Final report

Shelf life of lamb primals using new high adhesion vacuum packaging

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Abstract

Through this project the shelf-life of lamb racks using a new self-sealing packaging film was investigated, including the effects of air- and spray-chilling and hand- and water-Frenching. Cap-off racks were stored for up to 132 days at -0.6°C and assessed weekly from Day 97 onwards for sensory and microbiological attributes. Total microbial counts plateaued around 7 $\log_{10}$ cfu/cm^2 shortly after 97 days while sensory attributes – vacuum, appearance and odour – remained close to excellent throughout the trial. Based on these and previous results the self-sealing vacuum bags offer a longer shelf-life at a given temperature than conventional vacuum bags, thus providing a buffer against shelf-life loss during transport to distant markets. In addition, the new bags require less packaging in the form of bone guards resulting in labour savings and a reduced environmental footprint. Additional cost savings are achievable through spray chilling and water-Frenching without deleterious effects on shelf-life.

Executive summary

Background

Currently, Processor A states the shelf-life of many products to around 80 days, compared with the 100 days stated on New Zealand products. However, two previous trials – one with conventional packaging film and one with self-sealing packaging film – demonstrated that a shelf-life for Frenched racks of at least 115 days is feasible when stored at a mean temperature of -0.3°C. The use of self-sealing film negates the need for bone-guards, with additional cost savings due to reduced handling and pack weight which, together with the indication from the previous trial, of enhanced shelf-life was the focus of the present trial.

Objectives

The project objective was to assess the shelf-life of lamb products using self-sealing packaging using Film A.

In addition, the effects on shelf-life of air- and spray-chilling and hand- and water-Frenching of racks were investigated.

Methodology

Cap-off racks from air- and spray-chilled carcases were selected and subjected to either hand-Frenching or water-Frenching using high pressure water jets using a Vertical French Rack Machine. Racks were subsequently packed in self-sealing Film A bags, with a soaker pad included – no additional bone guards were used.

Racks were chilled overnight and transported by air to the South Australian Research and Development Institute (SARDI) laboratories at the Waite campus, Urrbrae, where they were stored at an average temperature of -0.6°C for up to 132 days.

On days of shelf-life assessment, which was weekly from 97 days onward, three racks from each chilling and Frenching combination were removed from storage, photographed and assessed organoleptically using the Australian national guidelines using a score from 0 (poor) to 8 (excellent) for vacuum, appearance and odour, and swabbed (100 cm^2) for total microbial counts.

Results/key findings

By Day 97 total microbial counts had reached 6.6 log_{10} cfu/cm^2 for hand-Frenched racks and 7.3 log_{10} cfu/cm^2 for water-Frenched racks, with the differences between air- and spray-chilled carcases being negligible. The difference between counts from hand- and water-Frenched racks became less with increased storage duration, stabilising around 7 log_{10} cfu/cm^2.

Only a single leaker was observed in the 72 stored racks despite no bone guards being used, as is common with conventional packaging. Average vacuum scores for all products did not drop below 7.5, while average appearance scores did not drop below 7.3. Similarly, average odour score did not drop below 6.0, indicating a slight odour being present 5 minutes after pack opening; confinement odour was more evident near the end of storage trial.

Benefits to industry

Self-sealing vacuum packing (Film A) offers a longer shelf-life at a given temperature than conventional vacuum bags, thus providing a buffer against shelf-life loss during transport to distant markets.

In addition, due to their self-sealing nature, Film A bags require less packaging resulting in labour savings and a reduced environmental footprint.

Additional cost savings are achievable through spray chilling and water-Frenching without deleterious effects on shelf-life.

Future research and recommendations

Given the findings documented in this report for Frenched racks, the natural next steps would be to extend the work using other cuts, or possibly even a whole carcase.

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1 Background

Over the last 2 years, the company has undertaken studies on the shelf life of chilled, vacuum-packed lamb cuts and has also monitored the cold chain to distant markets using real-time temperature loggers. Currently, the company states the shelf-life of many products to around 80 days, compared with the 100 days promised by competitors in New Zealand.

In an initial trial (part of MLA project V.MFS.0446) using mainly conventional packaging films a shelf-life of 98 days was possible for shanks and up to 111 days for frenched racks (cap-on and cap-off), when stored at -1.13°C.

In a second trial "New packaging for extending lamb shelf-life and cold chain management" (MLA project P.PIP.0586) the shelf-lives of Frenched racks packed in a conventional and in a self-sealing film were compared. At a mean storage temperature of -0.3°C racks (cap-on and cap-off) were still acceptable after 115 days storage, though sensory scores were superior for product packed in a self-sealing film.

Use of self-sealing film negates the need for bone-guards, with additional cost savings due to reduced handling and pack weight which, together with the indication from the previous trial, of enhanced shelf-life was the focus of the present trial.

2 Objectives

The project objective was to assess the shelf-life of lamb products using the new packaging (Film A).

3 Methodology

3.1 Collect Samples, data logging started

Drs John Sumner and Andreas Kiermeier visited Processor A on 20 April 2022 and collected product samples required for the trial and to undertake microbiological testing of carcases and primal cuts (Day 0). The primal cuts included:

- Hand-frenched Racks (Cap-off) from Spay-chilled and Air-chilled carcases
- Water-frenched Racks (Cap-off) from Spay-chilled and Air-chilled carcases

On Wednesday 20 April, air-chilled carcases were removed from the chillers and processed either by hand or by passage through a water-Frenching machine (WFR3 Vertical French Rack Machine, Wassco Engineering, New Zealand), as shown in Figure 1.

Figure 1: WFR3 Vertical French Rack Machine, Wassco Engineering, New Zealand. Image source: http://www.wassco.co.nz/wassco/industry_solutions/index.htm?prod=182&catname=WFR3+Vertical+French+Rack+Machine

After completion of each mode of Frenching, 24 individual racks were collected, placed into Film A bags (oxygen transmission 18 cc/m2/day at 23°C, 80% RH) and vacuum packed. This process was repeated for spray-chilled carcases and products were labelled to indicate the type of chilling and Frenching method.

Samples were placed into 3 large, insulated chests and stored overnight in Processor A's fast chiller at -1°C, with the lid open, until 05:00 on Thursday 21 April 2022, when they were removed and a real-time data loggers (Sensitech TempTale Ultra Fit, 10-minute recording interval) placed inside each chest between meat cuts. Frozen ice packs were added and the chests were transported by car to the airport, transferred to Adelaide, thence to a cold storage facility at SARDI on the Waite campus, Urrbrae, where they were unloaded and placed into cardboard cartons inside a cool room set to -0.8°C. Additional data loggers were placed inside cartons on 9 August 2022, shortly before the initial data loggers stopped recording due to their storage limit being reached (16,000 records).

3.2 Organoleptic and microbiological testing

Carcases used for preparation of racks were swabbed for microbiological testing on 20 April 2022. Assessment of racks was planned for and undertaken on the dates listed in Table 1.

Table 1: Sampling days and dates

Day	Date
0	Wednesday, 20 April 2022
97	Tuesday, 26 July 2022
104	Tuesday, 2 August 2022
111	Tuesday, 9 August 2022
118	Tuesday, 16 August 2022
125	Tuesday, 23 August 2022
132	Tuesday, 30 August 2022

3.2.1 Organoleptic testing

Assessment was performed by a three-member informal panel comprising three scientists experienced in assessing the sensory quality of meat products at the SARDI laboratories at the Waite campus, Urrbrae SA. All sensory assessments utilised the ordinal scales from 0 (poor performance) to 8 (good performance) described in Table 2 based on the national guidelines (MLA, 2016). In particular, odour was assessed approximately 5 minutes after opening the pack to allow confinement odour to dissipate.

Table 2: Scoring scheme for organoleptic characteristics

Score	Vacuum	Appearance	Odour
8	Complete, tight package adhesion	Very fresh, not discoloured	Fresh odour
6	Good vacuum	Fresh, slightly discoloured	Slight odour
4	Moderate vacuum	Good, acceptable	Medium odour
2	Poor vacuum	Poor	Strong/off odour
0	No vacuum, probable leaker	Severe discolouration	Putrid odour

3.2.2 Microbiological testing

After resuscitating a sterile sponge (Whirl-Pak Speci-Sponge) with 25 mL of chilled Butterfield's solution, a single area (100 cm^2) of was sponged using firm, back-and-forth strokes both along and across the lateral side of each cut. On chilled carcases three areas were similarly sponged: the base of the tail, the mid loin and the elbow according to the *Guideline for the Microbiological Sampling and Testing of Export Meat and Meat Products* (DAWE, 2021).

On Wednesday 20 April 2022, ten carcase swabs each of air-chilled and spray-chilled carcases were collected prior to carcases being removed from the chillers. Racks were swabbed immediately after each type of Frenching operation was performed.

All samples were tested as follows. Bacteria were removed from the sponge by "squishing" sponges by hand in the sample bags for 30 seconds and, from the moisture expressed, preparing serial dilutions in 0.1% buffered peptone water blanks (9 mL) using 1 mL aliquots. Aliquots (1 mL) from each dilution were spread on Aerobic Plate Count (APC) Petrifilm (3M) and incubated at 25°C for 96 hours. Colonies were identified and counted as colony forming units (CFU) as per the manufacturer's instructions.

4 Results

4.1 Storage Temperature

The temperature records, averaged across all recording data loggers, are shown in Figure 1. Product temperatures dropped during the initial overnight chilling from around 6°C to around 2.5°C the following morning, rising briefly to 6°C around 16:00 in the SARDI chiller before active chilling took effect. The average temperature dropped to below 0°C by 11:00 on 22 April 2022. Throughout the storage trial, the temperature averaged -0.6°C with a standard deviation of 0.3°C and a minimum of -0.9°C.

Of note are the apparent temperature deviation observed after 9 August 2022 using the new set of three loggers placed between product layers, in three separate cartons. Between 9 and 16 August 2022, temperature excursion to above 1.5°C were observed every 8 hours, possibly related to defrost cycles. These deviations in (air) temperature lasted for a single temperature record at a time, i.e. 10 minutes before and after the deviation a temperature below 0°C was recorded.

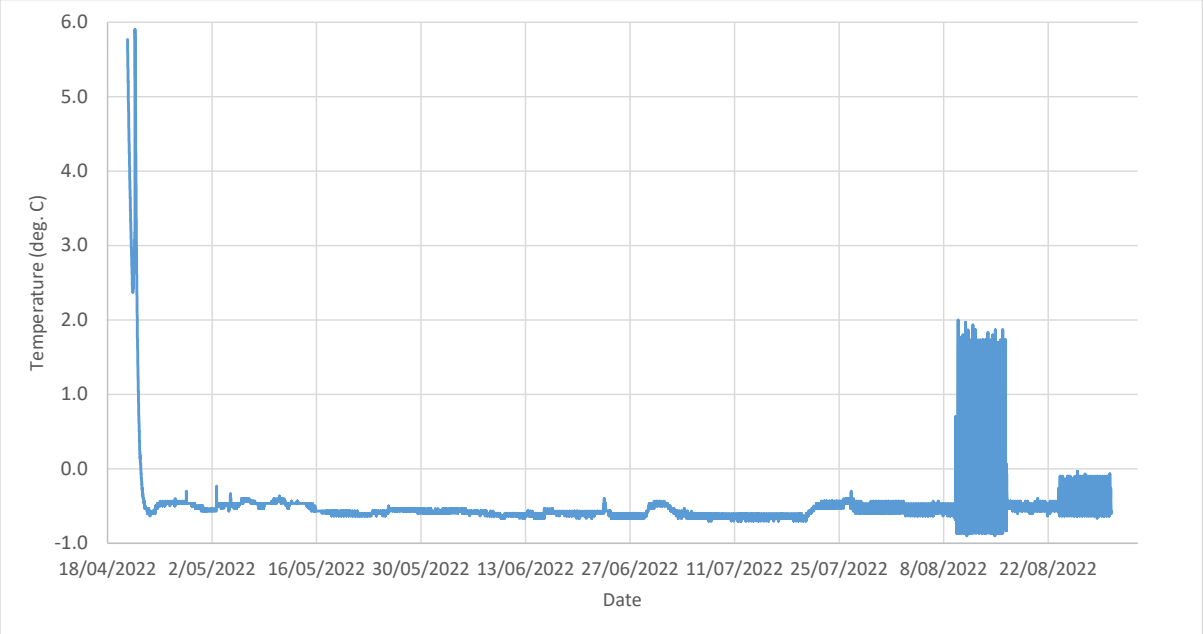

Figure 2: Temperature trace for product transported from Processor A to SARDI, Waite SA, and subsequent storage in a cool room at -0.8°C.

4.2 Sensory Assessment

A summary of sensory scores for each product type assessed across the storage period is shown below. The raw data are provided in Appendix 8.1. Across all 72 racks assessed, only a single leaker was observed on Day 132, which was replaced by an intact pack. Interestingly, on opening the leaking pack, some confinement odour was observed, which was not offensive, and quickly dissipated rendering the final product acceptable; no microbiological testing was performed on this sample.

Average vacuum scores (n=3) are shown in Table 3. Vacuum was generally very tight across all products. Later in the storage period some products, especially the water-Frenched racks, due to the presence of drip around the ribs, exhibited small air bubbles, and these products were subsequently scored slightly lower. However, it is likely that these are a result of air escaping from the exposed bone surfaces or a by-product of microbial or chemical changes. As noted above, only a single leaker was observed and for this product air pockets around the soaker pad were apparent while the packaging still adhered well between and around the ribs.

Table 3: Average scores (n=3) for Vacuum assessment of racks stored for up to 132 Days at -0.6°C.

Chilling	Frenching	Day 97	Day 104	Day 111	Day 118	Day 125	Day 132
Air	Hand	8.0	8.0	8.0	8.0	8.0	8.0
Air	Water	8.0	8.0	7.5	6.0	8.0	8.0
Spray	Hand	8.0	8.0	8.0	7.7	8.0	8.0
Spray	Water	8.0	8.0	7.5	6.3	8.0	7.5

Average appearance scores (n=3) are shown in Table 4. Overall, water-Frenched racks scored marginally lower than hand-Frenched racks due to the accumulation of drip around the rib bones (see photo in Appendix).

Table 4: Average scores (n=3) for Appearance assessment of racks stored for up to 132 Days at -0.6°C.

Chilling	Frenching	Day 97	Day 104	Day 111	Day 118	Day 125	Day 132
Air	Hand	8.0	8.0	8.0	8.0	8.0	7.3
Air	Water	7.3	7.2	6.7	7.3	7.7	7.3
Spray	Hand	8.0	8.0	8.0	8.0	8.0	8.0
Spray	Water	7.3	7.2	8.0	7.3	7.0	7.5

Average odour scores (n=3) are shown in Table 5. Water-Frenched product scored marginally lower than hand-Frenched product though none of the samples scored less than 5.5, i.e. did not exhibit an offensive or off odour after allowing the confinement odour to dissipate. Presence of noticeable confinement odour was observed occasionally after Day 111 (9 August), though this did consistently relate to storage duration. In particular, on Day 132 only a single air-chilled water-Frenched rack had a noticeable confinement odour upon opening of the pack.

Table 5: Average scores (n=3) for Odour assessment of racks stored for up to 132 Days at -0.6°C.

Chilling	Frenching	Day 97	Day 104	Day 111	Day 118	Day 125	Day 132
Air	Hand	8.0	7.5	7.5	6.8	7.5	6.7
Air	Water	7.7	6.7	6.7	7.0	6.0	6.0
Spray	Hand	8.0	7.5	7.5	7.5	7.3	7.5
Spray	Water	8.0	6.8	7.5	7.3	7.2	7.2

In addition, it was noticed but not formally assessed that the packaging film adhered more strongly to the meat product (i.e. was stickier) later in the trial.

In assessing shelf-life in this trial, the criteria and a scoring system as per the national guidelines in "The Shelf Life of Australian Red Meat" (MLA, 2016) were used, in effect providing a scientific assessment. However, as outlined in the same document there are three occasions where end users – the supermarket manager and shopper – assess quality:

1. At purchase, when the meat appearance and package are evaluated
2. On pack opening, when odour is the main sensory criterion
3. On consumption, when cooked odour, flavour and texture are assessed

The question therefore arises on how end users will regard:

- Reddening / drip around the ribs at the time of purchase
- Confinement odour at the time of pack opening
- Stickiness when peeling back the film

Of these, the first and last bullet points are unlikely to present a concern or reduction in quality perception unless a side-by-side comparison with a conventional packaging film is made or "fresher" product is made. However, the second bullet point is harder to discern and confinement odour may not be acceptable to the end-consumer.

4.3 Microbiology of lamb carcases and racks

A summary of the mean $\log_{10}$ APC/cm^2 for carcases and Frenching method for each chilling regime at the time of sample collection (Day 0) is shown in Table 6. The raw data are provided in Appendix 8.2. There was no difference between air and spray-chilled carcases in terms of initial microbial loading. After processing, racks had an APC approximately 0.5 $\log_{10}$ cfu/cm^2 higher than carcases, which equates to an increase by a factor of 3 due to handling.

In addition, there was little difference between racks from air-chilled and spray-chilled carcases nor between hand- or water-Frenching, with the obvious exception being hand-Frenched racks from spray-chilled carcase, which were about 1 $\log_{10}$ cfu/cm^2 lower than all other products tests. No logical explanation is available for this, except that these racks may have originated from exceptionally clean carcases.

Table 6: Average $\log_{10}$ APC/cm^2 (n=10 for carcases and n=4 for racks) by Frenching method and chilling regime at the time of product packing (Day 0).

Average of Log (APC)	Air-chilled	Spray-chilled
Carcase	2.2	2.1
Racks – Hand Frenched	2.7	1.7
Racks – Water Frenched	2.7	2.6

A summary of the mean $\log_{10}$ APC/cm^2 for product type and chilling regime over time is shown in Table 7 and in Figure 2 from which it can be seen that by Day 97 microbial counts approached (hand-Frenched) or had reached (water-Frenched) their maximum population limits, with the counts remaining fairly stable thereafter.

Table 7: Average $\log_{10}$ APC/cm^2 (n=3) by Frenching method and chilling regime for racks stored for up to 132 Days at -0.6°C.

Chilling	Frenching	Day 97	Day 104	Day 111	Day 118	Day 125	Day 132
Air	Hand	6.6	6.6	7.1	7.1	7.2	6.9
Air	Water	7.3	6.6	7.1	7.1	7.1	7.2
Spray	Hand	6.7	6.7	6.9	7.2	7.0	6.7
Spray	Water	7.4	7.4	7.2	7.2	7.3	7.2

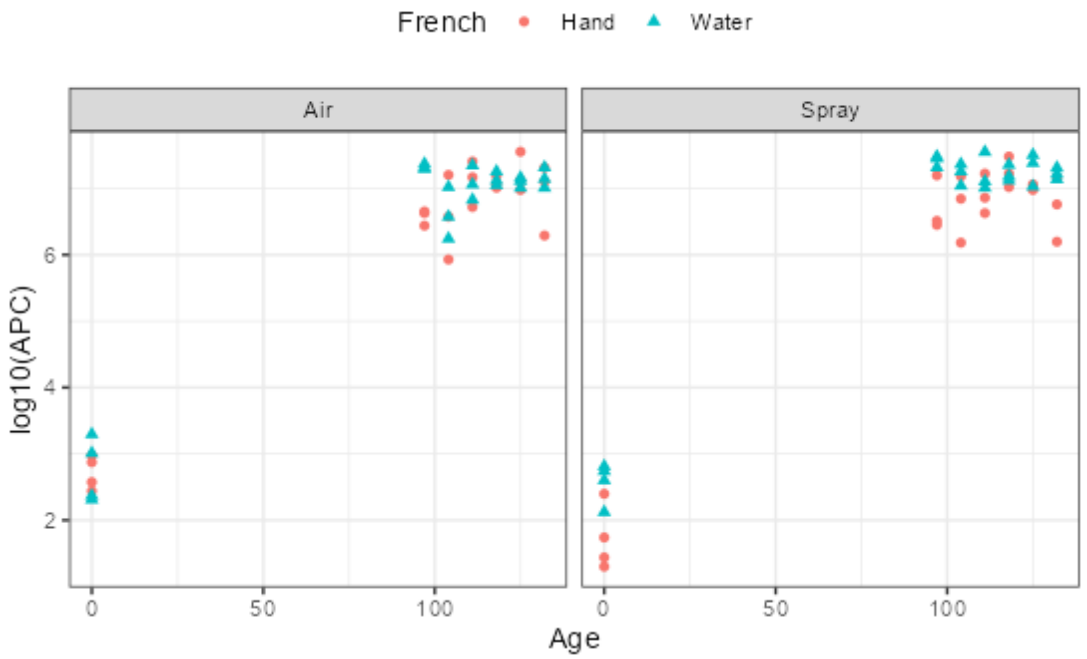

Figure 3: Aerobic Plate Counts (APC) on hand and water-Frenched racks from air- and spray-chilled carcases over time when stored at -0.8°C in self-sealing vacuum packaging.

5 Conclusion

The results from this trial confirm and extend those from previous trials undertaken at Processor A using Film A self-sealing packaging. In particular, the current results confirm and extend previous findings on cap-on and cap-off racks (MLA P.PIP.0586) where a shelf-life of at least 115 days was established when product was stored at an average temperature of -0.3°C. In contrast, the current trial results and those from trial 2 (MLA P.PIP.0586) were better than those observed during the first trial (part of MLA project V.MFS.0446) when product was stored at an excellent average temperature of -1.13°C for 118 days using conventional packaging, though product did not perform quite as well and only being considered just acceptable at the end of the trial.

Self-sealing vacuum packing offers a longer shelf-life at a given temperature than conventional vacuum packaging, thus providing a buffer against shelf-life loss during transport to distant markets.

Due to their self-sealing nature, Film A bags require less packaging, in particular bone-guards, that would otherwise be needed to reduce likelihood of leakers and subsequent loss of product. An example of the amount of plastic used for bone-guard in conventional vacuum bags is shown in Figure 4. Clearly, not having to use these plastics has a positive environmental benefit and therefore contributes positively to the processor's social license to operate.

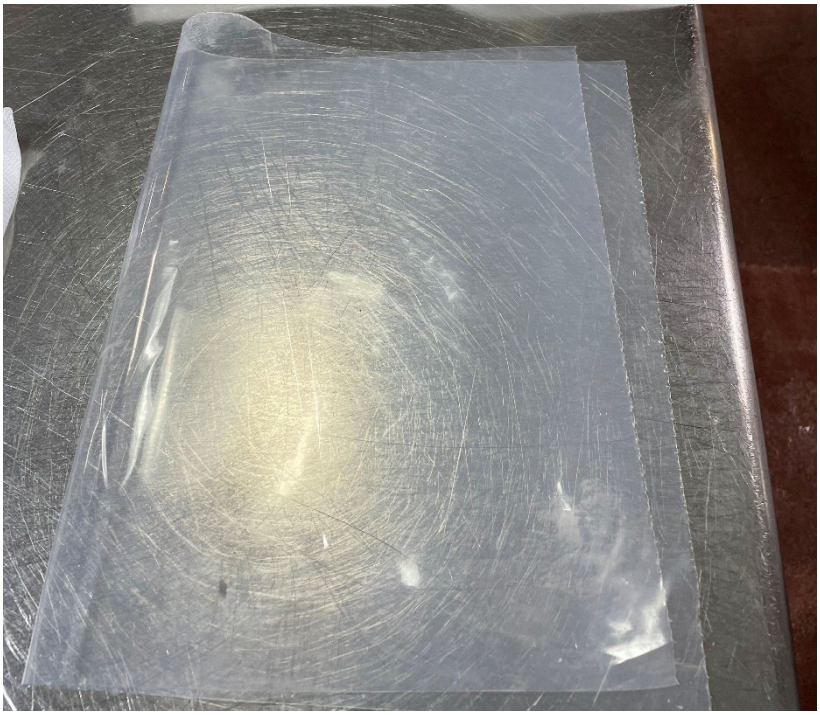

Figure 4: Plastic material used as bone-guard for racks packed in conventionally vacuum-bags.

In addition, less labour is required to pack product as bone-guards and additional wrapping are not required. Processor A estimates that a labour saving of $0.40 packed unit can be achieved, which exceeds the additional 30% cost of the self-sealing bags compared with conventional vacuum bags.

The effect of packaging punctures from bone on product quality are less notable. During the current trial only 1 leaker was observed in the 73 stored packs that were assessed. Despite the apparent air in the pack, package adhesion between ribs was strong due to the self-sealing nature and the product was scored highly in terms of odour on opening, with no offensive odour being observed.

Spray-chilling provides a commercial advantage of around 2% increased saleable yield (Treffone and McPhail, 2011). For example, assuming an average carcase weight of 25 kg and a company slaughtering 1,000,000 sheep per year, this equates to an additional 500,000 kg annually. At an average carcase value of $10 per kg, this results in approximately $5,000,000 additional revenue per year.

Water-Frenching does not appear to have a deleterious effect on shelf-life, despite the noticeably wetter product being packed, when used with Film A packaging. In addition, water-Frenching at the plant could save an estimated 12-16 labour units compared with hand-Frenching.

5.1 Key findings

The key findings from this project are:

- Frenched, cap-off racks packed under vacuum in Film A bags have a shelf-life of at least 132 days when stored at an average temperature of -0.6°C.
- No practically important sensory or microbial differences were observed between racks originating from air- and spray-chilled carcases, the latter resulting in improved carcase yield after chilling.

- No practically important sensory or microbial differences were observed between racks that were hand- or water-Frenched.
- Water-Frenching is less labour intensive and thus provides substantial potential labour savings.

5.2 Benefits to industry

1. Self-sealing vacuum packing offers a longer shelf-life at a given temperature than conventional vacuum bags, thus providing a buffer against shelf-life loss during transport to distant markets.
2. Due to their self-sealing nature, these bags require less packaging, in particular bone-guards, that would otherwise be needed to reduce likelihood of leakers and subsequent loss of product. This has a positive environmental benefit due to less plastic ending up in landfill.
3. In addition, less labour is required to pack product as bone-guards and additional wrapping are not required.
4. The effect of packaging punctures on product appearance are minimised.
5. Spray-chilling has a beneficial effect resulting in around 2% increased saleable yield.
6. Water-Frenching does not appear to have a deleterious effect on shelf-life, when used with self-sealing packaging, yet provides considerable labour savings.

6 Future research and recommendations

Given the findings documented in this report for Frenched racks, the natural next steps would be to extend the work using other cuts, or possibly even a whole carcase.

7 References

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8 Appendix – Data

8.1 Sensory Data

Sample Date	Age	Chilling	French	Rep	Vacuum	Appear	Odour	Comment
26/07/2022	97	Air	Hand	1	8	8	8	
26/07/2022	97	Air	Hand	2	8	8	8	
26/07/2022	97	Air	Hand	3	8	8	8	
26/07/2022	97	Air	Water	1	8	7.5	8	
26/07/2022	97	Air	Water	2	8	7.5	8	
26/07/2022	97	Air	Water	3	8	7	7	Slight greenish tinge and strong confinement odour which dissipated within 5 minutes
26/07/2022	97	Spray	Hand	1	8	8	8	
26/07/2022	97	Spray	Hand	2	8	8	8	
26/07/2022	97	Spray	Hand	3	8	8	8	
26/07/2022	97	Spray	Water	1	8	7.5	8	
26/07/2022	97	Spray	Water	2	8	7.5	8	
26/07/2022	97	Spray	Water	3	8	7	8	Large amount of drip not soaked up by soaker pad
2/08/2022	104	Air	Hand	1	8	8	7.5	
2/08/2022	104	Air	Hand	2	8	8	7.5	
2/08/2022	104	Air	Hand	3	8	8	7.5	
2/08/2022	104	Air	Water	1	8	7	6	slight greening along bones
2/08/2022	104	Air	Water	2	8	7	7	slight greening along bones
2/08/2022	104	Air	Water	3	8	7.5	7	
2/08/2022	104	Spray	Hand	1	8	8	7.5	
2/08/2022	104	Spray	Hand	2	8	8	7.5	
2/08/2022	104	Spray	Hand	3	8	8	7.5	
2/08/2022	104	Spray	Water	1	8	7	7	
2/08/2022	104	Spray	Water	2	8	7	6.5	
2/08/2022	104	Spray	Water	3	8	7.5	7	
9/08/2022	111	Air	Hand	1	8	8	7.5	
9/08/2022	111	Air	Hand	2	8	8	7.5	
9/08/2022	111	Air	Hand	3	8	8	7.5	
9/08/2022	111	Air	Water	1	8	6	7	A little greenish around bones; Blood around ones; Obvious confinement odour
9/08/2022	111	Air	Water	2	7	7	6	Small air bubbles visible around bones; Blood around bones; Obvious confinement odour - dairy smell
9/08/2022	111	Air	Water	3	8	7	7	Blood around bones; Obvious confinement odour
9/08/2022	111	Spray	Hand	1	8	8	7.5	
9/08/2022	111	Spray	Hand	2	8	8	7.5	
9/08/2022	111	Spray	Hand	3	8	8	7.5	

Sample Date	Age	Chilling	French	Rep	Vacuum	Appear	Odour	Comment
9/08/2022	111	Spray	Water	1	7.5	8	7.5	Very few, small air bubble visible
9/08/2022	111	Spray	Water	2	7.5	8	7.5	
9/08/2022	111	Spray	Water	3	7.5	8	7.5	
16/08/2022	118	Air	Hand	1	8	8	7.5	
16/08/2022	118	Air	Hand	2	8	8	7	
16/08/2022	118	Air	Hand	3	8	8	6	Slight residual odour
16/08/2022	118	Air	Water	1	4	8	7.5	Large air bubbles around bones
16/08/2022	118	Air	Water	2	7	7	6	Small air bubbles visible around bones; Some slight residual odour
16/08/2022	118	Air	Water	3	7	7	7.5	Small air bubbles visible around bones
16/08/2022	118	Spray	Hand	1	7	8	7.5	
16/08/2022	118	Spray	Hand	2	8	8	7.5	
16/08/2022	118	Spray	Hand	3	8	8	7.5	
16/08/2022	118	Spray	Water	1	6	7	7.5	
16/08/2022	118	Spray	Water	2	6	7	7	
16/08/2022	118	Spray	Water	3	7	8	7.5	
23/08/2022	125	Air	Hand	1	8	8	7.5	
23/08/2022	125	Air	Hand	2	8	8	7.5	
23/08/2022	125	Air	Hand	3	8	8	7.5	
23/08/2022	125	Air	Water	1	8	7	6	Visible drip with large bubbles; Small amounts of residual odour
23/08/2022	125	Air	Water	2	8	8	6	Small amounts of residual odour
23/08/2022	125	Air	Water	3	8	8	6	Small amounts of residual odour
23/08/2022	125	Spray	Hand	1	8	8	7	
23/08/2022	125	Spray	Hand	2	8	8	7.5	
23/08/2022	125	Spray	Hand	3	8	8	7.5	
23/08/2022	125	Spray	Water	1	8	7	7	Small amounts of drip; slight green tint under certain light
23/08/2022	125	Spray	Water	2	8	7	7	Small amounts of drip; slight green tint under certain light
23/08/2022	125	Spray	Water	3	8	7	7.5	Small amounts of drip; slight green tint under certain light
30/08/2022	132	Air	Hand	1	8	7	6	Small light green area on top left
30/08/2022	132	Air	Hand	2	8	7.5	7	
30/08/2022	132	Air	Hand	3	8	7.5	7	
30/08/2022	132	Air	Water	1	8	7.5	5.5	
30/08/2022	132	Air	Water	2	8	7	6.5	Small air bubble
30/08/2022	132	Air	Water	3	8	7.5	6	Strong confinement odour which dissipated quickly; Small light green area on top left
30/08/2022	132	Spray	Hand	1	8	8	7.5	
30/08/2022	132	Spray	Hand	2	8	8	7.5	
30/08/2022	132	Spray	Hand	3	8	8	7.5	
30/08/2022	132	Spray	Water	1	7.5	7.5	6.5	Some drip and small air bubbles
30/08/2022	132	Spray	Water	2	7.5	7.5	7.5	Some drip and small air bubbles
30/08/2022	132	Spray	Water	3	7.5	7.5	7.5	Some drip and small air bubbles

8.2 Microbiological Data

Sample Date	Age	Chilling	Product	French	Rep	APC per cm2	Log (APC)
20/04/2022	0	Air	Carcase		1	567	2.8
20/04/2022	0	Air	Carcase		2	93	2.0
20/04/2022	0	Air	Carcase		3	125	2.1
20/04/2022	0	Air	Carcase		4	66	1.8
20/04/2022	0	Air	Carcase		5	101	2.0
20/04/2022	0	Air	Carcase		6	1,300	3.1
20/04/2022	0	Air	Carcase		7	183	2.3
20/04/2022	0	Air	Carcase		8	47	1.7
20/04/2022	0	Air	Carcase		9	383	2.6
20/04/2022	0	Air	Carcase		10	53	1.7
20/04/2022	0	Air	Rack - cap off	Hand	1	750	2.9
20/04/2022	0	Air	Rack - cap off	Hand	2	375	2.6
20/04/2022	0	Air	Rack - cap off	Hand	3	950	3.0
20/04/2022	0	Air	Rack - cap off	Hand	4	275	2.4
20/04/2022	0	Air	Rack - cap off	Water	1	205	2.3
20/04/2022	0	Air	Rack - cap off	Water	2	1,975	3.3
20/04/2022	0	Air	Rack - cap off	Water	3	235	2.4
20/04/2022	0	Air	Rack - cap off	Water	4	1,025	3.0
20/04/2022	0	Spray	Carcase		1	142	2.2
20/04/2022	0	Spray	Carcase		2	117	2.1
20/04/2022	0	Spray	Carcase		3	592	2.8
20/04/2022	0	Spray	Carcase		4	125	2.1
20/04/2022	0	Spray	Carcase		5	100	2.0
20/04/2022	0	Spray	Carcase		6	142	2.2
20/04/2022	0	Spray	Carcase		7	16	1.2
20/04/2022	0	Spray	Carcase		8	350	2.5
20/04/2022	0	Spray	Carcase		9	40	1.6
20/04/2022	0	Spray	Carcase		10	267	2.4
20/04/2022	0	Spray	Rack - cap off	Hand	1	250	2.4
20/04/2022	0	Spray	Rack - cap off	Hand	2	28	1.4
20/04/2022	0	Spray	Rack - cap off	Hand	3	55	1.7
20/04/2022	0	Spray	Rack - cap off	Hand	4	20	1.3
20/04/2022	0	Spray	Rack - cap off	Water	1	650	2.8
20/04/2022	0	Spray	Rack - cap off	Water	2	133	2.1
20/04/2022	0	Spray	Rack - cap off	Water	3	400	2.6
20/04/2022	0	Spray	Rack - cap off	Water	4	550	2.7
26/07/2022	97	Air	Rack - cap off	Hand	1	4,250,000	6.6
26/07/2022	97	Air	Rack - cap off	Hand	2	4,500,000	6.7
26/07/2022	97	Air	Rack - cap off	Hand	3	2,750,000	6.4
26/07/2022	97	Air	Rack - cap off	Water	1	20,500,000	7.3
26/07/2022	97	Air	Rack - cap off	Water	2	19,750,000	7.3
26/07/2022	97	Air	Rack - cap off	Water	3	23,500,000	7.4
26/07/2022	97	Spray	Rack - cap off	Hand	1	2,825,000	6.5
26/07/2022	97	Spray	Rack - cap off	Hand	2	3,250,000	6.5
26/07/2022	97	Spray	Rack - cap off	Hand	3	15,750,000	7.2
26/07/2022	97	Spray	Rack - cap off	Water	1	20,750,000	7.3
26/07/2022	97	Spray	Rack - cap off	Water	2	28,500,000	7.5
26/07/2022	97	Spray	Rack - cap off	Water	3	30,250,000	7.5
2/08/2022	104	Air	Rack - cap off	Hand	1	16,000,000	7.2
2/08/2022	104	Air	Rack - cap off	Hand	2	3,750,000	6.6
2/08/2022	104	Air	Rack - cap off	Hand	3	850,000	5.9
2/08/2022	104	Air	Rack - cap off	Water	1	3,750,000	6.6
2/08/2022	104	Air	Rack - cap off	Water	2	10,500,000	7.0
2/08/2022	104	Air	Rack - cap off	Water	3	1,750,000	6.2
2/08/2022	104	Spray	Rack - cap off	Hand	1	15,250,000	7.2
2/08/2022	104	Spray	Rack - cap off	Hand	2	7,000,000	6.8
2/08/2022	104	Spray	Rack - cap off	Hand	3	1,525,000	6.2
2/08/2022	104	Spray	Rack - cap off	Water	1	11,000,000	7.0
2/08/2022	104	Spray	Rack - cap off	Water	2	18,000,000	7.3

Sample Date	Age	Chilling	Product	French	Rep	APC per cm2	Log (APC)
2/08/2022	104	Spray	Rack - cap off	Water	3	23,250,000	7.4
9/08/2022	111	Air	Rack - cap off	Hand	1	14,750,000	7.2
9/08/2022	111	Air	Rack - cap off	Hand	2	25,500,000	7.4
9/08/2022	111	Air	Rack - cap off	Hand	3	5,250,000	6.7
9/08/2022	111	Air	Rack - cap off	Water	1	11,500,000	7.1
9/08/2022	111	Air	Rack - cap off	Water	2	22,250,000	7.3
9/08/2022	111	Air	Rack - cap off	Water	3	6,750,000	6.8
9/08/2022	111	Spray	Rack - cap off	Hand	1	4,250,000	6.6
9/08/2022	111	Spray	Rack - cap off	Hand	2	7,250,000	6.9
9/08/2022	111	Spray	Rack - cap off	Hand	3	16,750,000	7.2
9/08/2022	111	Spray	Rack - cap off	Water	1	10,250,000	7.0
9/08/2022	111	Spray	Rack - cap off	Water	2	12,750,000	7.1
9/08/2022	111	Spray	Rack - cap off	Water	3	35,500,000	7.6
16/08/2022	118	Air	Rack - cap off	Hand	1	10,250,000	7.0
16/08/2022	118	Air	Rack - cap off	Hand	2	11,750,000	7.1
16/08/2022	118	Air	Rack - cap off	Hand	3	15,500,000	7.2
16/08/2022	118	Air	Rack - cap off	Water	1	13,250,000	7.1
16/08/2022	118	Air	Rack - cap off	Water	2	18,000,000	7.3
16/08/2022	118	Air	Rack - cap off	Water	3	11,250,000	7.1
16/08/2022	118	Spray	Rack - cap off	Hand	1	30,250,000	7.5
16/08/2022	118	Spray	Rack - cap off	Hand	2	10,500,000	7.0
16/08/2022	118	Spray	Rack - cap off	Hand	3	16,750,000	7.2
16/08/2022	118	Spray	Rack - cap off	Water	1	22,750,000	7.4
16/08/2022	118	Spray	Rack - cap off	Water	2	13,250,000	7.1
16/08/2022	118	Spray	Rack - cap off	Water	3	15,250,000	7.2
23/08/2022	125	Air	Rack - cap off	Hand	1	13,250,000	7.1
23/08/2022	125	Air	Rack - cap off	Hand	2	35,750,000	7.6
23/08/2022	125	Air	Rack - cap off	Hand	3	9,500,000	7.0
23/08/2022	125	Air	Rack - cap off	Water	1	13,000,000	7.1
23/08/2022	125	Air	Rack - cap off	Water	2	10,250,000	7.0
23/08/2022	125	Air	Rack - cap off	Water	3	14,500,000	7.2
23/08/2022	125	Spray	Rack - cap off	Hand	1	11,500,000	7.1
23/08/2022	125	Spray	Rack - cap off	Hand	2	9,500,000	7.0
23/08/2022	125	Spray	Rack - cap off	Hand	3	10,750,000	7.0
23/08/2022	125	Spray	Rack - cap off	Water	1	10,750,000	7.0
23/08/2022	125	Spray	Rack - cap off	Water	2	32,000,000	7.5
23/08/2022	125	Spray	Rack - cap off	Water	3	24,250,000	7.4
30/08/2022	132	Air	Rack - cap off	Hand	1	1,950,000	6.3
30/08/2022	132	Air	Rack - cap off	Hand	2	12,750,000	7.1
30/08/2022	132	Air	Rack - cap off	Hand	3	20,500,000	7.3
30/08/2022	132	Air	Rack - cap off	Water	1	10,250,000	7.0
30/08/2022	132	Air	Rack - cap off	Water	2	20,750,000	7.3
30/08/2022	132	Air	Rack - cap off	Water	3	14,000,000	7.1
30/08/2022	132	Spray	Rack - cap off	Hand	1	1,575,000	6.2
30/08/2022	132	Spray	Rack - cap off	Hand	2	5,750,000	6.8
30/08/2022	132	Spray	Rack - cap off	Hand	3	14,750,000	7.2
30/08/2022	132	Spray	Rack - cap off	Water	1	13,750,000	7.1
30/08/2022	132	Spray	Rack - cap off	Water	2	16,500,000	7.2
30/08/2022	132	Spray	Rack - cap off	Water	3	20,500,000	7.3