Final report

Preliminary evaluation of flavourless smoke in chilled Australian lamb

Project code: V.RMH.0095

Prepared by: Philip Green and Dr Matthew Flynn
Greenleaf Enterprises

Date published: 1st April 2021

PUBLISHED BY
Meat and Livestock Australia Limited
PO Box 1961
NORTH SYDNEY NSW 2059

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

This project was undertaken to explore the use of flavourless smoke to improve the colour and shelf life of lamb to create higher value for the Australian industry. The addition of flavourless smoke as a "processing aid" has to date shown promising results, yet there remains no commercial uptake, a lack of clarity for food labelling, and an optimal application process. The method for this project involved background research into packaging methods, food standards, smoking processes; small scale preliminary trials; investigation into food labelling requirements; and scoping initial business model concepts to show the value propositions for flavourless smoke. The results showed that flavourless smoke has a significant value proposition and can: a) maintain the natural state of high-quality fresh meat for up to 30% longer than a control product, and b) slow the rate of colour oxidation to enhance shelf presentation, while c) complying with state-based food safety and regulatory requirements. Commercial trials were planned within the scope of this project, however due to the impact of COVID, including export and supply chain pressures these trials have been put on hold. Further research should involve a State based authority and processing company to conduct commercial trials as a precedent for widescale adoption. Importantly, this exploratory research has produced the foundational information for a business case analysis to help processors trial on a commercial basis the benefits of flavourless smoke.

Executive summary

Background

The purpose of this project is to investigate the use of flavourless smoke to improve the colour and shelf life of lamb to create higher value for the Australian industry. The addition of flavourless smoke as a "processing aid" has to date shown promising results, yet there remains no commercial uptake, a lack of clarity for food labelling or, and an optimal application process. This project will review work completed and address this gap with small scale trial work, as well as define the value proposition for its use to be shared with the wider industry.

Objectives

The objectives of this project involve: defining the value proposition(s) for flavourless smoke, completing project trials, seeking market feedback, legislative position on food labelling, and cost benefit analysis.

Methodology

This project considered not only “can we add flavourless smoke” but “should we” – namely, what is the value proposition(s) and barriers to entry; and development of proof of concept and commercial validation. Whilst preliminary trials indicated improved meat colour and shelf life was achievable with 40 minute exposure, multiple application methods and pathways were considered as well as further discussions with industry to understand commercial processing limitations, and food labelling laws.

Results/key findings

The results of this project showed that flavourless smoke has a significant value proposition and can: a) maintain the natural state of high-quality fresh meat for up to 30% longer than a control product, and b) slow the rate of colour oxidation to enhance shelf presentation, without impacting consumer perception of taste and smell. From a technology perspective the flavourless smoke generation process is presented in stepwise format. Food labelling was found not to be a barrier; however, adoption of the technology requires working with a state authority to confirm the application method, microbiological testing results and subsequent impact on shelf-life claims. This report also presents some initial business model concepts for consideration.

Commercial trials were planned within the scope of this project, however due to the impact of COVID, including export and supply chain pressures these trials were put on hold before fully completed.

Benefits to industry

This research has produced the foundational information for a business case analysis and the development of future educational materials to help processors determine the application of flavourless smoke to their businesses.

Future research and recommendations

Further trials are required to determine the shelf-life for different packaging methods and their associated return on investment for different cuts and input costs. It is recommended that these trials involve a State based food authority to set a jurisdictional precedent and to encourage adoption from other States and processing companies.

Table of contents

1. Background

Improving the colour and shelf life of lamb can significantly create higher value capture for Australian industry through reduced markdowns and market access to improved consumer experience. The addition of flavourless Smoke as a "processing aid" has to date shown promising results yet there remains no commercial update plus lack of clarity in labelling as well as optimal application. This project will review work completed and address this gap with small scale trial work, as well as define the value proposition for its use to be shared with the wider industry.

Further, there has been several studies looking at optimising “persistent pink” in high pressure processed and sous vide meat (e.g., to deliver extended shelf-life rare roast beef) which require colour stability in high pH meat and perhaps a flavourless smoke application may be viable.

Whilst this technology is not new, there has been no commercial uptake in the Australian red meat industry with no process for applying the smoke in-line application, no reference in Food Standards Australia and limited understanding of how the technology should be applied across different cuts and pack methods. That is, the opportunity is unlikely to be adopted in its current state based on the past ad-hoc approach the Australian red meat industry has taken – therefore, the aim of the project is to define and deliver this opportunity space. With significant volumes of Australian lamb exported via ship, improvements in colour stability and shelf life could add value and help grow demand for Australian red meat industry.

2. Objectives

This project intended to create value for the Australian lamb industry in the following ways:

- Define the value proposition(s) for flavourless smoke inclusion with Australian sheep meat
- Complete project trials to develop pathways and proof of concept development and specifications
- Seek market feedback and legislative position regarding its inclusion, food labelling laws etc and target market “jobs to be done”
- Present key findings, Cost Benefit Analysis, and recommendations

3. Methodology

This project considered not only “can we add flavourless smoke” but “should we” – namely, what is the value proposition(s) and barriers to entry; and development of proof of concept and commercial validation. Whilst preliminary trials indicated improved meat colour and shelf life was achievable with 40 minute exposure, multiple application methods and pathways need to be considered as well as further discussions with industry to understand commercial processing limitations, opportunties along with food labelling laws.

The project method involved four phases as seen in Figure 1. This began with background research into packaging methods, food standards, smoking processes, and cost modelling lamb yields. A series of small scale preliminary trials were then conducted which are shown in the results section of this report. This included the scoping of a cost benefit analysis. Investigation into food labelling requirements was undertaken which involved working with regulatory bodies to ensure clarity around how the food standards code is applied to the flavourless smoke, the labelling required and the associated branding that links these aspects to the consumer value propositions. The final phase involved the development of business model concepts that will show the value propositions for flavourless smoke.

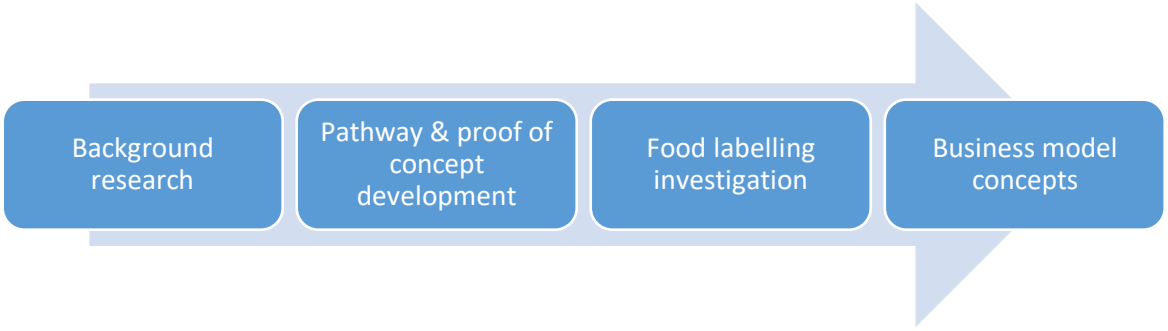


Figure 1. Project method

4. Results

4.1 Market value propositions

The primary value propositions are about maintaining the natural state of high-quality fresh meat products for longer. Secondary value propositions will result along the chain. They are discussed later in this section along with their associated benefits.

4.1.1 Primary value propositions

Managing microbial load (increasing shelf life) – by slowing the rate of growth of bacteria on the surface, the smoke application extends the shelf life depending on the meat cut and process by up to 30% beyond the control product. This process is the same principle as any other modified atmosphere packaging which is globally in the meat industry. However, the more complex naturally occurring gas mixture in the smoke seems to have a better impact on shelf life, like that of smoked seafood. The key difference to smoked seafood is the removal of tar particulates from the gas which also removes the smoke flavours.

Maintaining colour stability – by slowing the rate of oxidation of the meat when exposed to oxygen and by maintaining a state of oxymyoglobin or cherry red colour in the surface of the meat even after vacuum packaging. Colour oxidation occurs, as in the control, but at a slower rate. This keeps the bright presentation of the meat redder for longer and enhances the on-shelf presentation of the meat as shown in the comparison in Figure 2 and Figure 3.

Retail trials demonstrated an increased visual desirability with shelf sales almost doubling on treated product as compared to similar priced and packaged product without the treatment.

Figure 2: Lamb cutlet treated for 20 minutes with flavourless smoke, then vacuum packed

Figure 3: Lamb cutlet of same primal packed under normal vacuum pack.

4.1.2 Secondary value propositions

Increasing the shelf life on product and improving the retail shelf presentation together result in the following secondary benefits of flavourless smoke.

Reduced mark down and dumps – results from having a longer shelf life on the product label before it must be discounted. Improved product appearance also improves shelf turnover. Work with retailers showing differences in stock turnover can improve markdowns and dumps (shrinkage) from 10% in a bad performing product to less than 3% in a high performing product. Appearance and days shelf life both help reduce shrinkage.

Reduced freight costs – in international markets where chilled product is currently shipped by air freight due to shelf-life limitations, product treated with flavourless smoke could be sent by sea freight with as much as $0.70/kg in savings.

Increased meat sales – will result for product packaged with flavourless smoke over product that is not. Consumers buy with their eyes and the presentation of the product is superior to normally packaged meat. Furthermore, small trials of the product have demonstrated sales rates at twice that of previous sales in retail and at a much faster rate than competitor products adjacent to trial product against foreign product.

Increased per capita meat consumption – although very difficult to influence given the year-on-year decline in red meat consumption, could be impacted positively. Note that decline in beef consumption has slowed over the past 3-year period. Note also from MLA market research indicates 25% of shoppers intending to purchase beef at retail change their minds and switch to an alternative protein like chicken or pork at point of purchase. Many decisions such as price, meal occasion, and visual appeal impact this decision. People buy with their eyes and the more inviting a product looks, the more likely they will purchase it, particularly where a purchase decision is not yet set.

Potential improvement in eating quality – over traditional MAP packaging could occur. This needs to be tested and based on the sample sizes required, was not possible in this study. However, the principle is that carbonic acid, formed from the interaction of CO2 with the meat surface has a toughening effect on the meat. Although CO2 forms a large portion of the flavourless smoke gas, it is naturally occurring and includes other component gases not present in traditional MAP. This organic mix of gas could limit the creation of carbonic acid but would need to be tested later.

4.2 Pathway development and proof of concept development

Generation of the smoke, how it is processed and stored and how it is then applied to the product are all important considerations in terms of regulatory compliance and commercial application.

4.2.1 Technology platform

Smoke generation process - flavourless smoke is a patented process. The process involves the generation of smoke from burning wood in the same way that smoke is generated in smoke houses when naturally smoking fish fillets.

Raw Material – is 100% Gidgee acacia that is sustainably produced and naturally cleared from central Australia. The resultant flavourless smoke is also carbon neutral. No other ingredients or processing aids are used in the creation of flavourless smoke.

Smoke collection and filtering – passes smoke through a super cold filtering process that removes the tar, ash, and heavy carbon material from the smoke. These particles give the smoky flavour to preserved meats. When these particles are removed the flavouring component of the smoke is removed. However, the meat colour stabilisation and shelf extension benefit that are in smoked fish are maintained in the flavourless smoke. After gas is filtered and cooled, it is filled into compressed air gas bottles, ready for application.

All natural – nothing is added to the wood before, during or after the process. In terms of application, it is the same as:

- smoking Texas slow cooked meat (just without the flavour),
- Smoked Tasmanian same in retail skin pack (just without the flavour), and
- applying MAP packaging to a retail mince or fresh meat product except that the flavourless smoke is naturally produced gas, compared with manufactured gas in MAP.

Smoke concentration - Length of time during the smoke generation process changes the concentration of the flavourless smoke. Trials to date show that a much faster smoking process (less concentrated) gave the best colour stabilisation for lamb. A slower, more concentrated smoke used in fish creates an unnatural look to the fresh meat. Although this is expected in salmon and other smoked seafood, it is not suitable for fresh red-meat.

4.2.2 Product application

Absorption of gas into the meat - is required for the flavourless smoke to have an impact on the shelf life and colour of the packaged meat. The method for application in the seafood industry has been as a manual batch process in small scale operations which is summarised in Figure 4.

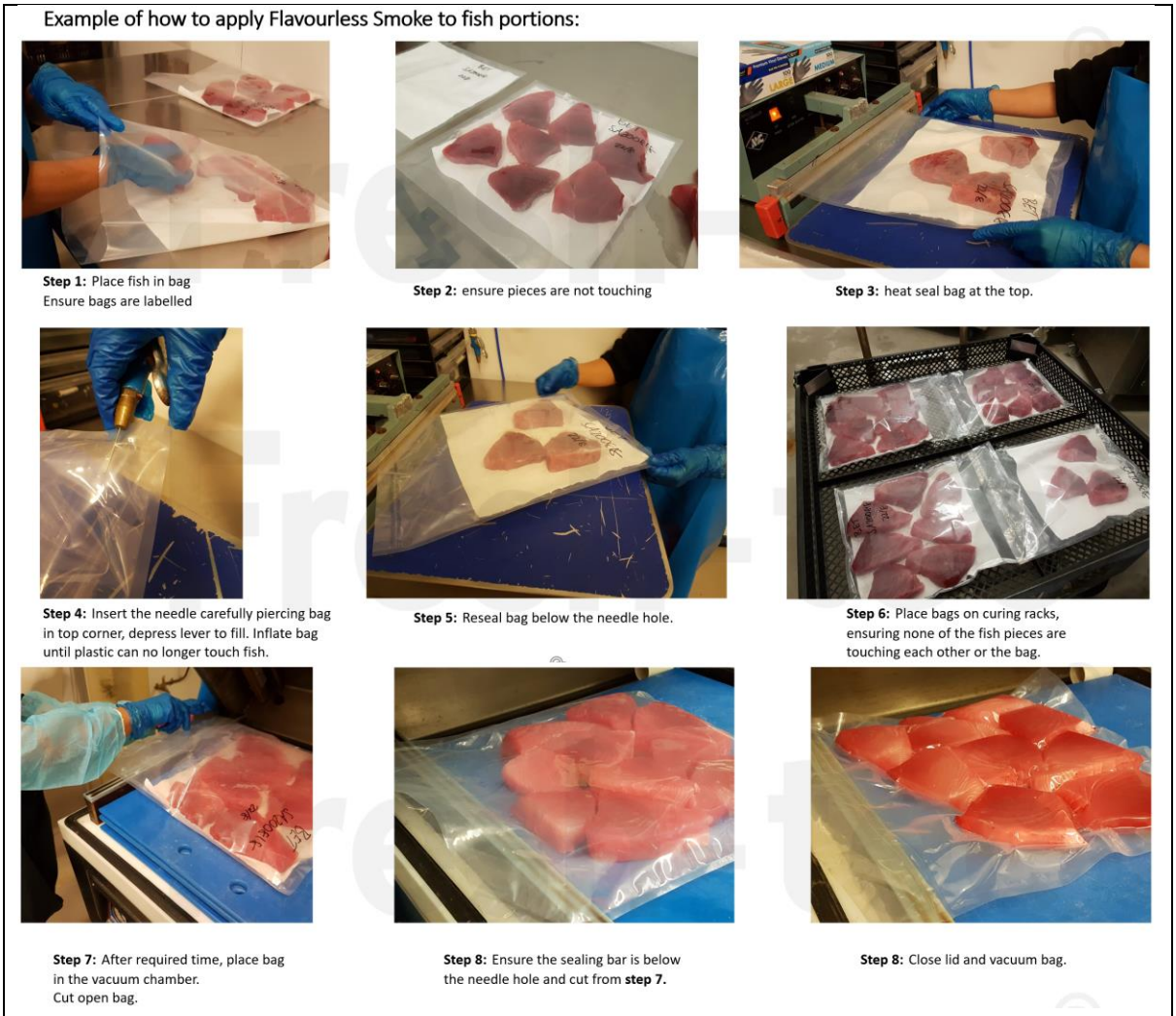


Figure 4: Method for application of flavourless smoke to portion fish fillets

This process is also included as the "Darfresh Portion" method, second from the left of Figure 5. Several other methods of application have been considered during this project and are summarised in the figure.

Commercial integration – including a suitable way of integrating into high-speed red-meat processes has been one stumbling block for industry adoption of this technology. Commercial application to red meat is a key question and one this project is exploring.

The approach taken is to consider the easiest method (or minimal viable application) required to test the commercial value proposition, to get the product certified, and to have it being used on an ongoing commercial basis. From there, more complex application methods can be developed.

The first and second application options from the left of Figure 5 have been tested and include the following application methods.

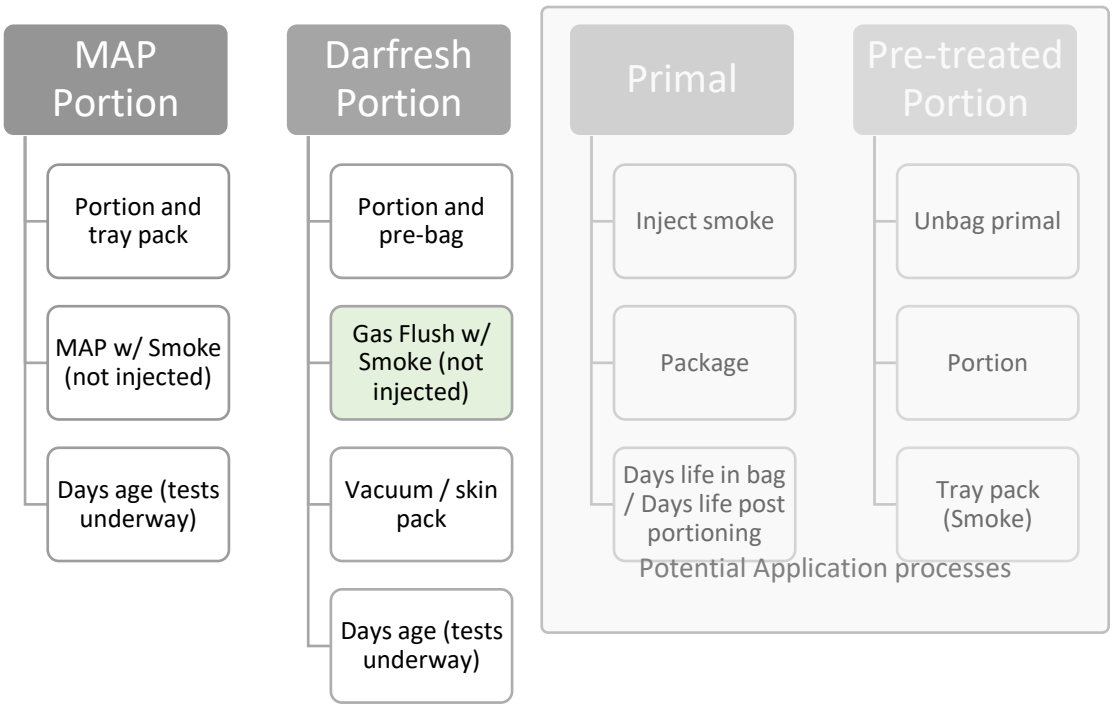


Figure 5: Application processes – current and potential

MAP Portioned application – is the easiest to integrate to current processes. Disconnecting the existing MAP gas mixture from existing gas flush processes and reconnecting with Flavourless smoke is as simple as swapping out a gas bottle.

Small scale trials show that a fast smoke with higher concentrations of CO2 and N2 are more suitable for MAP packs. This is because the volume of gas mixture remains in the product as compared to the Darfresh process where meat is exposed to the smoke for a short period before vacuum packing.

There are opportunities to make the smoking extraction and collection process more efficient by blending gas for different applications, post filtering. But this is not part of the preliminary research trials and does not impact on the treatment results.

Darfresh Portioned application– and including vacuum packaging, involves a batch process where meat is held in contact with a smoke environment for 20-40 minutes to allow absorption into meat before vacuum packing. This is the same process as smoking salmon but must be adapted to meat processing facilities. The process included in **Error! Reference source not found.** describes the method of application. The second step, shaded in Figure 5 is the current bottle neck and difficulty for processors to accept in terms of adoption to packing processes that are either bottle necks already, or becoming faster through automation.

Although this is the most versatile application method, the batch processing nature limits this to high value cuts that would be processed in small volumes in processing plants like portion cut lamb racks or bone-in OP ribs in beef.

Retailer butchers would be able to apply this process to a wider range of products due to the higher labour cost and more manual processes already in place. However, the shelf-life benefits will be less important given butchers “make-to-order” process. Colour stability is an issue in butcher shops and would be improved for cuts sold in sealed packs. This is addressed more in the customer value propositions section of the report.

The application of flavourless smoke to primals and the processing or pre-treated primals as portioned meat cuts has not been tested during the trials. There is more complexity in these processes and not part of the current trial work.

The challenge is making an environment that will allow the gas to be absorbed into the meat. This happens very quickly at the surface. Figure 6 shows the bright cherry red colour in a lamb cutlet held under gas for 40 minutes has absorbed almost through to the centre of the product.

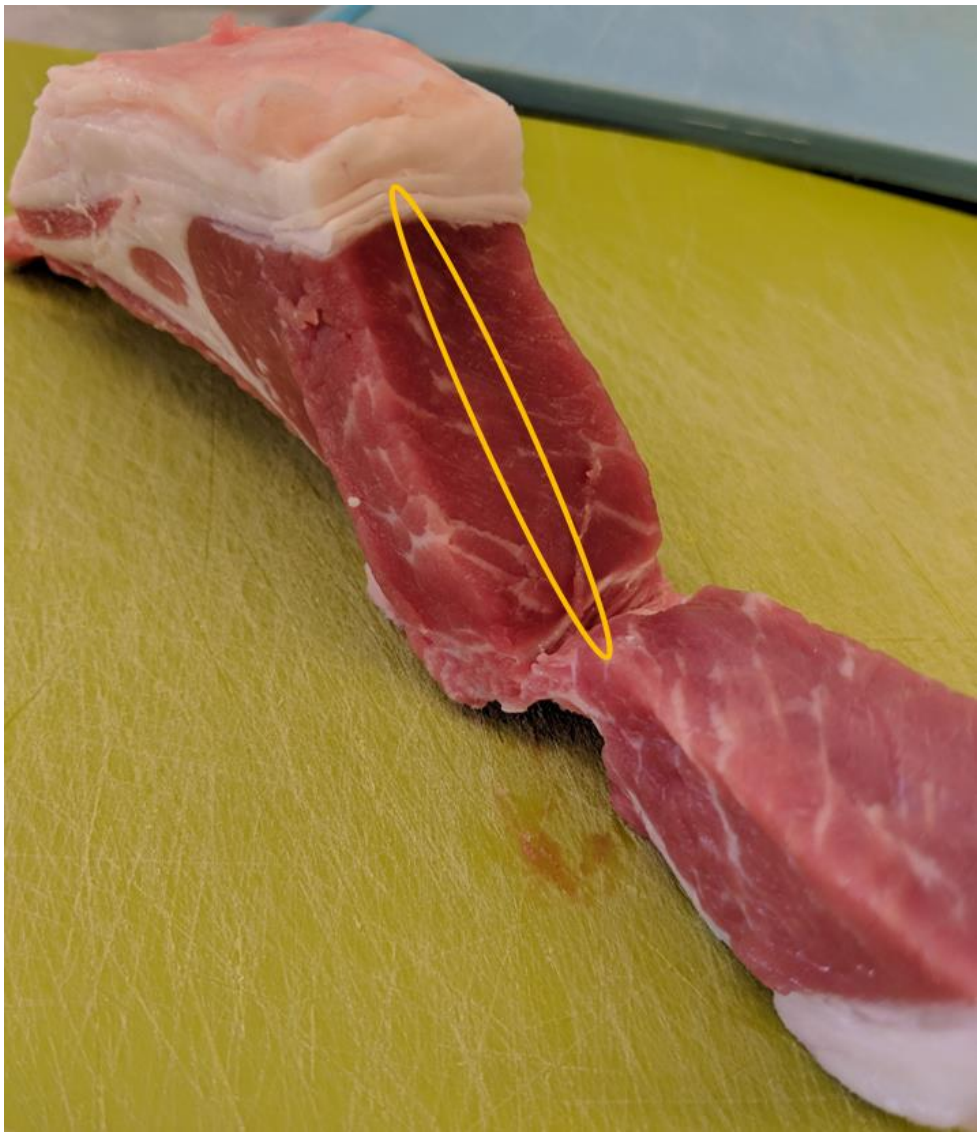


Figure 6: Rapid absorption on high surface area product

4.2.3 Potential application methods

The challenge in treating larger pieces of meat that will not be portioned until further downstream, addressed in the third and fourth process flow in 5, is the dwell time required for a whole primal.

The process for treating primals could be to inject in a similar way to injected whole muscle cuts. This is done with fresh pork and blade tenderisation of red meat using a similar (accepted/approved) invasive process, although the impact on eating quality and moisture is more in those processes than with injection of gas.

Figure 7: Meat injectors with adaptation for gas injection

4.2.4 Laboratory testing

Trials conducted during the project have been designed to test smoke generation times to assess impact on colour and for integration to commercial process flows. Further to this, testing is being undertaken to assess the changes in microbial load on shelf-life. Shelf-life trial testing matrix in

Table 1 has been applied to 3 different meat cuts and packaging formats.

Gas concentration levels have also been tested from a range of smoke generation speeds with the faster smoke extraction being most suitable for lamb and beef meat. The smoke applied to meat is much faster than that required for fish.

Third party laboratory tests show typical analysis of the smoke being N_2 – 48%, CO_2 - 38% and the remaining 14% being made up of 5-6 other gases naturally occurring in wood smoke.

- It seems this natural combination of gases in wood has other preserving qualities that factory created MAP gas mixtures.

Recent studies as part of the MSA eating quality standards has shown that Modified atmosphere packaging has a negative impact on meat tenderness. It is believed carbonic acid created from CO_2 toughens the meat. There is potential this could be reduced with FreshTec because of the other gases present in the mixture. However, there is no indication of this and would need to be tested. This eating quality testing has not been included in the scope of this project.

Table 1: Matrix for shelf-life testing of Lamb products

Matrix for Shelf life testing

LAMB					
Product		Mince	Steak	Bone in whole muscle	
Packaging style	MAP	0	1	1	
	DarFresh	0	1	1	
	Total	0	2	2	
Treatment	Control	1	1	1	
	20 minutes	1	1	1	
	40 minutes	1	1	1	
	Total	3	3	3	
Total Samples		0	6	6	12

		Test (1 or 0)			**Total Samples**
Days age	Day 1	1	1	1	**12**
	Day 10	0	0	0	**0**
	Day 20	1	1	1	**12**
	Day 25	1	0	0	**0**
	Day 30	1	1	1	**12**
	Day 35	0	1	1	**12**
	Day 40	0	1	1	**12**
	Day 45	0	1	1	**12**
	Day 50	0	1	1	**12**
LAMB	**TOTAL SAMPLES**				**84**

The trials being undertaken in the above regime will be presented at the end of the project and will inform the final business application, types of meat cuts and packaging styles and the expected net profit position for a company wanting to use the product under each of other scenarios tested. Contribution of shelf-life testing to financial benefit includes by way of example, improvements in shipping costs, reduced markdowns and other value propositions included in the business model in following sections of this report.

4.2.5 Draft application for each process flow

The application methods that seem to work the best for chilled lamb under trial conditions are included in the "**Error! Reference source not found.**".

After the shelf-life trials are completed for each packaging and cut type, refinement of application methods considering the commercial process flows and financial and operational constraints.

Packaging and cut type have an impact on commercial adoption of the technology and are considered here.

4.2.5 Market application by primal cut

Not all products in the lamb category will benefit from application of flavourless smoke to the degree required to generate acceptable return on investment. The Table 2 forms up the data being collected to be used in future research. As this table of data is being populated it will support the development of business case analysis and future educational materials to help processors determine the benefit to them of Flavourless smoke, which cuts are best to apply it to and the type of packaging method most suitable. Consideration of sales channel, required shelf life and savings in shrink, transport costs and sales increases will form part of the final business case.

Table 2: Application of Flavourless Smoke to lamb cuts – product mix and return on investment (Draft)

Produced	Primal	Item Description2	MAP	Darfresh	Gas $	Labour $	Price increase	Days life	Mark down %	Savings $	ROI
Case Ready	Bones	Lamb Off Cut C/Ready									
	Chump On Loin	Lamb Fillet C/Ready									
		Lamb Mid Loin Chops C/Ready									
		Lamb Rump Steak C/R									
	Leg	Diced Lamb C/Ready									
		Lamb Leg Chops C/Ready									
		Lamb Leg Steak C/Ready									
		Roast Lamb Leg C/Ready									
		Roast Lamb Leg Half C/Ready									
		Roast Lamb Leg Twin Pack C/Ready									
		Roast Lamb Round C/R									
		Stir Fry Lamb C/Ready									
	Mince	Lamb Mince C/Ready									
	Rack	Lamb Cutlets C/Ready									
		Lamb Frenched Cutlets C/Ready									
		Roast Lamb Rack C/Ready									
		Roast Lamb Rack C/Ready									
	Shank	Lamb Shanks C/Ready									
	Sq Cut Shoulders	Lamb Forequarter Chops C/Ready									

Domestic Sales – including retail processing at central packing plant is considered versus at abattoir processing.

Consideration of supplementary cuts and how they would be integrated into the process for a retailer are also being considered and summarised in Figure 8.

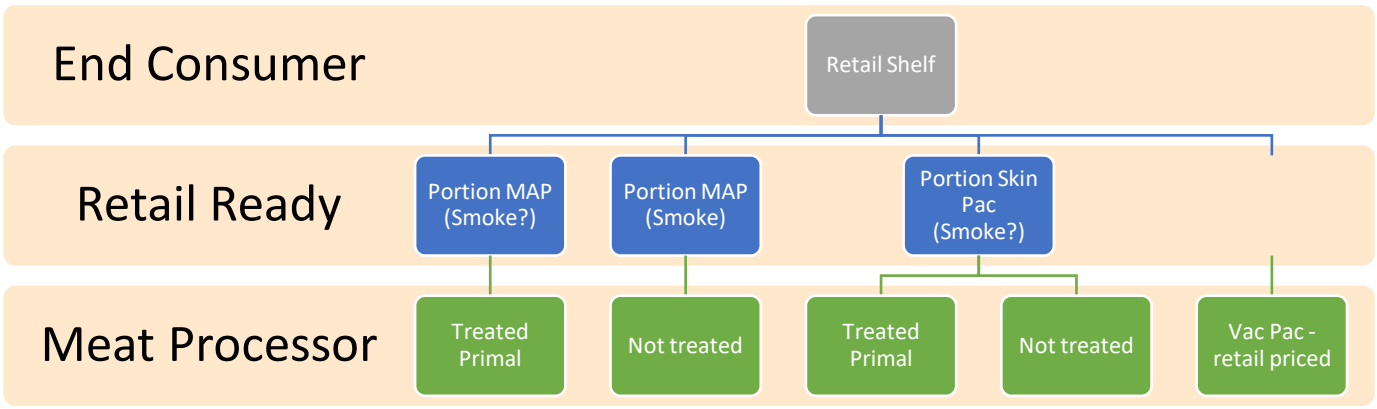


Figure 8: Retail-ready product distribution standards for meat processors

4.3 Domestic food labelling requirements

FSANZ has provided written confirmation that application of flavourless smoke to red meat did not conflict with the food standards code prior to this project. Although FSANZ has no concerns about the application of flavourless smoke, the interpretation of the code and the administration of the code is done by the food authority in each state.

Preliminary testing of the product was not clearly defined with state food regulatory authorities. This left an open-ended misunderstanding of what the product should be called, how it should be interpreted within the food standards code and how that would then impact on application to red meat from the perspective of each state regulatory authority.

A large part of the focus of this project has involved working with regulatory bodies to ensure clarity around how the food standards code is applied to the flavourless smoke, the labelling required and the associated branding that links these aspects to the consumer value propositions.

The services of an external food safety and QA consultant were engaged as part of the project to review the product, the food standards code and then to work with us and with the regulatory authorities to ensure the product and its application meet all domestic requirements.

The next step after domestic adoption is to seek approval from importing countries to ensure compliance with their requirements. This has not yet been done due to the project being placed on hold.

4.3.1 Precedents set with application of flavourless smoke to seafood

As mentioned already, the application of flavourless smoke to seafood has already been approved and is used widely across the premium grade sector of the Australian seafood industry. Processing of salmon and tuna offshore using the same patented technology is imported into Australia. Australian seafood is also exported under existing country requirements.

Application of flavourless smoke is written into the food standards code. “FSANZ – Approval Report – P1019 and Standard 1.3.3 – Processing Aids” states that natural smoke being used to process fish as a food is approved.

4.3.2 Processing aid or Ingredient according to the code?

Defining the technological function – of the smoke is important in determining how best to label the product. The key point according to the code is whether the function alters the natural state of the product or not.

- FSANZ Schedule 14 - Outlines technological purpose as a food additive

The extracts from the code in Figure 9 determine whether a technological function results in a product being categorized as a processed food or not.

The smoke has a natural preserving antimicrobial function and slows bacterial growth for the purpose of extending shelf life in a similar way to existing functions of MAP packaging in Safe Food QLD's documentation.

[3] ***Standard 1.3.1*** *of Volume 2 is varied by -*

[3.1] *omitting from clause 1, the definition* technological function *and inserting directly following the* Editorial note *to the definition of* processed food –

Commonwealth of Australia Gazette
No. FSC 1, 9 May 2002

technological function means a function set out in Schedule 5, but does not include the addition of a food additive to a single ingredient food that is not required by this Code to be labelled where a single process is applied and the food is presented in a manner which suggests that the organoleptic qualities have been altered, other than through the process.

Figure 9: FSANZ extract 1 regarding technological function

The application of Flavourless smoke does not alter the natural state of the product. It is intended to maintain the natural attributes of the single ingredient fresh meat for longer and not to alter them in any way. Given the product is not classified as "processed", the smoke is not considered a processing aid.

Further to the definition, the code does not state anywhere that smoke or MAP gas must be included as an ingredient on a single, or multi-ingredient food label.

Truth in labelling – needs to ensure the consumer is not misled by inclusion or omission of information from the product. The extract from the code in Figure 10 further clarifies how a product should be labelled to ensure consumes are not misled.

Editorial note:

When prawns are cooked, they generally turn red in colour. If a red food colour was also added to cooked prawns, consumers may be misled into believing that the red quality was attributable to the cooking process, and not the addition of a red food colour.

Food that has been smoked generally has a 'smoky' taste. If a smoke flavouring substance was also added to a smoked food, consumers may be misled into believing that the smoke taste was attributable to the smoking process, and not the addition of a smoke flavouring substance.

Figure 10: FSANZ extract 2 regarding technological function

Flavourless smoke meets these consumer labelling requirements given it is only maintaining the fresh natural flavours of meat for longer.

MAP application and labeling precedents - The application of the smoke is not different to traditional and readily accepted modified atmosphere packaging methods, has predominately the same gas components as some MAP mixtures and maintains the colour of the product and shelf life to similar degrees as MAP packaged product. No requirement exists to label MAP or gas flushed and vacuum-packed fresh meat with gas packaging details.

International food labelling requirements
Three key markets Australian exporters are concerned about in terms of setting specific labelling requirements that are representative of most export destinations are the USA, China, and MENA. Preliminary investigation has been undertaken into requirements in each country. For example, USDA & FDA inspection of fish imports for gas composition must be within acceptable limits which are documented by the USDA. Flavourless smoke trials undertaken to date fall within these limits.

International country certifications will not be finalised until domestic state regulatory bodies are in agreeance that all aspects of the flavourless smoke comply with the food standards code. Further trials before the completion of this project will validate the levels of each gas within flavourless smoke, present in the meat samples after holding for normal storage and logistic periods.

4.3.3 Labelling and branding opportunities

Given that flavorless smoke is naturally produced (not manufactured like traditional MAP gases), is carbon neutral and is produced from sustainable materials, there is a good story to tell in differentiating between traditional packaging products. But creating a clear and accurate message about the product is important for the consumer.

Furthermore, processors using the product have their own brand names and stories about the meat. Any labelling regarding the smoke needs to give the consumer added confidence in the brand owners story and not detract or confuse the messaging.

Natural "Super Cold Smoke" fresh meat, and other similar brand names imply the product will have a 'smoky' taste and is not the case.

However, a subtle integrity seal on the background of a product package may be an option for processors that do want to state the use of flavourless smoke. For others, it will be treated the same as any other MAP packaging which is not mentioned on the pack.

Some branding and labelling options being considered with processors are summarised in Figure 11 and Figure 12.

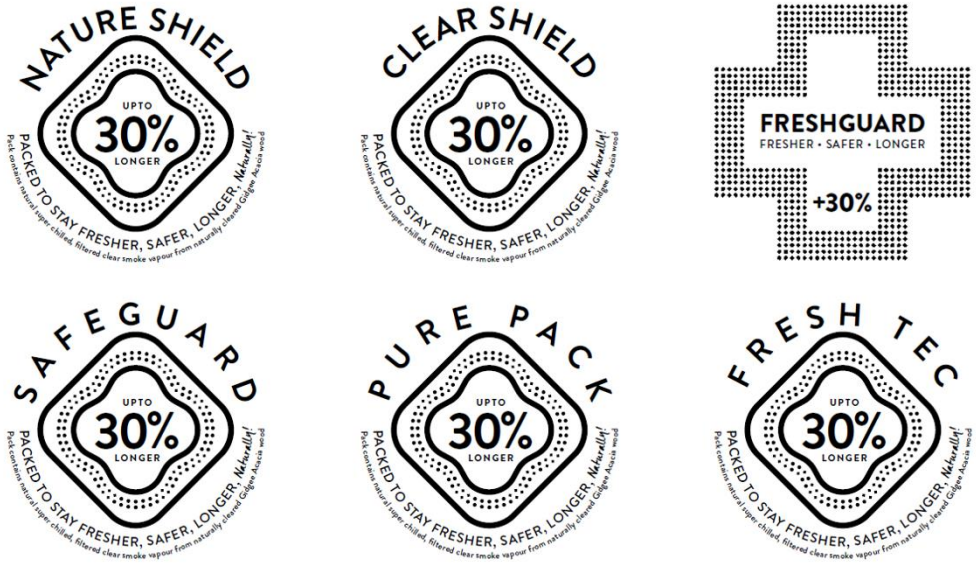


Figure 11: Proposed Logo Designs for the flavourless smoke product packaging certification

Figure 12: Vacuum-Sealed Product with flavourless smoke certification

4.4 Business model canvas refinement

The "Strategyzer" value model canvas method (Figure 13) has been used to identify how the value propositions generated from flavourless smoke could deliver value to the different users along the supply chain by relieving specific pains and creating gains in value, monetary or otherwise.

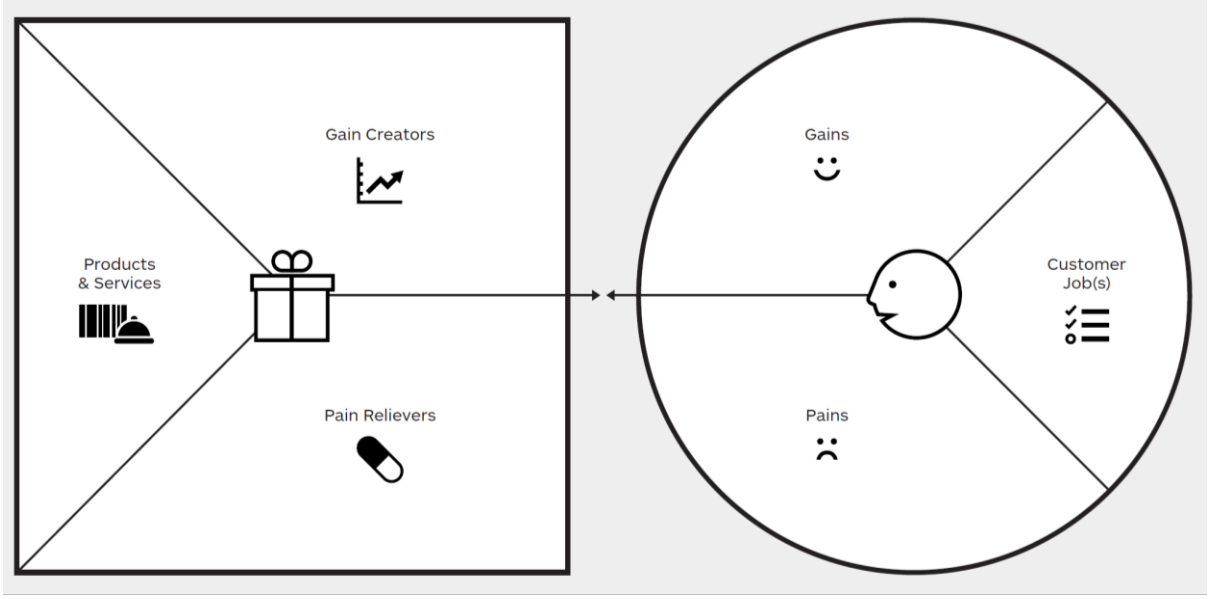
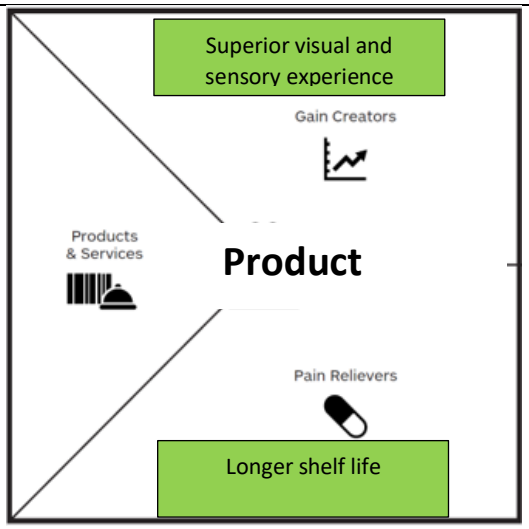
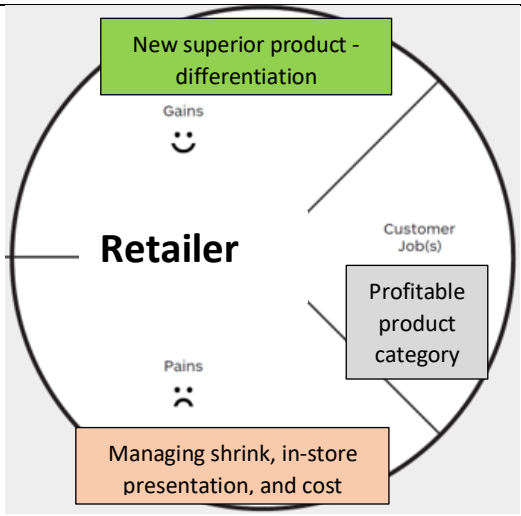
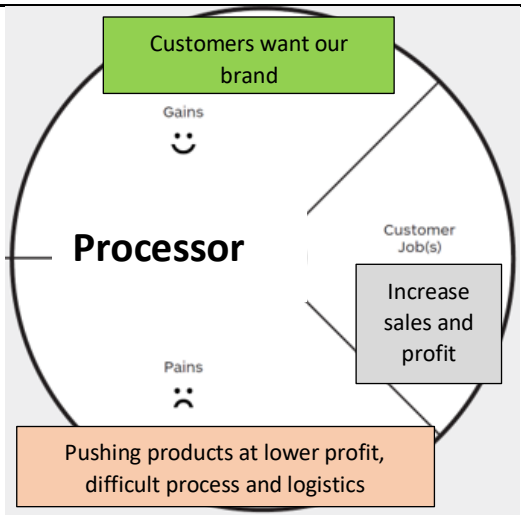


Figure 13: Pains & Gains- the value flavourless smoke offers to consumers

4.4.1 Testing the value propositions

Product		**Quote: (I buy with my eyes. If it looks good, I am more likely to buy it)** Market research shows 25% of Australian retail shoppers who intended to purchase red-meat switch to another protein in store. **Product:** **Gain Creators**: • Longer shelf life gives more time as high-quality presentation • The best visual presentation of meat - Brighter cherry red meat colour for longer in all pack styles including skin pack **Pain Relievers**: • Better odour immediately after opening bag • Less discolouration of bone-in product Increase colour • Increase shelf life (reduced plate counts) • Replacement for existing MAP gas mixture • Reduce airfreight costs to sea freight

Retailer		**Quote: (Flavourless smoke packaged meat looked better on shelf and sold faster than untreated product)** **Retailer Job:** Category volume, value, and profit growth. Achieve sales targets. Well-presented butcher case that attracts customers. **Gain**: • Longer shelf life gives more time as high-quality presentation. • Faster stock turn and increased product sales. **Pain**: • High mark down and dumps (product shrinkage) is a direct cost to the retailer and reduces sales. • Higher cost products that reduce volume sales. • Inefficiencies and bottle necks in processing. • Dependable skilled labour is hard to get. I want processes to be simple and reliable. • Import labelling and certification to maintain country listings is critical to business profitability.
Processor – Brand Owner		**Quote:** I love what FS can do for our business, but does it comply with regulation and is it worth the cost? **Processor Job:** Achieving sales volume and value, customer store ranging. **Gain**: • Differentiating product on shelf to increase sales • Higher demand - Retailers and customers look for our product due to increased confidence/satisfaction and brand equity **Pain**: • High mark down and dumps (product shrinkage) is a direct cost to the retailer and devalues the brand, reduces sales, and risks de-listing. • High cost of transport to some countries for shorter shelf-life retail packs. • Short shelf life increases risk of product loss • High processing costs

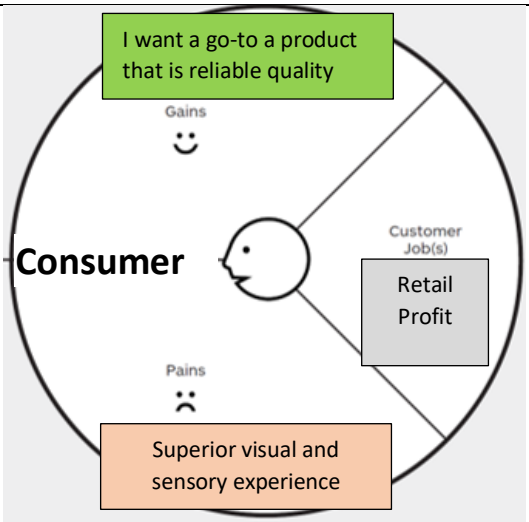
Consumer		**Customer Job:** When I buy steak, it is for that occasion meal a week. I want it to be special for those eating it. I do not want any negative experience. **Gain**: • Discolouration of meat in pack reduces sales, increases markdowns and dumps. • Skin pack product has a dull greyish colour and reduces consumers eye appeal. • Bright cherry-red to pink meat colour is most acceptable to consumers who buy with their eyes. • Product integrity in some countries like China make packaging of product in the final retail pack in Australia a more desirable option for in-market sales channels. **Pain**: • Vacuum product has a great shelf life BUT it just does not look good (bluish brown) • Vac Pak has a funny smell when I open it up. • MAP product increases toughness in red-meat (due to carbonic acid – we think) which reduces eating quality satisfaction • The bone goes brown and smells a bit if we do not eat it that day. • Tray overwrap starts to go brown around the edges and makes the whole cabinet look bad • Red meat is more expensive than chicken and pork. When I buy it, I want it to be good. If it does not look good, I am probably not going to buy it this time. • I am buying on a budget. I pay a higher price for special occasions, but it cannot be too costly.

Table 3: The Pains & Gains for both retailers and consumers

4.5 Challenges or barriers to adoption

There has been strong interest in the application of flavourless smoke, but the following challenges have been raised. Some have been addressed already, while others are still being addressed in this project.

- **Cost of packaging is very sensitive** - and treated as a simple cost. Demonstrating the return on investment in a way that is easily communicated to the processors is required and forms part of the next milestone. Many of the benefits are not at the point of packaging so flow of

value increase through the chain is required to demonstrate feasibility. Currently there is a low cost of packaging materials and existing gas mixtures and high-speed process flows to apply the packaging.
    - MAP packaging – is easy to integrate across all retail packs but naturally produced smoke is costly and limits application to smaller volumes of high value products that suffer from shelf life and presentation issues like bone in grilling cuts.
    - Skin pack - requires an additional manual batch process which adds a bottle neck.
- **Export labelling requirements** – Food labelling for export needs to consider multiple country labelling requirements and makes it a higher risk proposition for exporters to be the first to take on a new product concept.
- **Regulatory approvals** – are still required and the biggest potential output from this project. Many processors sell a majority of product to export markets. They develop QA systems and processes that are not different between domestic and export. Although different QA processes can be applied for domestic product, it is a hurdle for many processors to adopt flavourless smoke for domestic use without having export labelling and regulatory requirements already approved.
- Process of trialling product was quite expensive and was based on small batches.

5. Conclusion

5.1 Key findings

- Flavourless smoke can maintain the natural state of high-quality fresh meat for up to 30% longer than a control product
- Flavourless smoke can slow the rate of colour oxidation to enhance shelf presentation
- From a technology perspective the flavourless smoke generation process is achievable
- Food labelling does not appear to be a barrier for red meat processors subject to the approvals of State authorities
- Although further R&D is required, indications of profitability are achievable for the right applications of flavourless smoke

5.2 Benefits to industry

As a result of this project there are specific benefits to red meat industry:

- Flavourless smoke can provide a superior visual experience for consumers
- Longer shelf-life
- Provides an opportunity for product differentiation
- May generate an acceptable return on investment

6. Future research and recommendations

Further trials are required to determine the shelf-life for different packaging methods and their associated return on investment for different cuts and input costs. It is recommended that these trials involve a State based food authority to set a jurisdictional precedent and to encourage adoption from other States and processing companies.

7. References

Osterwalder, Alex et al (2020) The Invincible Company. Strategyzer.com/invincible

Strategyzer (2019) https://www.strategyzer.com/canvas/business-model-canvas

8. Appendix

8.1 Occupational health & safety operational process

8.1.1 Safety requirements to note prior to flavourless smoke application

APPLICATION & EXTRACTION PROCEDURE

1. Food portions are placed in a bag and heat sealed.
2. The needle applicator is inserted at the top of the bag, inflate the bag until the food has no top surface contact, then reseal hole ensuring no FRESH-TEC® flavourless smoke can escape.
3. Place in chiller; store below 4 degrees Celsius during smoking period.
4. When it is time to pack the processed Protein, insert extraction nozzle into the sealed bag evacuating FRESH-TEC® flavourless smoke to atmosphere then continue to pack to required specifications.

Extraction fan must be fitted above application point.

Evacuation nozzle is fitted with extraction unit.

All extraction fans & units must vent to atmosphere.

Sediment filter fitted before application point.

FRESH-TEC® cylinders are to be disconnected after each shift and the valve closed tight.

Cylinder storage must be outside, locked, and secure.

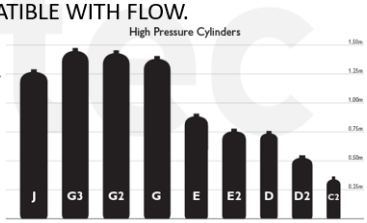
MSDS for FRESH-TEC® must be attached to cylinder storage.

Trade name: Compressed Gas Mixture – FRESH-TEC,
Flavourless Odourless Filtered Wood Smoke – Food Grade

- For Food Application / Cold Smoking: A Filtered Smoke (Gas) which is non-flammable, non-toxic.
- Take Note of Label Risks & Safety Use of a Compressed Atmosphere (Gas) Cylinder

RISKS:
- HIGH PRESSURE. ASPHYXIANT IN HIGH CONCENTRATIONS. SLIGHT SMOKY ODOUR.
- LIGHTER THAN AIR. HEAT FIRE OR IMPACT DAMAGE MAY CAUSE CYLINDER RUPTURE.
- AVOID CYLINDER SHOCK.

SAFETY:
- OPEN VALVE SLIGHTLY & SLOWLY. CLOSE VALVE SHUT AFTER USE.
- KEEP AND USE IN A WELL VENTILATED AREA. DO NOT DROP. KEEP CYLINDER COOL.
- KEEP FREE FROM OIL & GREASE. USE REGULATOR & EQUIPMENT COMPATIBLE WITH FLOW.
- DO NOT BACK CONTAMINATE CYLINDER. REFER MSDS.
- ASPHYXIATION OCCURS IN HIGH CONCENTRATION IN CONFINED SPACES.



PHYSICAL CHARACTERISTIC OF THE CYLINDER
- G SIZE CYLINDER; G, G2 OR G3 SIZE MAY BE SUPPLIED

Where to Find Information; MSDS, Labels & Example of Label: Compressed Gas Mixture – FRESH-TEC Flavourless Odourless Filtered Wood Smoke – Food Grade

Cylinder Valves Safety

Before operating a cylinder valve

OPENING or CLOSING cylinder valves

OPEN by turning the handwheel or cylinder valve key anti-clockwise. Only use reasonable force.

CLOSE by turning the handwheel or cylinder valve key clockwise. Only use reasonable force.

When in use, cylinder valves used in the fully open position may become stuck in this open position. To prevent this ensure that the handwheel or cylinder valve key is turned back half a turn.

Cylinder Valves may have a valve guard.

Some valves may have a heat shrink shroud to prevent valve movement in transport.

Always take care of the valve and observe valve position during operation.

Open

Close

Valve Guard

Only use equipment that is fit for purpose

The gas cylinder and outlet valve are designed to supply gas through pressure regulators that meet the requirements of the relevant Australian Standards.

Pressure regulators thread directly to the cylinder valve outlet (also applies to cylinder packs) so it is vital that the size and tolerance are to specification and meet the specified machining tolerance.

Never install additional piping or fittings between regulators and the outlet valves of cylinder packs.

When individual cylinders of the same gas are manifolded together to a common outlet, the pressure regulator must be connected to this single manifolded outlet.

Use the adjustment valves downstream of the pressure regulator only and not those fitted upstream, as this will starve the regulator of flow.

Pressure regulators: check the inlet spigot connection first

Make sure the pressure regulator is designed for use with high pressure gas cylinders and that the inlet spigot thread matches the cylinder valve outlet and that the O-ring or seal is in place, clean and undamaged.

Never force any regulator connection that does not fit. Regulator connections can be fully threaded in by hand and then only require a fraction of a turn to achieve a gas tight seal. Regulators must be maintained in accordance with the manufacturer's instructions.

Do not attempt to repair or modify the regulator. Take it to the manufacturer's authorised service centre.

Release (i.e. turn anti-clockwise, 'back off') **the regulator adjusting knob before attaching the pressure regulator.**

Before connecting a pressure regulator to a full cylinder always screw out (anticlockwise) the pressure adjusting knob so that there can be no flow through the regulator when the cylinder valve is initially opened.

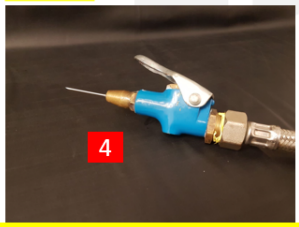
Only use the gas for the intended purpose.

1	Outlet or Regulated Pressure Gauge	
2	Inlet or Cylinder Pressure Gauge	
3	Regulator Outlet Connection	
4	Inlet Spigot (regulator)	
5	Cylinder Valve	
6	Regulator Control Knob	Increase Pressure (Turn Clockwise)
		Decrease Pressure (Turn Anti-clockwise)

IMPORTANT: Downstream Flow: Cylinder to Regulator to Filter to Smoke Gas Applicator

EXAMPLE: TYPICAL PRESSURE & FLOW RATE FROM REGULATOR THROUGH FILTER FOR USE OF FLAVOURLESS SMOKE PROCESSING & CURING OF FOOD IN PLASTIC PROCESS BAGS IS; 50 PSI OR APPROX 44 L per minute.
MAKE SURE SAFE WORKING pressure is less than rated spec of Filter ie. < 90 / 100psi as applicable.

Example: set regulator flow rate at 50 PSI OR APPROX 44 L / minute flow rate **Usually 50 psi is adequate to fill plastic bags**



Example: 50 PSI OR 44 L / minute flow rate

Example: depending on filter spec housing max pressure rating is 90 / 100 psi depending on the model.

Example: Flavourless Smoke Cylinder Pressure filled to minimum 1015 psi ~ 70 Bar.

1. Regulator: Set your pressure according to application and flow required. **Usually 50 psi is adequate to fill plastic bags.** DO NOT exceed pressure of lowest rated downstream component, example filter.
2. Flavourless Smoke Cylinder: Filled to a Pressure of 1015 psi ~ 70 Bar – check your valve position and open slowly.
3. Water & or Sediment Filter: Usually a max operating pressure of 90 to 100 psi - check your specification.
4. Flavourless Smoke Gas Injector for bag inflation – OUTPUT PRESSURE SET TO 50 PSI.

8.1.2 Safe operation of gas regulators

OPERATING INSTRUCTIONS FOR COMPRESSED GAS REGULATORS

WARNINGS

Only operate this regulator if you have been trained in its proper use, or you are operating under competent supervision.

Oxygen is not flammable, however, the presence of increased levels of oxygen will drastically increase the speed and force with which burning takes place. Oxygen and oxidising gases must never be allowed to contact oils, greases or other combustible contaminates. Therefore use no oils, greases or unapproved substances on the regulator, cylinder valve or downstream equipment.

Do not use this regulator with gases other than those for which it is intended.

Do not use this regulator unless you are familiar with the hazards associated with the gases you are using.

Always open cylinder valves slowly to minimise possible dangers caused by rapid pressurisation of the regulator.

Always pressurise the system downstream of any regulator slowly in a controlled manner. This is particularly important for gases such as helium and hydrogen. Do not allow the regulator to free flow gas to atmosphere without any back pressure.

Consideration should be given to remotely venting the exhaust of pressure relief valves if the regulators are operated in areas that are not well ventilated area. This is especially important for fuel gases, toxic gases and asphyxiant gases.

Setting up Equipment.

1. Secure cylinder to wall, stand or trolley so it will not tip over or fall.
2. Remove the protective dust seal from the cylinder valve.
3. Inspect the cylinder valve for damaged threads, traces of dirt, dust, oil or grease.
   NOTE: If oil or grease is detected, DO NOT use cylinder. Inform your gas supplier of this condition immediately.

4. With the cylinder valve outlet pointing away from people and sources of ignitions, "crack" the cylinder by momentarily opening and closing the cylinder valve. **Always** "crack" fuel gas cylinders in a well ventilated area. **Do not** "crack" cylinders of toxic or corrosive gases.

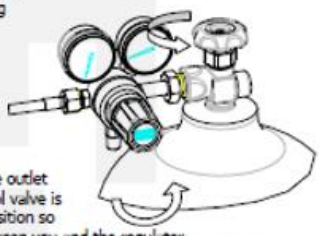
Fitting the Regulator.

1. Make sure the regulator has the correct inlet fitting to fit the cylinder valve. Check the fitting for any damaged threads. If the fitting is so equipped, make sure the flat sealing washer or o-ring is in place between the regulator and the cylinder valve outlet. The threads may be either right hand or left hand depending on the gas being used. Regulator inlet connections with left hand threads have a "V" notch machined into the hex to signify a left hand thread.

2. Tighten the regulator inlet nut securely with a spanner, or hand tighten if the regulator has a medical yoke T-screw.
3. Connect the downstream equipment to the regulator outlet fitting.

Turning on the Cylinder.

1. Be sure that the adjusting knob of the regulator (adjustable models) is fully "backed-off" (ie. fully counter clockwise). For preset pressure regulators ensure that the downstream equipment is fitted to the outlet connection and its control valve is turned off. Stand in a position so the cylinder valve is between you and the regulator.



   NOTE: For greater safety never stand in front of a regulator when opening the cylinder valve. Slowly turn the cylinder valve on in a counter clockwise direction until you hear the gas begin to flow into the regulator. Wait about 10 seconds then proceed to fully open the cylinder valve.
2. To check for leaks, close the cylinder valve and observe the high pressure gauge for 5 minutes. If the high pressure gauge reading drops, there is a gas leak in the cylinder valve, inlet fitting, high pressure gauge or regulator seat. Retighten the regulator to cylinder connection and repeat step 1. Should the high pressure gauge continue to drop after retightening, the regulator must be removed and returned for servicing.

Adjusting Regulator Delivery Pressure.

1. After the regulator has been securely attached to the cylinder valve, adjust the delivery pressure by turning the adjusting knob in a clockwise direction until the required pressure is reached.

2. If the regulator is equipped with a flow control valve or flowmeter, flow can be controlled by proper adjustment of the valve/flowmeter.

Turning Off Cylinder Valve.

1. When you have finished using the regulator, close the cylinder valve off in a clockwise direction and allow the regulator to de-pressurise. The pressure has been released from the regulator when gas ceases to flow and the pointers on both pressure gauges indicate zero.

2. After all pressure has been released from the regulator, release the tension on the regulator adjusting knob by turning it fully counter clockwise.

Removing the Regulator.

1. It is not necessary to remove the regulator unless the cylinder is being moved, or an empty cylinder is being replaced.
2. NEVER attempt to remove the regulator if any pressure is showing on either pressure gauge. If pressure is showing, follow the "Turning Off Cylinder Valve" procedure described previously.
3. Remove the regulator from the cylinder and replace the protective cap on the cylinder.
4. Place the regulator in a secure place to avoid damage and contact with oils, greases, dust or any other possible contaminants.

COMMONLY ASKED QUESTIONS AND MISTAKES ABOUT GAS REGULATORS

Q. Is my brass body regulator OK for ultra high purity application, or do I need a stainless steel body regulator?
A. Brass regulators are acceptable for ultra high purity applications so long as it has a stainless steel diaphragm. Stainless steel bodies do not make regulators cleaner in regards to the gas flow. Stainless steel diaphragms are used in all high purity regulators regardless of their body material. Stainless steel body regulators are needed for corrosive gases and or harsh external environments.

Q. If the outlet pressure gauge shows 1000kPa, why won't it deliver to 1000kPa?
A. Regulators have springs inside that control the maximum delivery pressure possible. The pressure gauge does not dictate the maximum delivery pressure of the regulator. Most pressure gauge manufacturers do not recommended that their gauges are constantly operated at their full scale pressure.

Q. Can I set an outlet pressure of 20kPa when the rated outlet pressure of the regulator is 800kPa?
A. Not reliably. The regulator will actually fluctuate greatly if the rated outlet pressure is too high. It will probably allow the flow of gas, but the pressure will not be stable. As a rough guide regulators do not operate reliably at set pressures below 10% of the rated outlet pressure

Q. Will my pressure regulator control gas flow?
A. No. Pressure regulators control pressure not flow. A flow valve or flowmeter, in combination with a regulator, will be needed to control flow.

Q. Why does my gas regulator hum sometimes?
A. Regulator hum indicates that the seat and stem dampers are worn or inoperative. It is also possible that you are using an improperly ranged regulator. The regulator may need servicing

Q. Can I use any old regulator for my application?
A. Don't go into that drawer full of old regulators and assemble a regulator that fits. Gas cylinders fill pressures have up to significantly increased over the years. Accidentally putting an old regulator or a regulator designed for lower inlet pressure may result in a serious incident. Get the right regulator for the job or at least contact the manufacturer of the "old drawer dinosaur" and have them tell you if it will be OK for you intended application. Changing a regulator from one gas service to another without seeking advice is also risky practice.

Q. Do I need to use Teflon tape on the cylinder valve to regulator connection?
A. No, all cylinder connections are designed to connect without the use of Teflon tape. Some connections use flat washers or o-rings, but a lot of connections use metal-to-metal contact to form a leak free connection. The use of Teflon tape is not necessary.

Q. How tight should my cylinder connection be?
A. Tight enough not to leak. If the connection keeps leaking, check for damage to the face of the inlet fitting or debris in the cylinder valve connection. A sealing washer or o-ring could be missing as well. Do not use multi-grip pliers to tighten the inlet connection. It will ruin the nut and most likely leak, thus requiring the regulator to be repaired.

Q. When I turn the knob counter-clockwise (reduce pressure) on my regulator the delivery pressure does not change?
A. Most laboratory regulators are designed to be non-self relieving. The regulator will not reduce its delivery pressure unless the gas is flowing through the regulator. If the downstream segment of the system is static, the pressure will not drop unless you vent the system. However, the pressure will increase if you dial in a higher pressure when the system is static.

Q. If I have to fit a new outlet fitting to the regulator should I use some form of thread sealant?
A. Yes. The majority of regulators use ¼"NPT threaded connections which require a form of sealant. Oxygen cleaned virgin Teflon tape that has a green tint is the recommended sealant. It is not recommended to use other types of Teflon tapes (ie. white=plumbers, pink=water, yellow=natural gas), Teflon pastes, Loctites or other products without approval from the manufacturer.

Q. Does my regulator require any maintenance or servicing?
A. Yes. Like all pieces of equipment a gas regulator should be periodically inspected/tested and serviced. As a minimum, regulators should be checked for obvious damage, external leaks and pressure control performance annually. Contact the manufacturer for further information.

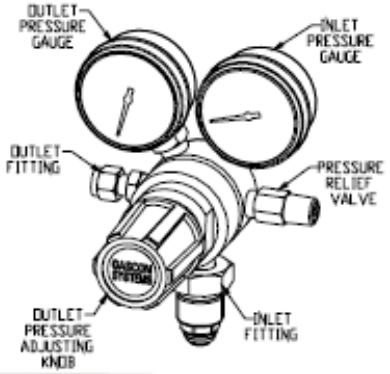
Q. Gas is flowing out of the pressure relief valve on my regulator, what should I do?
A. There is a problem with the regulator, remove it from cylinder valve and seek further advice about have it tested and/or serviced. Do not attempt to fix the problem by removing, capping the outlet or increasing the setting of the pressure relief valve.

Q. How do I connect the outlet of the regulator to my equipment?
A. There are many different ways of connecting the regulator to downstream equipment. Some of the more common methods are:

1. Compression fittings – they are usually either brass or stainless steel and are designed for connecting metal piping/tubing, (eg copper or stainless steel), to the regulator outlet. Brass compression fittings must not be used on stainless steel tubing. Some manufacturers make special plastic tubing for use with compression fitting, but these have much lower maximum working pressure than metal piping/tubing.
2. Rubber type hoses – these are very flexible but have limitations on their maximum working pressure. They usually connect using a nut and nipple connection on the hose and a matching fitting on the regulator. Because of the wide range of rubber hoses available, the material compatibility of the hose with the working gas may need to be considered.

Q. Can I accidentally connect my downstream equipment to something other than the regulator outlet connection?
A. Yes, it is possible on some regulators. Sometimes people can accidentally connect their equipment to the outlet of the pressure relief valve instead of the regulator outlet. The outlet connection should usually be stamped "LP" or "OUT". The outlet connection should normally be next to the outlet pressure gauge. If the regulator has a plastic plug screwed into the main body, then that should the outlet connection.

REGULATOR MAIN COMPONENTS



Transportation of Fresh-tec Cylinders:

Short Distances may allow for Ute Tray Back Transport

Transporting cylinders in a utility

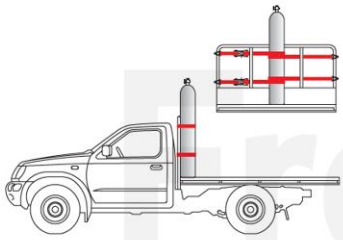
If you transport cylinders in a style-side or drop-side utility, do not place them in the cab.

Transporting cylinders upright

Restrain cylinders by lashing them to the vehicle body or containing them in a purpose-built frame.

If transporting cylinders upright against a headboard:

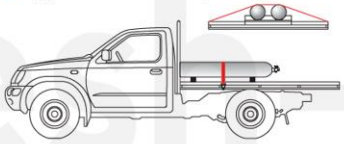
- The total weight of the cylinders should not exceed 250 kg.
- Apply at least two horizontal straps, as shown below.



Transporting cylinders lying down

If transporting cylinders lying down:

- Place the cylinders lengthwise on the deck.
- Place the cylinders on chocks to prevent them rolling sideways and to provide more grip to stop them sliding.
- Position the cylinders with the valves facing rearwards, with the base blocked against the headboard or another strong part of the load.
- Apply at least one tie-down strap, as shown below.



Transportation of Fresh-tec Cylinders:

LONG Distance Transport Requires Cylinders to be Secured within an Enclosed Cage for Safety.

Cylinders MUST be Strapped securely inside the cage And the cage door secured.

Securing Cylinders during Use.

Storage locations

- **Small** quantities of cylinders may be stored in a variety of locations, provided Dangerous Goods and local government regulations and the principles given in the following paragraphs are followed.
- **Larger** quantities of cylinders should be kept in a purpose-designed store or storage area, following the same principles.

Ideal storage

Full or empty compressed gas cylinders should be stored

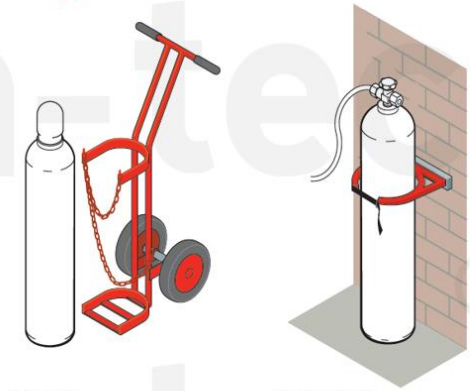
- in a well ventilated area,
- preferably in the open,
- with some weather protection.

The area on which cylinders are stored must be well-drained to prevent corrosion of cylinder bases. The location must be free from the risk of fire and well away from sources of heat or ignition.

Store cylinders standing vertically and secure them

1. It is recommended to store cylinders vertically.
2. Vertically stored cylinders must always be secured or under your direct control. When standing or rotating and 'walking' cylinders about their vertical axis, be aware of the hazards of uneven sloping, slippery and unstable surfaces as well as loose surfaces. Secure cylinders to prevent them falling as unsecured cylinders are a potential hazard to users and passers-by should they inadvertently bump them.

Securing cylinders



Cylinder trolley

Cylinder wall brackets

REFERENCES:

BOC AU : SPRM 2009 : Section 12 : Gas Cylinder Safety