 Treatment logistics

Cooling treatments were imposed on September 24th; 21 days after the animals were slaughtered. On this day the primal cuts were removed from vacuum packaging and sliced into steaks of 22mm thickness. Each steak was then packed individually in vacuum “skin” packaging, prior to imposition of the cooling process treatments.

Steaks within a primal were allocated randomly to treatment. Individual steak packs were then packed in cardboard cartons during the process treatment for blast chiller and blast freezer. For Supachill© treatments individual steaks were placed in a wire rack and then immersed for freezing. Following process treatments, the steaks were stored in either a blast freezer or chiller depending on the treatment. Frozen steaks were transferred to the blast chiller for thawing. Colour and purge loss measurements were done on day 0 of display; 29 days after slaughter and 7 days after cooling treatments were commenced, then again on day 4 of display and day 7 of display.

3.4 Measurements

A range of measurements were made including:

1. Meat quality attributes
    - purge loss (prior and post treatment)
    - retail display colour
    - shear force (estimate of tenderness)
2. Temperature

iButton data loggers were place in the centre of steaks at the time of cutting. Temperature was recorded at intervals of 1 minute during the duration of the experiment.

3. pH
    - Ultimate pH (pHu)
4. Food safety
    - Swab and culture
5. Ice crystal visualisation
    - Microscopy

Allocation of samples for the different measurement procedures is outlined in the sub-sampling protocol (Appendix 2).

4 Results

Trials conducted on Supachill by *Jacob et al.* 2009, provide the following outcomes in relation to cut steaks (cube, rump and striploin):

- Supachill provides a significantly reduced freezing time compared to blast freezing.
- Supachill shows less purge loss post thaw than blast frozen steaks.
- There was differences shown for colour lightness and hue across the different treatments (chilled, supachilled and blast frozen), but this difference was not clearly qualified as positive or negative (with further work required on this).

Additional trials were conducted on Supachill products in 2011 to determine the shelf life in retail value added and portion cut vacuum skin pack products after raw material had been aged for 28 days, supachilled then thawed. The trials indicated that the products achieved a shelf life of 21 days after thawing, slight discolouration and minimal purge loss during the thawing process, however the latter increased slightly throughout the remainder of the shelf life. A further trial was completed using 28-35day age raw material, Supachill, thawed then packaged in MAP, the trials indicated that the product achieved a 9 day shelf life (90% of chilled raw material performance).

Further work should be carried out to qualify the differences seen in lightness and hue from this trial, specifically in relation to colour acceptability.

4.1 Temperature time profiles

The changes in temperature were very similar within cooling process treatment for steaks from the different primal cuts (

Figure 1, Figure 2 & Figure 3)

However there were dramatic differences between cooling process treatments for the rate of temperature change. Supachilled steaks reached -10°C after about 24 minutes and a minimum temperature of -25°C after about 90 minutes of cooling. The temperature of Supachill steaks fluctuated within ±1°C of -25°C, presumably due to thermostatic control of the Supachill liquid. By comparison the temperature of the blast frozen steaks was 6.5°C at 90 minutes, reached -10°C at 15 hours and -25°C after about 1.8 days of cooling. The minimum temperature recorded in the blast chilled steaks was 2.1°C at day 1.15, but the temperature of blast chilled steaks stabilised at 4°C after this.

The temperature of Supachilled steaks increased from -25°C to -5.9°C after 1 day. This coincided with the washing of the packaged steaks from the Supachill machine in cold water prior to transfer of the steaks to the blast freezer for storage.

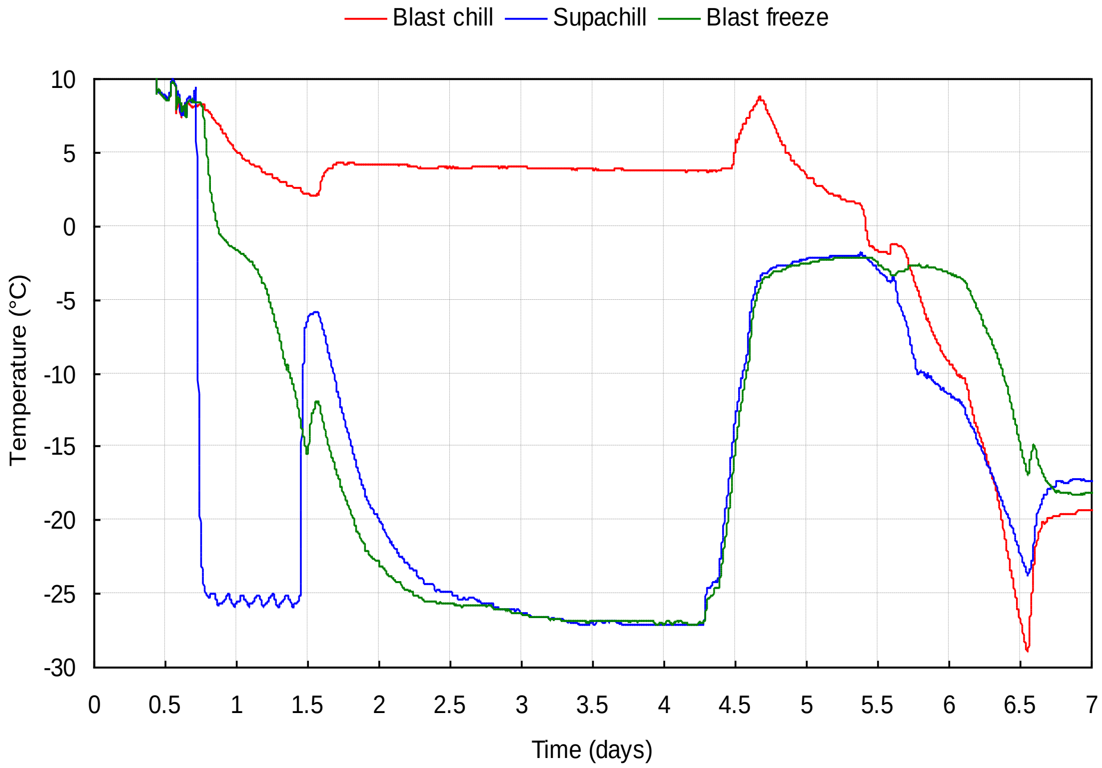


Figure 1 - Temperature of cube roll steaks over the 4 day period of process treatment (values are means of 5 steaks).

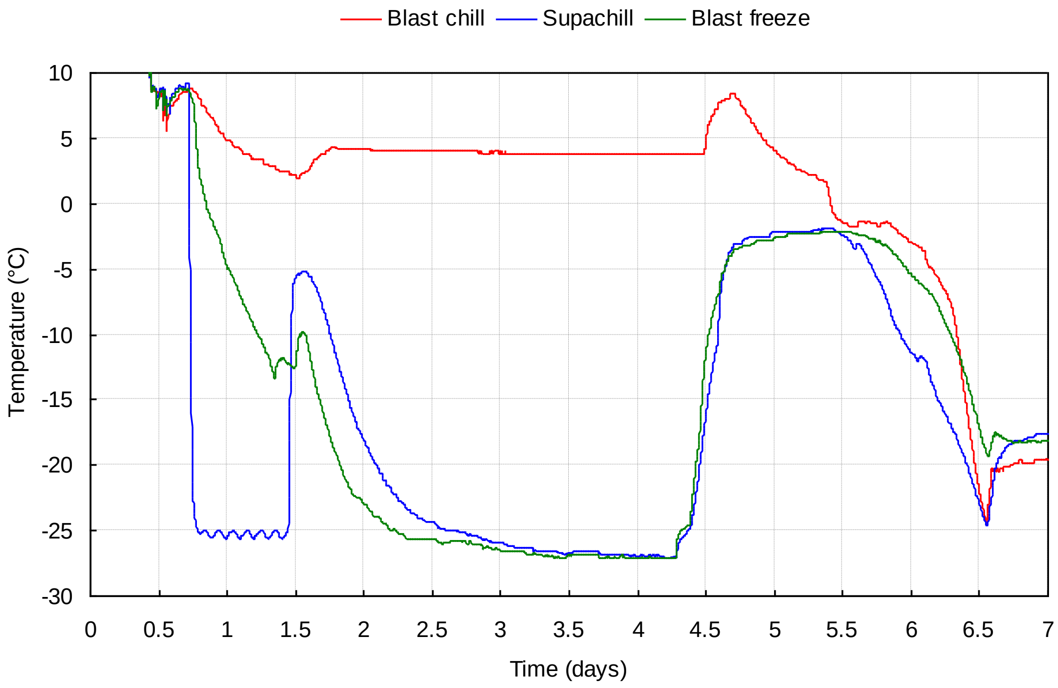


Figure 2 - Temperature of rump steaks over the 4 day period of process treatment (values are means of 5 steaks).

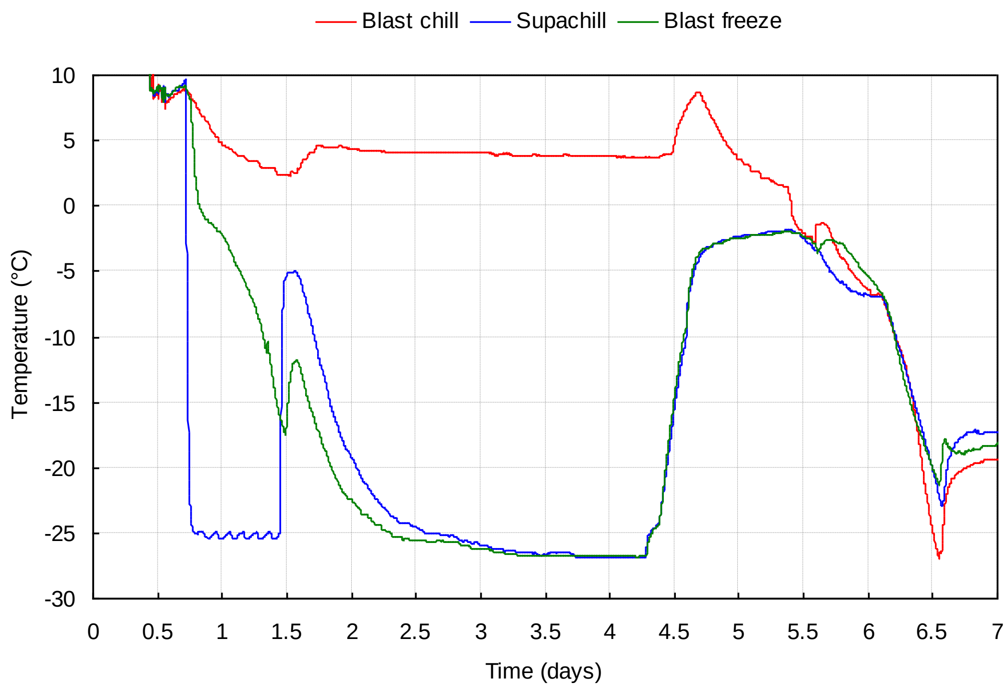


Figure 3 - Temperature of strip loin steaks over the 4 day period of process treatment (values are means of 5 steaks).

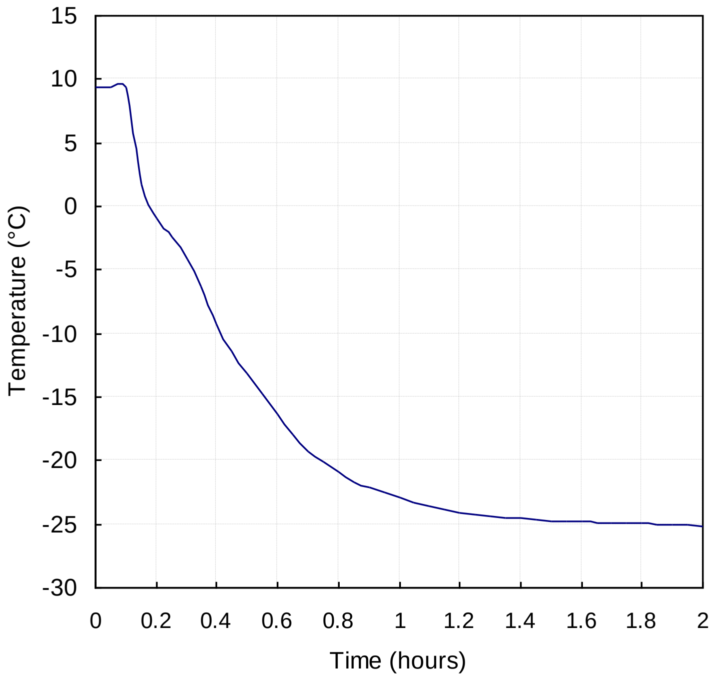


Figure 4 - Temperature of cube roll steaks in Supachill treatment for 2h after commencement of treatment (values are means of 5 steaks).

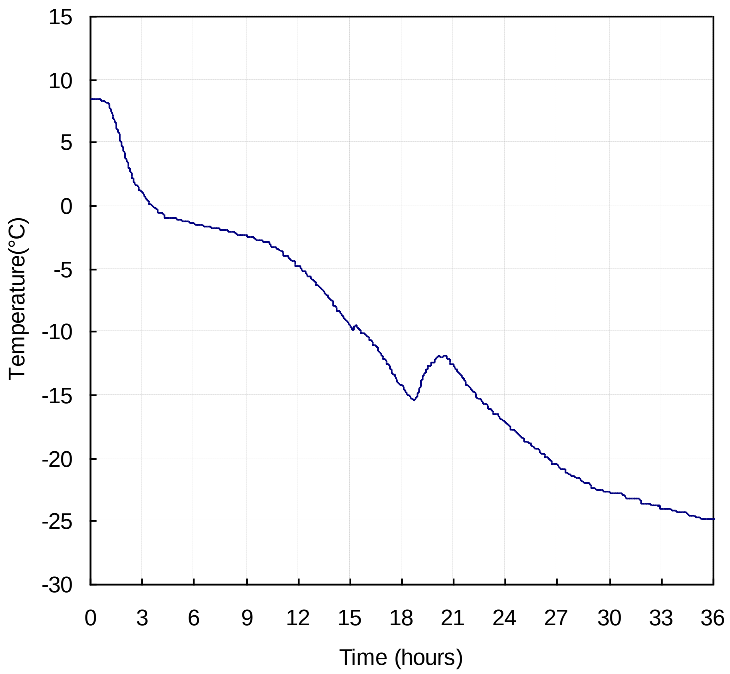


Figure 5 - Temperature of cube roll steaks in Blast freezer treatment for 36h after commencement of treatment (values are means of 5 steaks).

Cube roll steaks in the Supachill treatment reached the latent heat of freezing plateau 6 minutes after commencement of treatment and the plateau is difficult to observe as it only lasted for about 3 minutes (Figure 4). By comparison cube roll steaks in the Blast freezer reached the latent heat of freezing plateau 3 hours after commencement of treatment and the plateau lasted for about 6 hours (Figure 5).

4.2 Purge loss

There was a significant effect of primal cut, cooling process and display time but no interaction between any treatments for purge loss. There was no difference between cube (Figure 7) and strip (Figure 7) but the rump (Figure 8) had more purge loss than both cube and strip. There was no difference in purge loss between day 0 and day 4 but purge loss was greater on day 7 than on day 0 and day 4.

Blast chiller had a lower purge than Supachill© which had a lower purge than blast freezer.

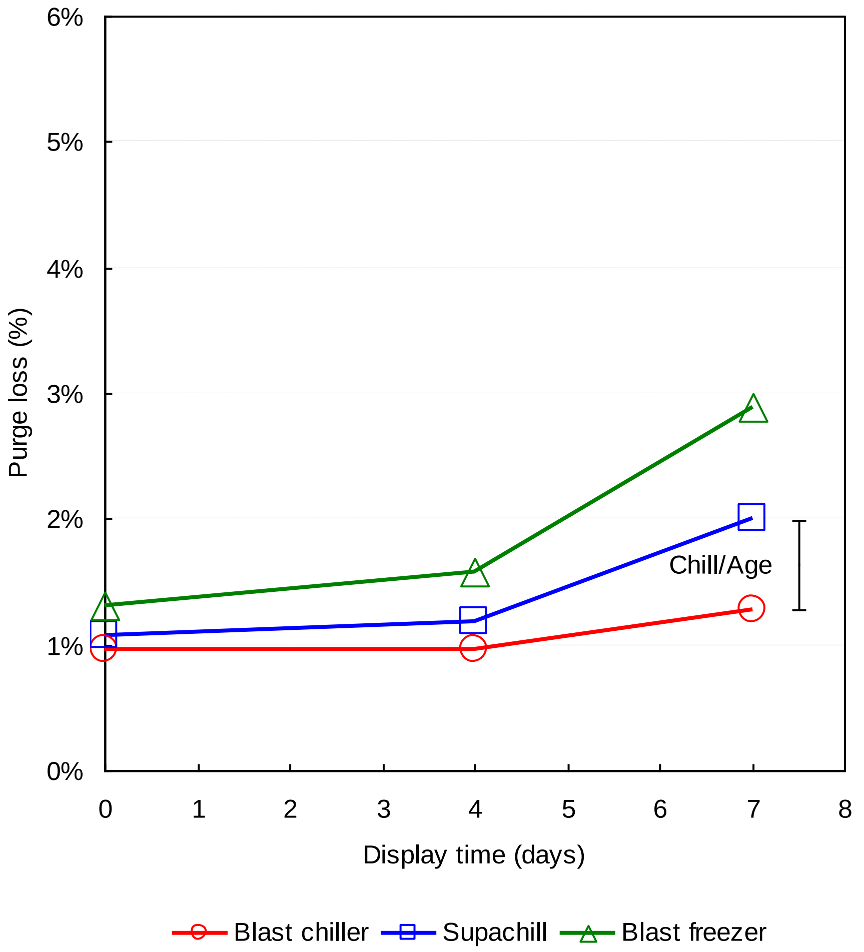


Figure 6 - Purge loss for cube roll steaks cooled with blast chiller, Supachill and blast freezer.

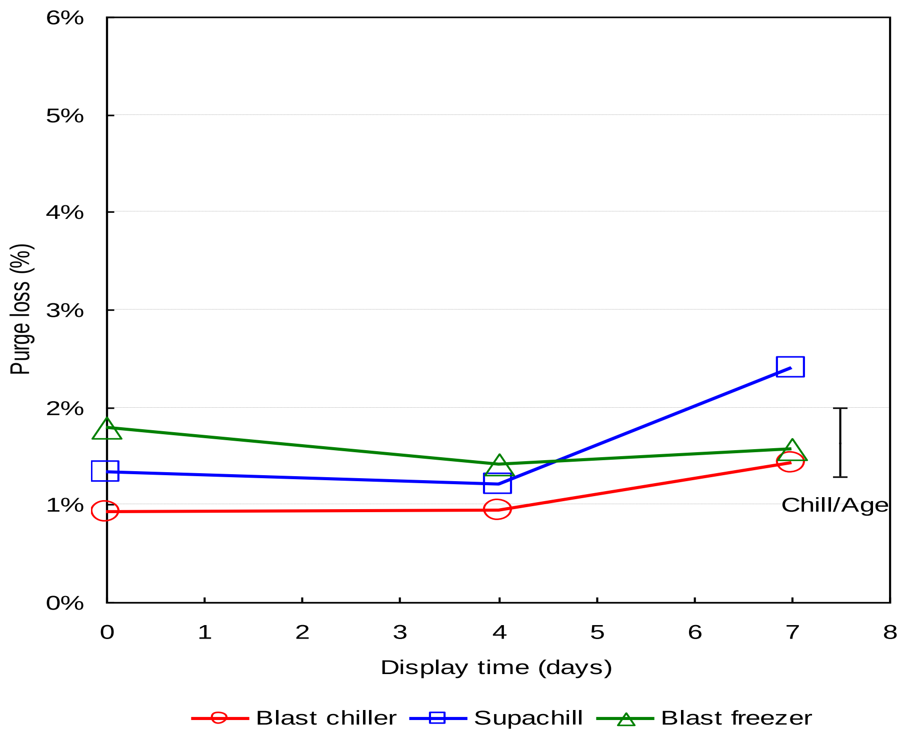


Figure 7 - Purge loss for strip loin steaks cooled with blast chiller, Supachill and blast freezer.

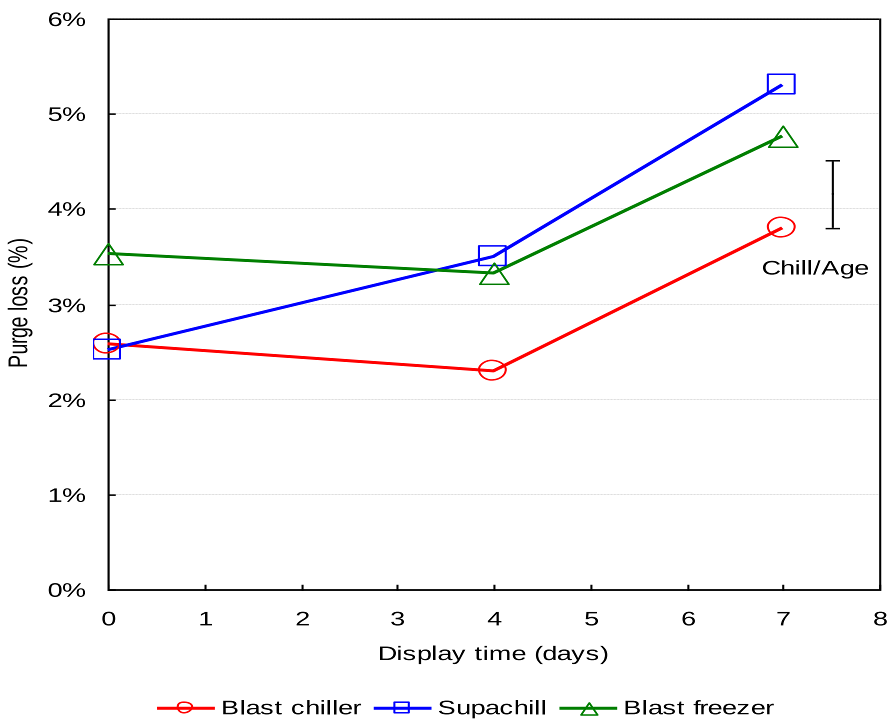


Figure 8 - Purge loss in rump steaks cooled with blast chiller, Supachill and blast freezer.

Variations in purge loss due to cooling treatment were visible after 7 days of display (Image 1, Image 2, Image 3).

Image 1 - The visual appearance of purge loss in Blast chiller rump after 7 days of display.

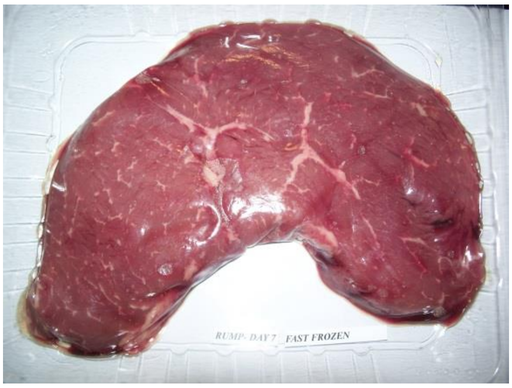


Image 2 - The visual appearance of purge loss in Supachill cooled rump after 7 days of display.

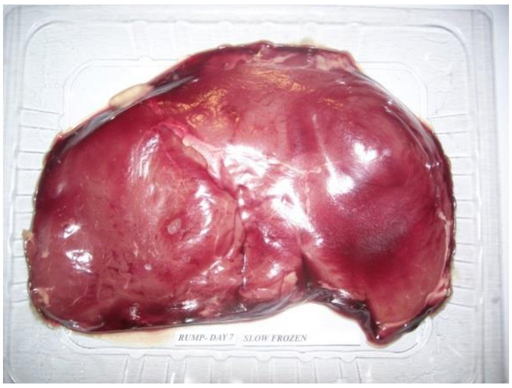


Image 3 - The visual appearance of purge loss in Blast freezer cooled rump after 7 days of display.

4.3 Colour

4.3.1 Lightness

There was an effect of primal cut and cooling process on the lightness (L value) of the steaks as well as an interaction between cooling process and display time (Figure 9, Figure 10, Figure 11). Cube roll steaks were lighter in colour than striploin and rump steaks. Steaks chilled and not frozen were lighter in colour than steaks frozen in Supachill and the blast freezer. Steaks frozen with Supachill were lighter than steaks frozen with the blast freezer but only on the first day of display.

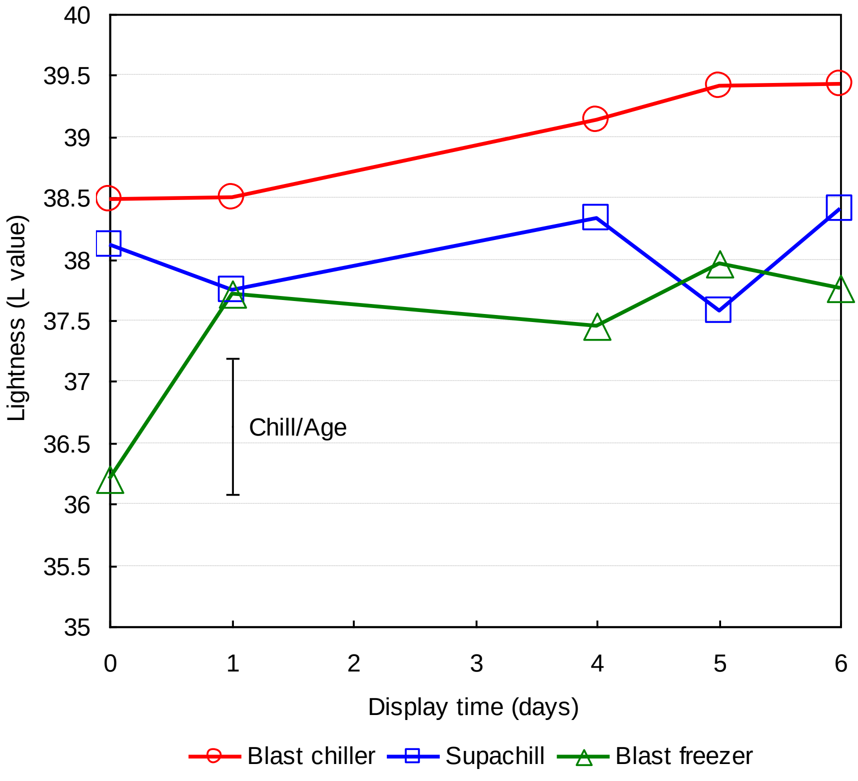


Figure 9 - The lightness of colour for steaks from cube roll cooled with blast chiller, Supachill and blast freezer during the display period (values are means, bar is least significant difference P<0.05).

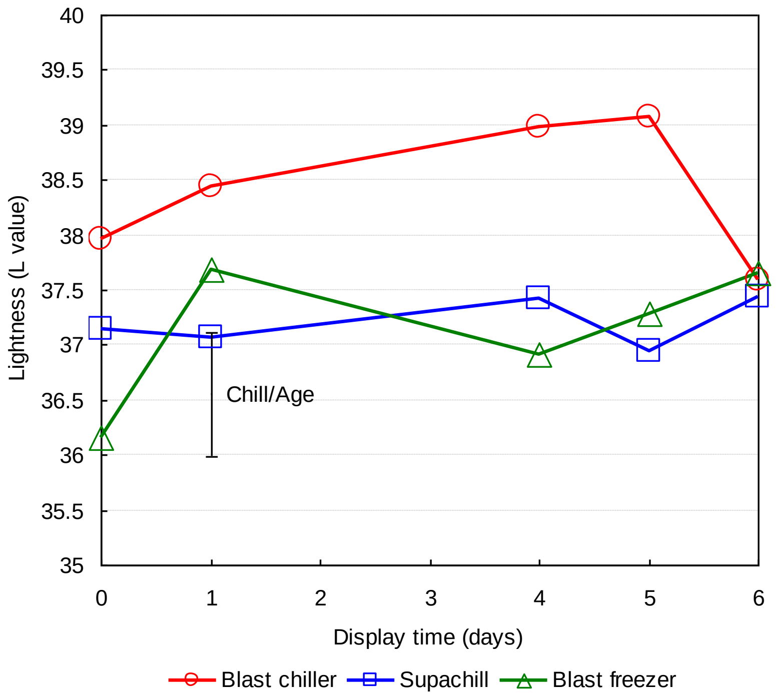


Figure 10 - The lightness of colour for steaks from strip loin cooled with blast chiller, Supachill and blast freezer during the display period (values are means, bar is least significant difference, P<0.05).

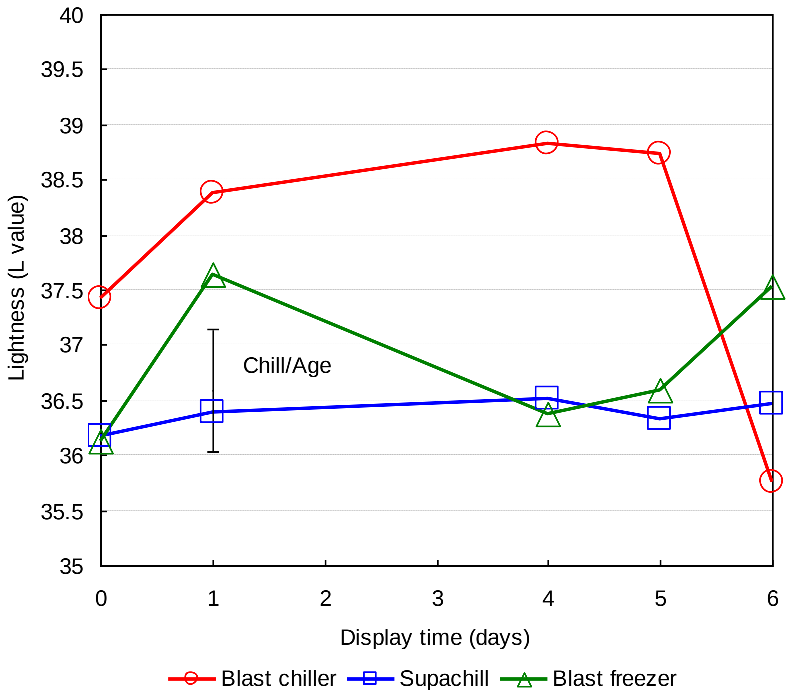


Figure 11 - The lightness of colour for steaks from rump cooled with blast chiller, Supachill and blast freezer during the display period (values are means, bar is least significant difference P<0.05).

4.3.2 Hue

Hue angle was affected by cooling process and display day (Figure 12). There was no difference between primal cut for hue angle and no interaction between treatment factors for hue angle.

Steaks frozen with Supachill had a higher hue value angle value than steaks frozen with blast chiller and steaks chilled and not frozen. This suggests that the colour of steaks frozen with Supachill would appear browner and less red in colour than for other treatments. The effect of display time on the hue of steaks was seen mainly between day 0 and day 1 of display and less so after this.

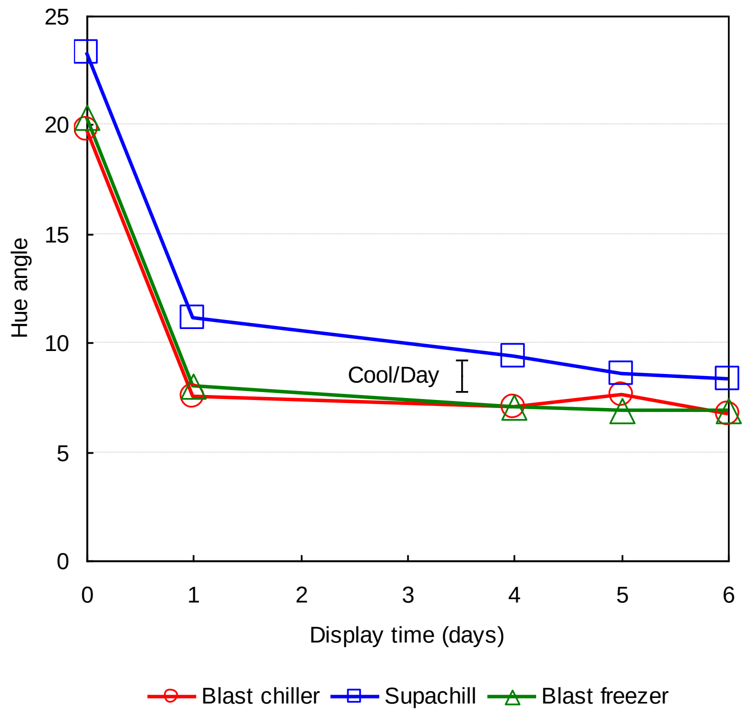


Figure 12 - Hue angle during the display period for steaks processed in blast chiller, Supachill and blast freezer (values are means of cube roll, strip loin and rump cuts, bar is least significant difference P<0.05).

4.3.3 Colour intensity

There was an effect of primal cut, cooling process and display day with an interaction between primal cut and cooling process for intensity of colour (Figure 14). Steaks from the rump were more intense in colour than those from the strip loin which were more intense than those from the cube roll.

Colour was more intense for steaks processed in the blast chiller than steaks frozen with Supachill and the blast freezer. There was no difference between the colour intensity of steaks frozen with Supachill compared to the blast freezer except for the rump. In the rump steaks frozen with Supachill were less intense in colour than those frozen with the blast chiller.

Colour on day 0 of display was less intense than colour on all other days.

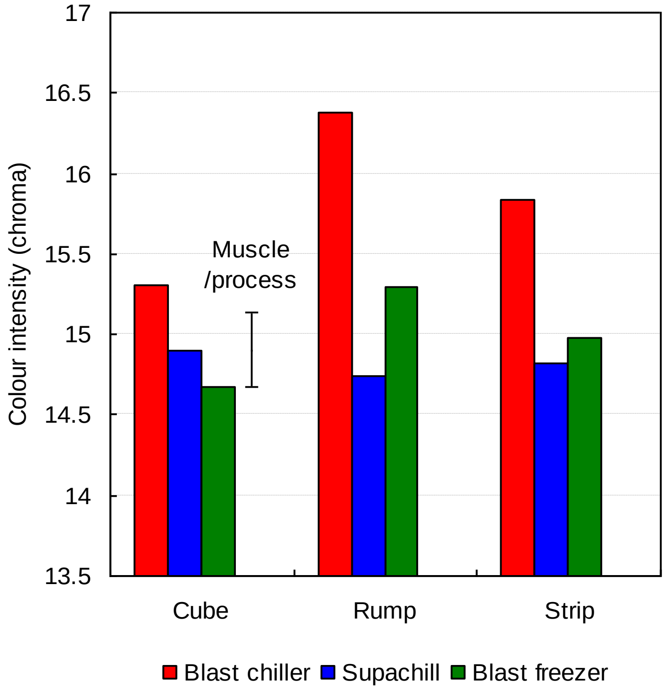


Figure 13 - Colour intensity (chroma) of cube roll, rump and strip loin steaks processed with blast chiller, Supachill and blast freezer (values are means, bar is least significant difference P<0.05).

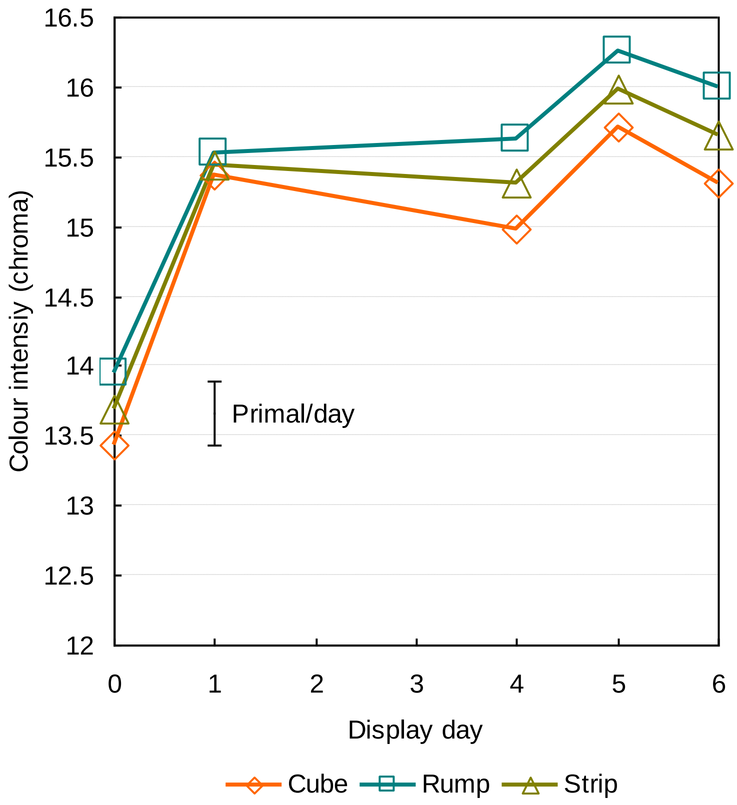
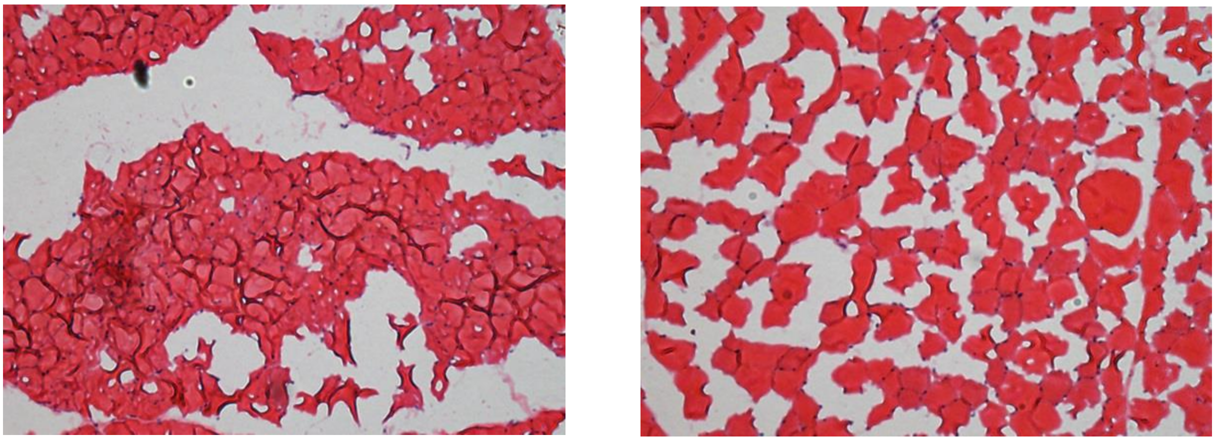


Figure 14 - The colour intensity of steaks from cube roll, strip loin and rump during the display period (values are means, bar is least significant difference, P<0.05)

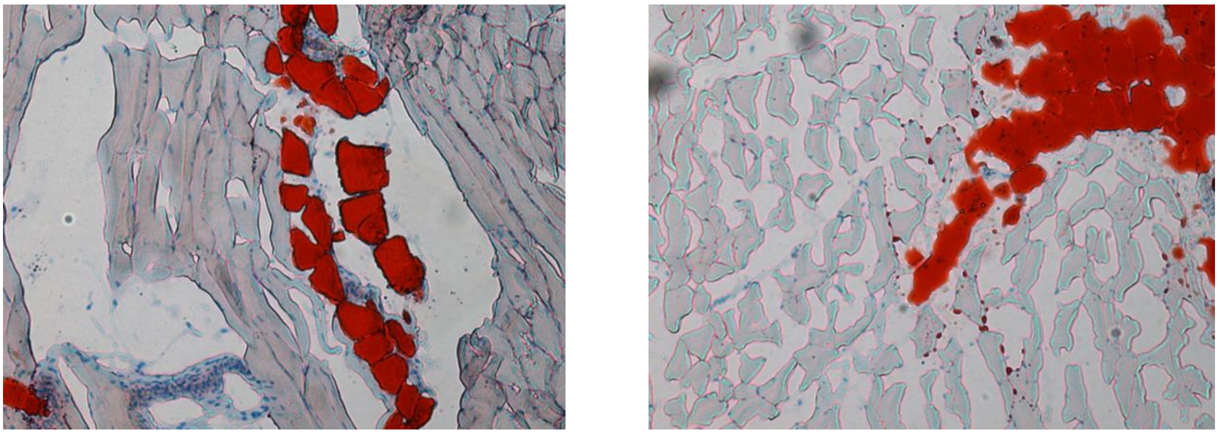
4.4 Microscopic Structure

Freezing process had an effect on the microscopic appearance of cube roll steaks. Spaces were apparent in tissues for both Blast freezer and Supachill treatments but the spaces were dispersed more uniformly through the tissue with Supachill compared to the blast freezer treatment (Figure 18, Figure 19). The failure of the spaces to stain with oil red O stain suggests these spaces will likely have contained ice and not lipid material.



(a) Blast (b) Supachill

Figure 15 - The microscopic visual appearance of cube steaks stained with hematoxylin and eosin (H&E) stain (magnification x5).



(a) Blast (b) Supachill

Figure 16 - The microscopic visual appearance of cube steaks stained with oil red O stain (magnification x5)

5 Discussion

5.1 Temperature profiles

As expected this study demonstrated that the steaks froze much faster with Supachill compared to the blast freezer. The trial indicated that nearly 2 days could be saved within the freezing process using Supachill. If desired, this 2-day saving could be used to extend the ageing period prior to freezing without extending the overall process time. This advantage may be more useful when ageing periods are shorter and closer to critical levels for tenderness than the 21 days used in this study (i.e. adding 2 days to a 7 day ageing period will have more effect than adding 2 days to a 21 day ageing period).

An unexpected finding that could be important for successful commercial application of the Supachill system was the rise in temperature during transition between the Supachill and the holding freezer (after day 1). This temperature spike was more acute and higher for the Supachill than for the blast freezer treatment. The likely reason for the higher temperature spike was the washing of the packaged steaks in cold water prior to transfer to the holding freezer; whereas the blast frozen steaks were not washed and had a much lower temperature spike.

This temperature spike after freezing Supachill may not be avoidable in practice as it may be necessary to wash the Supachill liquid off prior to packing into frozen storage. This temperature spike may affect the size of ice crystals, which are known to coalesce in frozen storage particularly when the temperature fluctuates, potentially causing cell damage that the rapid freezing of Supachill is intended to avoid.

Further work is required to determine the best way to manage the transition from Supachill to a storage freezer; including the technique to remove glycol solution from the outside of the packages (e.g. an air knife may be able to be used).

5.2 Visual appearance of the product

Purge loss and colour measurements together indicate that the Supachill product may appear different to consumers compared to blast frozen product depending on the period of display. The Supachill steaks appeared similar in lightness of colour to the chilled product but this advantage disappeared when the Supachill steaks were thawed. Reduced purge loss in thawed product is likely to improve the visual appearance of Supachill treated product at least up until 4 days of display after which no difference could be expected.

Of some concern is that the Supachill product was browner in hue than blast chilled and frozen product. The reason for this is unclear because the instrument used to measure colour was not a spectrophotometer that can measure reflectance of light over the full range of wavelengths. Whilst the assumption that the brown colour was due to oxidation of the red pigment to the brown form (metmyoglobin) is fair to make, this cannot be confirmed from the existing colour data. If the reason was metmyoglobin this result may have been influenced by the 21 day ageing period used prior to freezing.

At least some lipid peroxidation is likely to have occurred during this period making the meat susceptible to rapid colour change. If this was the case the problem may not be evident for meat aged for short periods prior to freezing. However this would have been true for all steaks and not just those in the Supachill treatment. Further investigation of this effect is therefore warranted in developing commercial applications of Supachill. In the meantime cuts that are particularly susceptible to browning, such as rump, might be excluded from packaging in this way.

5.3 Market acceptance trials

Over the past 2 years Teys Food Services has established an export customer base for SupaChill products. This customer base was initially built around existing and new customers predominantly in EU markets, however more recent times TFS has expanded the product range into the Asian market.

To gain product acceptance customers were inclined to purchase Supachill primals initially to compare the proposed positive attributes to the blast frozen and aged chilled products which the customer currently purchased. Customers purchased a variation of primals including D Rumps, Striploins, Cube Rolls and Tenderloins. Customers have purchased over 221MT in the past 12 months of Supachill primals.

Customers have clearly indicated that they are achieving substantial savings to the degree where customers are achieving between 4-5% in yield gain due to reduce purge loss in the tempering process, which has also contributed to enhanced eating quality.

In addition to the previous research conducted TFS has completed extra trials whereby primals were Supachilled, tempered to 0 degree, portion cut than packaged into Map. Product shelf life trials were conducted and the results were identical of chilled aged primals used in the same packaging process (10 days). Customers were pleased with shelf life results as the supachilled product gave them more flexibility for raw material, not having to discount chilled primals due to breeching raw material age limits to comply with micro and shelf life specifications.

Further shelf-life trials were conducted with a marinated Tri Tip roast, injected by 10% and vacuum tumbled prior to Supachilling. The result was slightly less than using a chilled raw material, achieving a 25 day compared to 28 days for chilled. However the slight reduction in shelf life was a positive outcome, again presenting export customers with a great alternative to chilled.

Over the past 6 months TFS has been supplying a Switzerland and Hong Kong supermarket chain with a range of Supachilled portion cut steaks. These products were received well by customers and additional orders have been received.

5.4 Value Proposition of SupaChill Technology

The potential benefits of the Supachill Technology were investigated by Greenleaf Enterprises in March 2010. Greenleaf assumed the manufacturer's claims on the benefits of the Supachill technology were true and based on this assumption, provided predictions of the significant value that could be added to meat carcases, primals and portioned products. The ability to freeze meat products that exhibit similar characteristics to fresh product, once thawed, could provide significant advantages for Australian meat and meat products in both domestic and export markets.

The objective of the Greenleaf study was to conduct a cost benefit analysis in order to quantify the value that could be created by this technology for TFS. A full cost benefit analyses was conducted by Greenleaf, and the detailed report is not available for public distribution due to the commercial sensitivities.

Benefits unique to the rapid freezing system included improvements in market access through alternative classification of product, reduction in airfreight rates, reduced drip loss resulting in improved retail presentation and extended shelf life, and raw material price reduction. Secondary benefits of using the Supachill freezing infrastructure to cool cooked products saves expenditure on blast freezing that would otherwise have been required.

The review established that the Supachill technology provides a number of distinct benefits to Teys for particular customers and markets as summarised in Table 4 below. These benefits do not apply to all types of supply channels and customers, but if focused strategically at the correct types of customers, will give a competitive advantage.

Table 4: Summary of Supachill benefits to TFS over 3 year period (dollars of margin generated because of Supachill).

SupaChill Benefit	2010	2011	2012
1. Market Access	$403,700	$932,580	$1,184,890
2. Freight Benefit	$17,500	$70,210	$81,240
3. Drip Loss saving	$377,400	$590,065	$629,320
4. Increased Shelf Life	$384,200	$654,218	$759,660
5. Inventory Optimization	$68,760	$181,010	$231,684
6. Infrastructure Utilization	$98,900	$278,185	$386,773
Total	**$1,350,460**	**$2,706,268**	**$3,273,567**

A modelling tool was built that enables TFS to order and prioritise customers and product developments to provide the best return on company resources. Based on the sales forecasting data inputted in conjunction with the TFS sales team, Supachill is expected to deliver a return on investment within 24 months of operation.

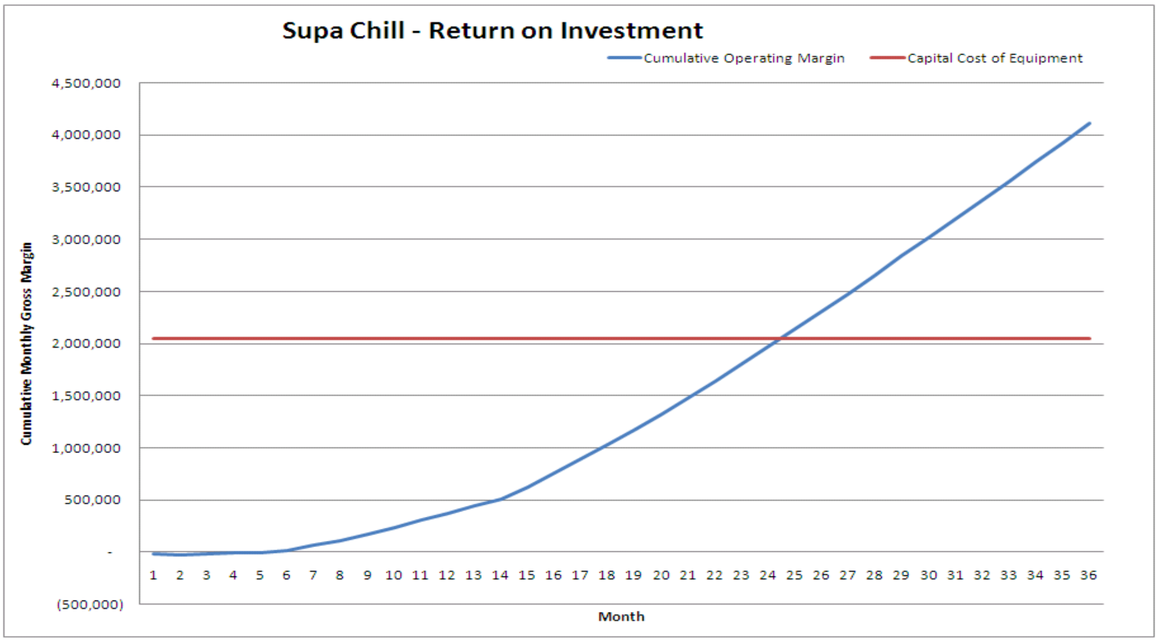


Figure 17 - Modelled return on Supachill investment using existing product mix and sales forecast

6 Industry implications

The findings were considered by Teys and the following key value opportunities were determined:

1. Market access

   Meat exports are controlled by volume quota and/or import tariffs and duties in most countries. The use of Supachill and subsequent product benefits, has allowed Teys to fit new product lines into their frozen quota. This is particularly of value in introducing new products into the EU market, where the Teys sales volumes and product mix has previously been limited by their available chilled quota.

2. Reduction in freight costs

   Where normal chilled product requires air freighting, Supachilled meats can utilise lower cost shipping for frozen goods, without the standard quality reduction seen in a frozen meat.

3. Improved quality

   When compared to standard frozen product, Supachilled meat shows less drip loss when thawed, and as such potentially longer post thaw shelf life. This opens the door for cut steaks in retail ready packaging to be sent directly to the market. When exported for further processing, there are also benefits from the reduction in drip loss, bacterial growth and discolouration of Supachill compared to a similar aged chilled product.

4. Raw Material Optimisation

   Supachill's ability to freeze and thaw meat while keeping its natural chilled qualities potentially creates opportunities for purchase of raw material when market prices are low, thereby reducing the average raw material cost. This potential benefit has not yet materialised for Teys.

7 Commercialisation

Due to intellectual property ownership of the Supachill technology being with Supachill and a 5 year exclusivity agreement between Teys and Supachill, Supachill will be the sole commercialisers for the Supachill VFC technology.

No significant regulatory issues were identified by Teys during the project. It was accepted on the advice of AQIS that product was to be labelled as frozen.

While not relating to this technology specifically, it is also important to be mindful that correct sourcing establishment and freezing establishment have to be identified on labelling etc

8 Conclusion

Supachill technology has been commissioned into the Teys Foodservice business and currently a full range of rapidly frozen value-added products are being produced. During the development process, Teys Food Services has established an export customer base for Supachill products.

A cost benefit analysis was conducted in order to quantify the value that could be created by this technology for Tey business. Benefits unique to the rapid freezing system included improvements in market access through alternative classification of product, reduction in airfreight rates, reduced drip loss resulting in improved retail presentation and extended shelf life, and raw material price reduction. Secondary benefits of using the Supachill freezing infrastructure to cool cooked products saves expenditure on blast freezing that would otherwise have been required.

The following outcomes were achieved from product trials :

- The colour, drip loss and tenderness of aged beef steaks subjected to three temperature regimes (blast chiller, Supachill and blast freezer) were compared.
- Supachill reduced freezing time by nearly 2 days compared to blast freezing.
- Supachill resulted in meat that had less purge loss but tended to be lighter and browner in colour than blast frozen meat. The magnitude of these effects depended on the period of time steaks were displayed after thawing.
- Colour was more intense and colour change due to freezing treatment was more perceptible in the rump than cube and strip loin steaks.
- Further research work is recommended to assist with developing commercial applications for Supachill.

The key value opportunities for Teys using Supachill technology were determined to be i) market access, ii) reduction in freight costs, iii) improved quality, and iv) raw material optimisation.

9 Recommendations

There is some additional trial work required to further validate the commercial validity of Supachill claims, including the evaluation of colour acceptability in thawed Supachill steaks when compared to chilled and blast frozen (from Jacobs et al).

Further to this, testing should be conducted to determine the validity of 21 day holding period (pre freezing) for primal cuts , by comparing purge loss and tenderness of primal cuts held 21 days versus 5 days. It is hypothesised that reduced holding time will equate to less purge loss, however the impact on tenderness will be a great determining factor on the feasibility of a reduction in ageing. Proposed cuts for this experiment would be rump, striploin and cube roll, as these are some of the highest selling primal lines in this market. They are also the items most scrutinised for tenderness in the marketplace.

It would be of value to assess purge loss over time for chilled meat, so that an accurate comparison could be made of exactly what the customer is receiving. As some customers use the 8 – 10 week ship freight time for aging, it is proposed that we should compare product that the end customer would actually receive versus material aged 21 days then supachilled. This comparison would more accurately reflect expected purge and quality attribute implications of freezing method used when applied to real life timeframes. Rump, striploin, cube roll and topside would be used for this trial, with product to be subjected to 3 holding parameters for comparison, being aged 21 days then superchilled, aged 21 days then blast frozen, aged 8 weeks then blast frozen. Primals would then be compared for purge loss, colour (and colour stability over slice pack shelf life), tenderness and slice pack shelf life of vacuum pack steaks.

During the project, Teys had a number of discussions with MLA regarding the potential application of the technology to hot boned product. While Teys was keen to trial these with Supa-Chill this did not occur due to the difficulty in sourcing hot boned product and the logistical challenges in getting it to the TFS facility.

10 References

Anon MC, Calvelo A (1980) Freezing rate effects on the drip loss of frozen beef. *Meat Science* **4**, 1-14.

McGeehin B, Sheridan JJ, Butler F (2002) Optimising a rapid chilling system for lamb carcasses. *Journal of Food Engineering* **52**, 75-81.

Ngapo TM, Babare IH, Reynolds J, Mawson RF (1999a) Freezing and thawing rate effects on drip loss from samples of pork. *Meat Science* **53**, 149-158.

Ngapo TM, Babare IH, Reynolds J, Mawson RF (1999b) Freezing rate and frozen storage effects on the ultrastructure of samples of pork. *Meat Science* **53**, 159-168.

Petrovic L, Grujic R, Petrovic M (1993) Definition of the optimal freezing rate--2. Investigation of the physico-chemical properties of beef M. longissimus dorsi frozen at different freezing rates. *Meat Science* **33**, 319-331.

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Warriss PD (2000) 'Meat Science: An Introductory Text.' (CABI Publishing).

Appendix 1 – Images of Supachill system

Loading VFC Racks

Unloading VFC

VFC Unit

Unloading VFC Rack

Loading Air Knife Conveyor

Product Exiting Air Knife Conveyor

VFC Pack off Station

Appendix 2 - Sub-sampling protocol

Phase 1: Harvest of suitable product for experiment

The striploin (code 7704), cube roll (code 7705) and rump (code 7703) primals from both carcase sides were harvested from 10 carcases for use in the current experiment. The protocol and procedure of carcase selection is detailed in the Teys Supachill raw material collection protocol. Briefly, on the day following slaughter the carcases were boned out and the required primals were identified, collected and vacuum packaged prior to being aged for 21 days before the commencement of the experiment.

Phase 2: Preparation of product before implementation experimental treatments

Sample preparation commenced with the collection of primal weight information, ultimate pH data and micro sample collection. Primals were then sub-divided, assigned to treatments, weighed and vacuum packaged in skin packs before the implementation of the experimental treatments.

The step by step instructions for sample processing is outlined below.

Step 1: Determination of purge loss of primal during ageing

a) Record the number of the animal.
b) Weigh and record the weight of the entire primal whilst still in the vacuum package.
c) Open the vacuum packaged, remove primal, scrape off the purge that has been lost during the ageing period.
d) Re-weigh the primal and record the weight.

Step 2: Determination of ultimate pH

a) Follow the established protocol for pH determination
b) Measure pH in 4 locations in the caudal end of the strip and cube roll primals and in the proximal end of the rump primal. Average measures to give an estimate for the ultimate pH of the primals. Measure temperature in the same region as pH measures.

Step 3: Primal sub-division

The left primals from all animals were used to determine purge loss. From the striploin and cube roll primals 9 x 22mm steaks were sliced from the caudal end of the primal. For the rump, 9 x 22mm steaks were sliced from the proximal end of the primal. Any additional meat was discarded. The 9 steaks were divided into 3 sets of steaks with the first set termed position 1, the middle set termed position 2 and the third set termed position 3. Experimental treatments were randomly allocated across the three sample positions and the ageing treatments were randomly allocated to individual steaks. Individual steals were then weighed and sample tags applied. Steaks were placed in individual skin packs before being vacuum sealed. The right primal from all animals were used to determine baseline tenderness, ice crystal development, colour stability and to monitor temperature profiles. From the striploin and cube roll primals 8 x 22mm steaks were sliced from the caudal. From the rump, 8 x 22mm steaks were sliced from the proximal end of the muscle. The remaining sections of the primals were retained to provide cook blocks for baseline tenderness.

The first 2 steaks from the cranial end were randomly allocated to either the slow freeze (SF) or fast freeze (FF) treatments to examine the ice crystal formation of the two freezing treatments. The next three steaks were used to examine the colour stability during ageing. These three steaks were randomly allocated to the three experimental treatments. The final three steaks, from the caudal end, were used to monitor the temperature profiles. I-button temperature loggers were inserted into the centre of each steak prior to being randomly allocated to the three chilling treatments. All steaks were placed in individual skin packages and vacuum sealed prior to the implementation of the experimental treatments.

Phase 3: Baseline tenderness and sarcomere length sampling methodology

On the day following treatment implementation the remainder of the right primal was sub-divided to obtain a 250g cook block and a 10g sarcomere length sample. The method of cutting the cook block is discussed in Appendix 3. During the preparation of the cook block a 10g slice of muscle, from the lateral side of the primal and along with the direction of the myofibres, was taken to conduct sarcomere length assessment. This sample was wrapped in aluminium foil, placed in a zip lock plastic bag with a tag and frozen at -20°C until sample testing.

Figure A2.1 - Sub-division template for the cube roll and striploin primals

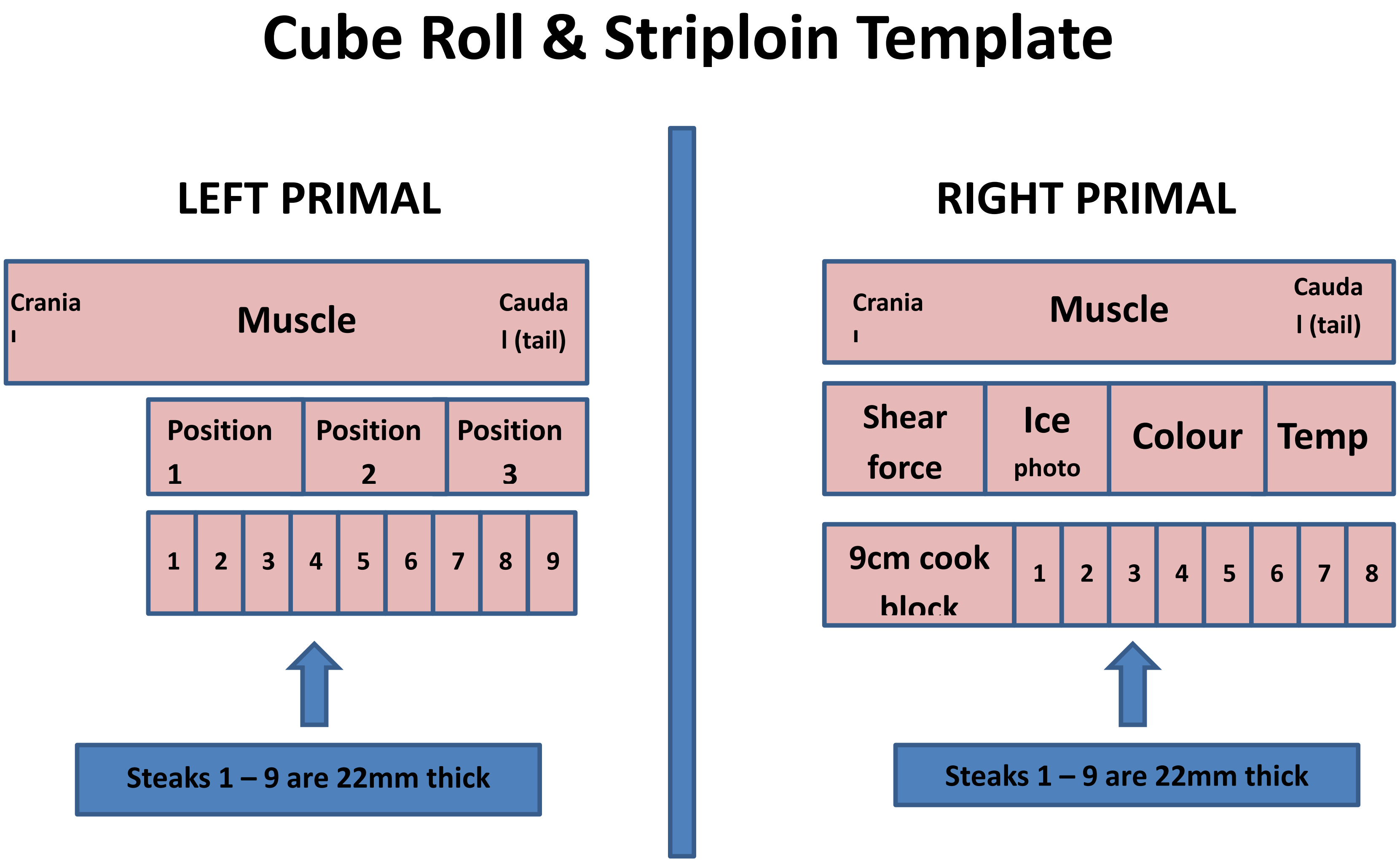
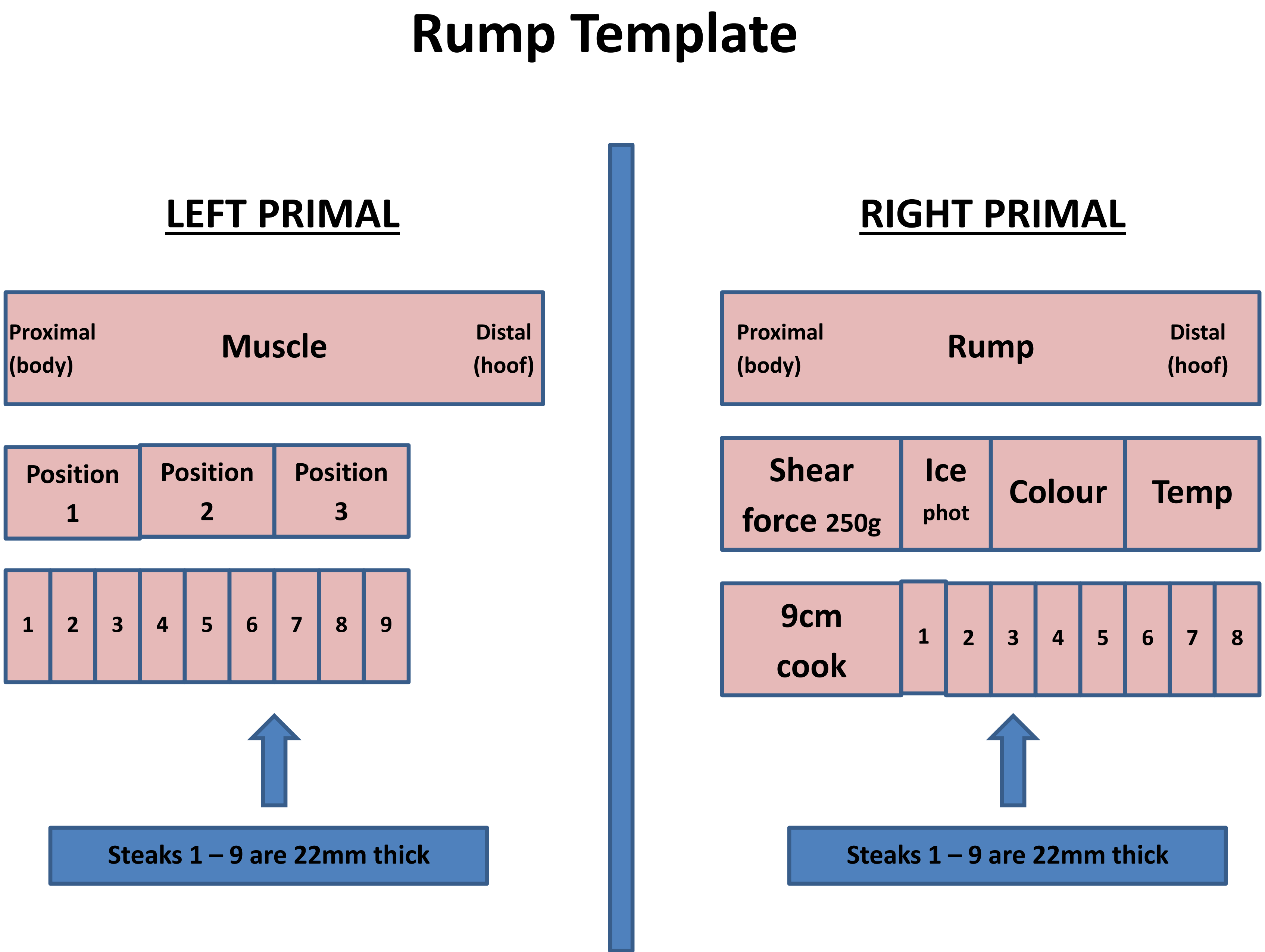


Figure A2.2 - Sub-division template for the rump primal.



Shear force sampling notes

Notes: Shear Force protocol – Taken 25th Sept 09 – TEYs Brisbane

Notes taken by Kirsty Thomson at TFS 25th Sept 09

Original Proposal: To determine tenderness on fresh day 21 day aged product. On 24th Sept, 9cm blocks were taken from the cranial end (head) of the strip and cube rolls and the proximal end (body) of the rump primals. The 9cm blocks were cryovaced and chilled at 0-5cm until tenderness testing could be completed using the tenderometer.

Issue: Due to time limitations it was not possible to process the tenderness samples from fresh as they will continue to age after the 24th of Sept. The outcome is that these samples will need to be frozen prior to testing.

Solution: Given that the samples needed to be frozen, which method should be used slow freeze or fast freeze? A proposal was suggested to test both freezing procedures by allocating half of the samples to the alternate freezing methods (and to insert temperature tags into a couple of blocks to measure the temperature declines achieved in the large shear force blocks).

The number of samples allocated to each treatment is listed in Table A2.1:

Table A2.1: Number of samples allocated to each freezing treatment.

Muscle	Slow Freeze	Fast Freeze	Temp	Total
Cube Roll	4	4	2	10
Striploin	4	4	2	10
Rump	4	4	2	10
Total	12	12	6	30

Note: the samples which have temperature loggers inserted into the centre of the meat will not be able to be tested for shear force as the placement of the logger will affect the muscle structure (i.e. – the presence of the temperature logger causes a hole in the centre of the meat where tenderness would be measured)

Orientation of samples: All samples are from the RHS of the carcass. The samples should be approximately 250g in weight and be 90mm (length) x 69mm (width) x 45-50mm (thick). The order of the sample preparation:

1) Orientate the sample cranial / caudal or proximal / distal,

2) trim the fat and silver skin from the sample, and

3) trim width to approx 60mm, and trim depth to approx 45-55mm from ventral side.

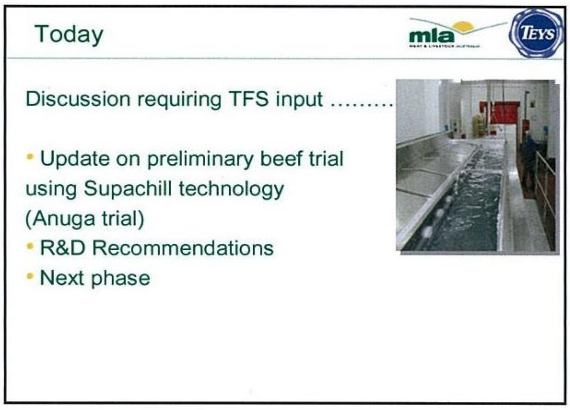
The initial weights for the tenderness samples are listed in Table A2.2.

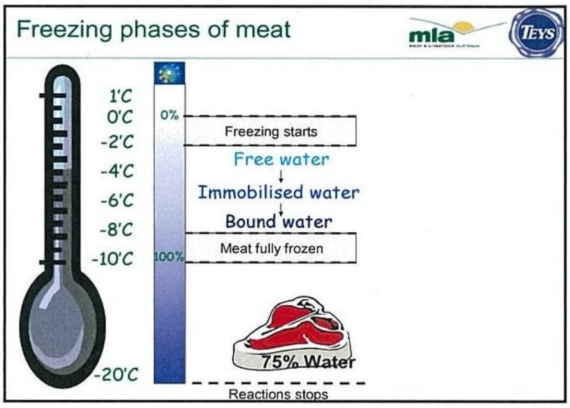
Table A2.2: Initial samples weight for tenderness samples before freezing (grams)

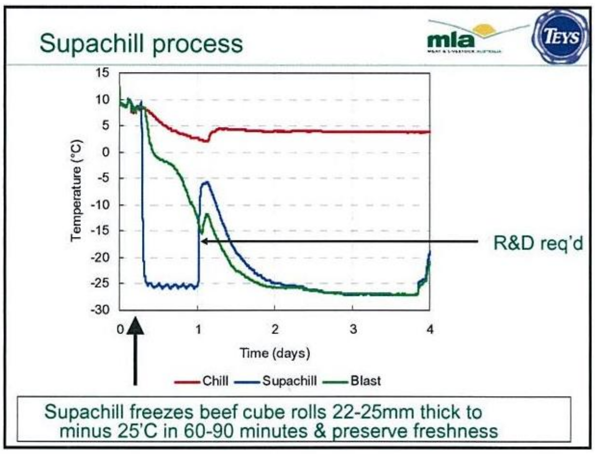
	Cube	Striploin	Rump
1	247.8	226.7	267.2
2	253.1	269.7	225.7
3	256.6	194.4	215.6
4	213.5	256.0	217.3
5	262.8	258.6	264.9
6	232.8	257.5	243.6
7	257.4	257.0	229.2
8	256.1	201.3	215.9
9	242.1	230.4	249.3
10	255.6	207.5	239.2

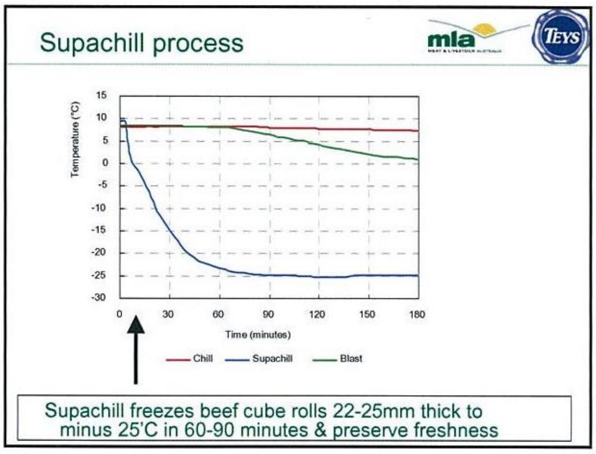
Samples were re-weighed (using pat dry method, without label attached) prior to cooking of the sample. Samples were re-weighed after cooking, following rinsing and drying procedure outlined in the tenderometer protocol. The collection of these weights enabled bag loss due to freezing / thaw treatment and cooking loss to be determined.

Appendix 3 – Notes on the proposed R&D

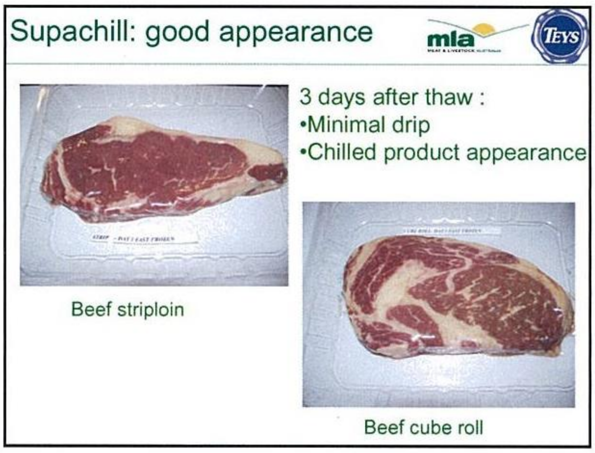


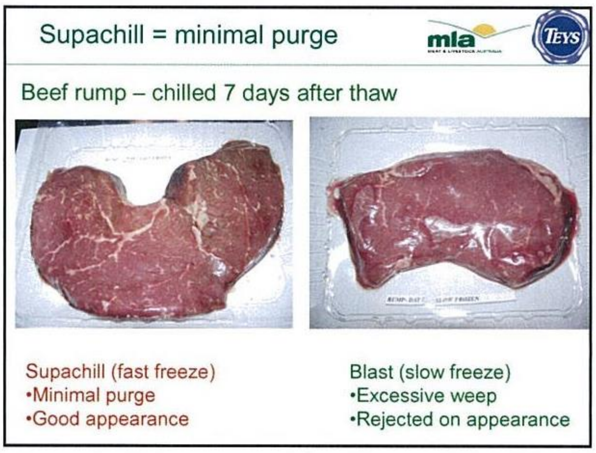


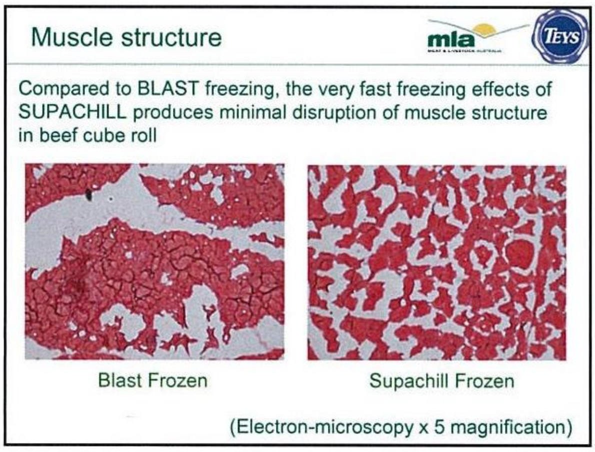

Supachill process
mla
TEYS
Temperature (°C)
Time (days)
R&D req'd
Chill
Supachill
Blast
Supachill freezes beef cube rolls 22-25mm thick to minus 25'C in 60-90 minutes & preserve freshness

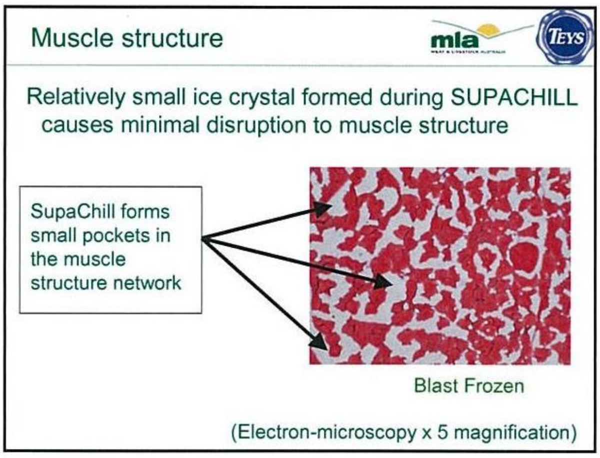

Supachill process
mla
TEYS
Temperature (°C)
Time (minutes)
Chill
Supachill
Blast
Supachill freezes beef cube rolls 22-25mm thick to minus 25'C in 60-90 minutes & preserve freshness

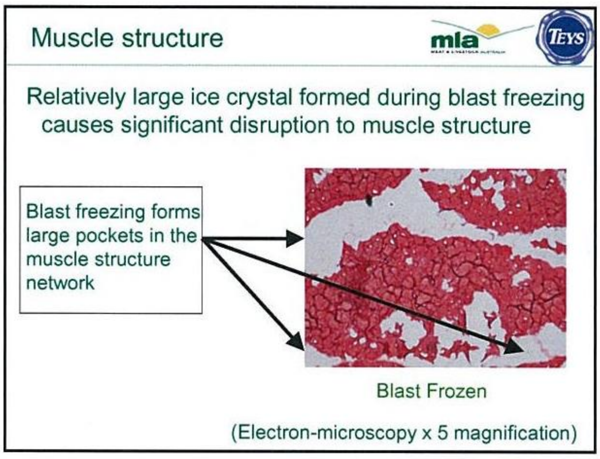

Supachill: freshness preserved
mla
TEYS
Supachilled beef striploin - thermoform packed
(3 days after thawing)

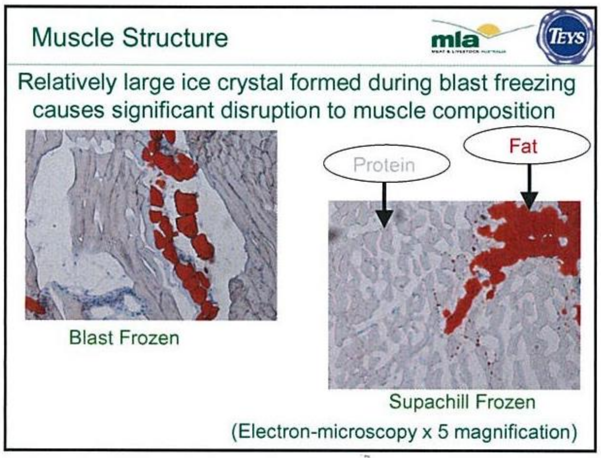

Supachill: good appearance
mla
TEYS
3 days after thaw :
•Minimal drip
•Chilled product appearance
Beef striploin
Beef cube roll

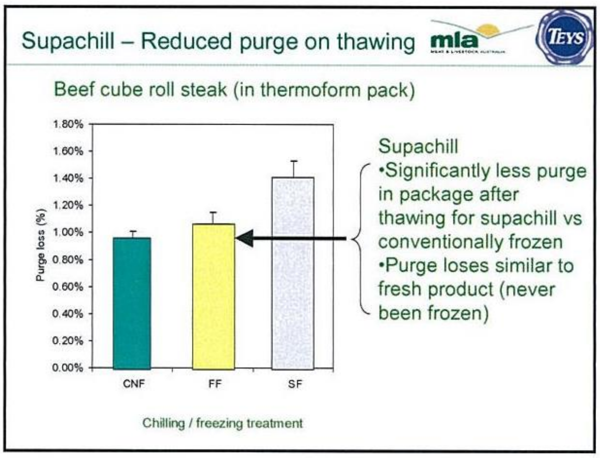

Supachill = minimal purge
mla
TEYS
Beef rump – chilled 7 days after thaw
Supachill (fast freeze)
•Minimal purge
•Good appearance
Blast (slow freeze)
•Excessive weep
•Rejected on appearance

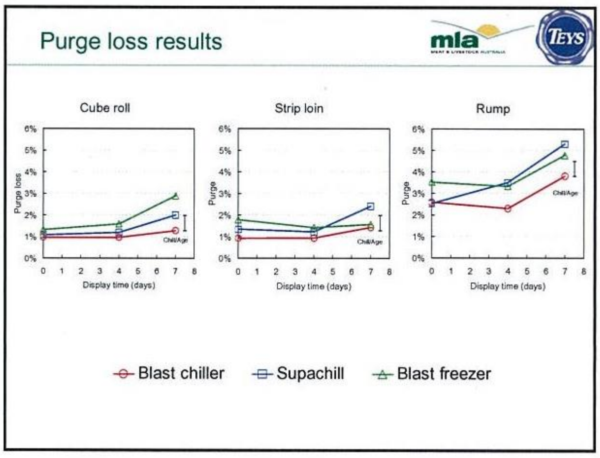

Muscle structure
mla
TEYS
Compared to BLAST freezing, the very fast freezing effects of SUPACHILL produces minimal disruption of muscle structure in beef cube roll
Blast Frozen
Supachill Frozen
(Electron-microscopy x 5 magnification)

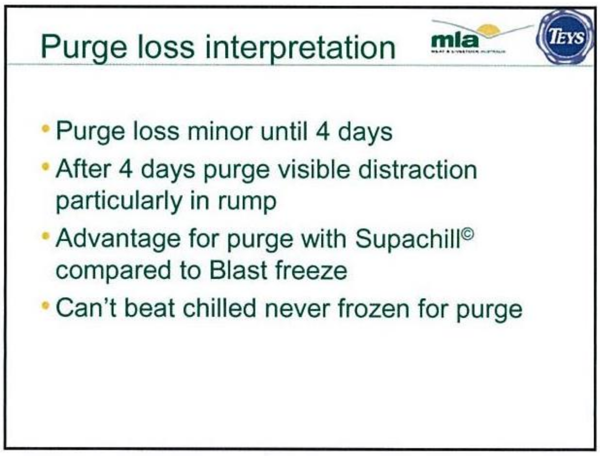

Muscle structure
Relatively small ice crystal formed during SUPACHILL causes minimal disruption to muscle structure
SupaChill forms small pockets in the muscle structure network
Blast Frozen
(Electron-microscopy x 5 magnification)


Muscle structure
Relatively large ice crystal formed during blast freezing causes significant disruption to muscle structure
Blast freezing forms large pockets in the muscle structure network
Blast Frozen
(Electron-microscopy x 5 magnification)


Muscle Structure
Relatively large ice crystal formed during blast freezing causes significant disruption to muscle composition
Protein
Fat
Blast Frozen
Supachill Frozen
(Electron-microscopy x 5 magnification)


Supachill – Reduced purge on thawing
Beef cube roll steak (in thermoform pack)
Purge loss (%)
CNF
FF
SF
Chilling / freezing treatment
Supachill
•Significantly less purge in package after thawing for supachill vs conventionally frozen
•Purge loses similar to fresh product (never been frozen)

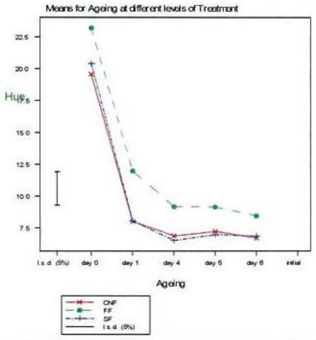

Purge loss results
Cube roll
Strip loin
Rump
Display time (days)
Blast chiller
Supachill
Blast freezer


Purge loss interpretation
• Purge loss minor until 4 days
• After 4 days purge visible distraction particularly in rump
• Advantage for purge with Supachill© compared to Blast freeze
• Can't beat chilled never frozen for purge

Supachill – enhanced colour

Beef cube roll steak (retail display)

Means for Ageing at different levels of Treatment



Supachill
•Brighter bloom colour when first opened out of pack (day 0)
•Brighter colour measured up to 6 days display life in retail display (0-6 days)

(Objective colour measured using Minolta Chromometer)

Colour lightness observations

- Supachill steaks appeared lighter than blast freezer steaks while frozen
- Supachill and Blast freeze steaks same lightness after thawing
- Chilled steaks were lighter in colour than thawed frozen steaks

Colour interpretations

- Supachill may look lighter than Blast freeze when frozen but not when thawed
- Supachill potentially browner once thawed
- Colour hue and intensity issues evident more in rump than strip and cube
- Colour effects of Supachill need further investigation

Processing applications using Supachill

1) Processing aid
- Fast chill of product
- Removal of heat from fully cooked product (to meet heat & eat spec)
- Temper for shaping (using press or moulds) for slicing

2) Rapid freezing
- Whole primals or sub primal porions
- Shaped portions (steaks)
- Raw and cooked

3) Very fast chilling (pre-rigor meat only) – Lower priority
- Accelerated tenderisation

Quality enhancement strategies

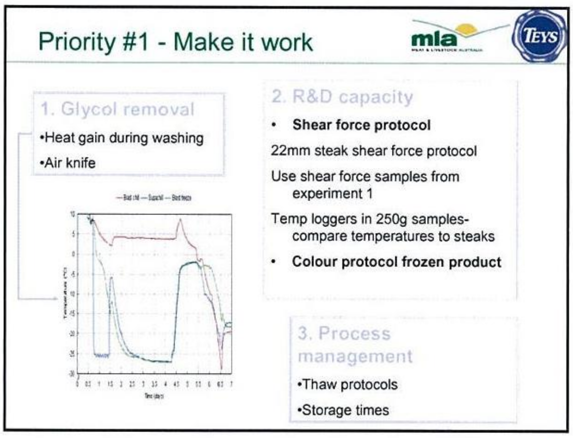
Enhanced tenderisation

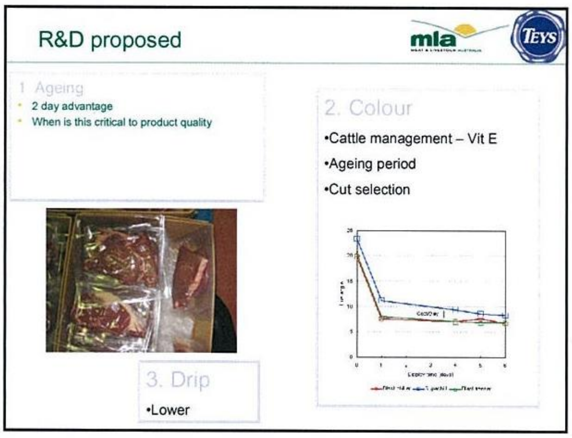
i) Cold-boned meat (Post-rigor)
- Ageing of raw materials (ageing primals only)
- Mechanical intervention (blade tenderisation)
- Injected & marinated (acid, alkaline, enzymic marinades)
- Slow cooking of high connective cuts (8+ hours low temp cook)
- Fast freezing = freshness (low purge)

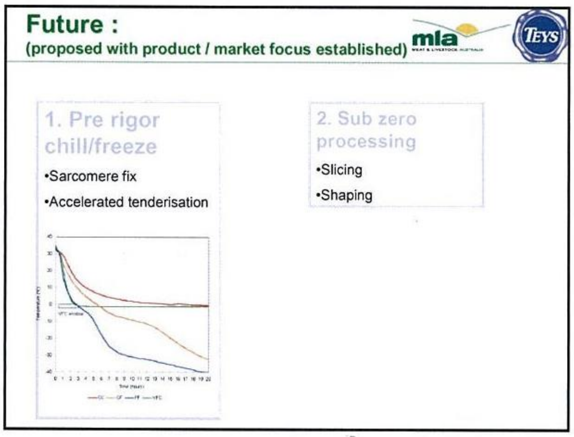
ii) Hot-boned meat (pre-rigor) – Lower priority
- Very fast chilling effect achieved
- Pre-rigor stretching (requiring 5 hours) before supachill
- High pH cooked meat products ??

R&D - Recommendations

1. Make it work
   - Glycol removal
   - R&D capacity -Product specific R&D
   - Process management – freeze, storage, thaw
2. Key products & markets
   - Match strengths/ weaknesses with product advantages
   - Ageing
   - Drip loss
   - Colour – cut/product selection, vit E
3. Explore Saupachill capaibility
   - Pre – rigor chill/freeze
   - Sub zero processing


Priority #1 - Make it work
1. Glycol removal
•Heat gain during washing
•Air knife
2. R&D capacity
• Shear force protocol
22mm steak shear force protocol
Use shear force samples from experiment 1
Temp loggers in 250g samples- compare temperatures to steaks
• Colour protocol frozen product
3. Process management
•Thaw protocols
•Storage times


R&D proposed
1 Ageing
2 day advantage
When is this critical to product quality
2. Colour
•Cattle management – Vit E
•Ageing period
•Cut selection
3. Drip
•Lower


Future :
(proposed with product / market focus established)
1. Pre rigor chill/freeze
•Sarcomere fix
•Accelerated tenderisation
2. Sub zero processing
•Slicing
•Shaping