Final report

ASAP IXON Technologies Platform Literature Review

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Abstract

IXON Advanced Sous Vide Aseptic Packaging (ASAP) is a novel, patent-pending thermal processing and packaging technology, which has been in development since 2017. IXON ASAP may be applied to fresh meats such as sirloin beef steak and lamb and pork chops, claiming to deliver a fresh, juicy eating experience with a long ambient shelf-life of up to 2 years. Recently IXON have secured a number of high calibre industry partnerships as well as a sizable degree of coverage in the global food industry press. The technology is now in the closing stages of a small scale pilot based in Hong Kong, with plans to move to the US for scale up and commercialisation next year.

MLA commissioned Prof. Consulting Group to investigate more about the process, its claims and offer insights and recommendations as to how ASAP could be of benefit to the Australian red meat industry. MLA have done similar reviews in technology platforms such as High Pressure Processing for example. This report presents findings resulting from a literature review and direct dealings with the IXON inventors themselves. Recommendations are suggested for partnership and further research to position MLA at the forefront of what could be a game changing technology for the Australian meat industry, potentially opening access to new markets, eliminating the need for cold chain storage and logistics and reducing food waste.

Executive summary

Background

With the strategic objective of the MLA to double the value of Australian red meat by 2030 it is critical to keep abreast of new and emerging technologies that can unlock access to new high value markets for ‘fresh’ meat. For the purpose of this report, the term ‘fresh’ is used to describe meat with the same sensory qualities of current chilled meat - as experienced by the end user.

Effective horizon technology scanning enables the MLA to capitalise and invest in high potential areas of innovation and development to deliver strong commercial outcomes with industry partners.

Recognising the significant cost of operating a chilled supply chain and reaching high potential global markets such as the Asia, Middle East and Europe, the initial claims associated with this technology offered a solution to this challenge. The MLA commissioned Prof. Consulting Group to investigate IXON Technology Advanced *Sous Vide Aseptic Packaging* (ASAP) and recommend how ASAP could be of benefit to the Australian red meat industry.

Sous vide, which means “under vacuum” in French, is a thermal process where food is vacuum-sealed in a bag and cooked in a water bath to a precise temperature and time. The process, employed by a number of processors in Australia (see: https://www.mla.com.au/research-and-development/search-rd-reports/final-report-details/Develop-New-Products/Sous-vide-technology/2781), can deliver an exact degree and consistency of cooking for restaurant-quality results. To safeguard food safety and quality sous vide products currently require storage at chilled or frozen temperatures and often have a restricted shelf life.

Aseptic packaging is a widely used manufacturing method in the pharmaceutical and food industry where various food products are sterilised separately and then combined and sealed under a sterilised environment.

This report presents key findings resulting from a literature review and direct dealings with the IXON inventors themselves.

Objectives

The project successfully fulfilled its objectives:

- Summary of the science behind the technology and guidance as to whether the technology could meet its claims.
- Details on the progress of the innovation so far and a summary of the potential benefits and applications for the red meat industry.
- Recommendations for future engagement with the IXON technology.

Methodology

Desk literature review complemented by face to face zoom calls with the inventors and IXON co-founders – key findings compiled into final report

Results/key findings

- Science based tech startup IXON, founded by Felix Cheung and Elton Ho, has progressed novel technology ASAP to the pilot plant stage.
- The theory behind the developing process looks robust, however more access to unpublished data is highly recommended to verify that the technology meets its claims.
- Big business partnerships with the likes of Cargill, Tyson and Sealed Air lend credence to the quality of the IXON project.
- The product features and benefits cited by the inventors such as improved product quality, convenience and extended shelf-life without the chill chain requirements are compelling and in line with customer product and industry trends.
- Success will be determined by customer acceptance and trust in the technology, as such, the Go to Market strategy is critical to raise awareness, educate and encourage customer trial of the product.

Benefits to industry

- The ability to compete successfully in far-reaching markets with a ‘fresh’ Australian red meat offer.
- ASAP has the potential to deliver a ‘fresh’ product without the need for a cold chain, which is a significant and wide-reaching advance for food safety and waste reduction.
- Early involvement in the development and application of this technology via an innovative processor or manufacturer, with the support of the MLA, would position the Australian red meat sector as a pioneering, progressive force in this technology.

Future research and recommendations

Prof. Consulting Group recommends further involvement with IXON’s and their technology. Recommendations are suggested for Australian partnership and further research to position MLA at the forefront of what could be a game changing technology for the meat industry. ASAP has the potential to improve access to markets such as the Middle East and Europe, as well as reducing food waste and costs of storage and distribution.

By partnering with IXON now the Australian red meat industry will be represented and actively engaged in the commercialisation of ASAP and be well positioned to unlock the future value potential that this technology represents. It is our recommendation that as the lead research organisation Prof. CG prepares a phase 2 industry development and commercialisation roadmap to support this process. It is understood MLA proposes to demonstrate the unit and compelling value proposition to key industry players in Australia to identify an early adopter to trial and develop prototype Australian red meat product range for market testing against current offering and or other processing platform interventions.

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1.0 Background

MLA commissioned Prof. Consulting Group to conduct an investigative review of a new thermal processing technology referred to as Advanced Sous Vide Aseptic Packaging (ASAP) that claims to keep cooked meat fresh and juicy for up to two years without refrigeration or the use of preservatives. ASAP was invented and is developed by Hong Kong based company IXON Food Technology.

As a new novel technology in development, little is known about ASAP outside of its own marketing press releases. The project investigated details of the process, benefits of the technology, an understanding of the project status and business model, and the degree to which its marketing claims could be substantiated. This report concludes with guidance to the question whether MLA should proceed with further investigation and engagement with IXON.

In our interviews with the IXON founders, they confirmed that MLA was the first industry body representative to show formal interest in ASAP; this report is the first to be commissioned by an Australian business entity.

Here follows a summary of findings, conclusions and recommendations meeting the requirements of the final report milestone of the ASAP research brief.

2.0 Objectives

The basis or reason for the project was knowledge, adoption and capacity building.

The original objectives of the project are shown below and success of meeting criteria or clarifying comments are added.

Objective	**Met successfully or clarifying comments**
A comprehensive scientific based literature review on the technology	*Yes - Section 4*
Benefits overview for the red meat industry	*Yes - Sections 4, 5, 6*
Supply chain applications and recommendations have been identified	*Yes - Sections 4, 6*
Will this technology work and does it support the initial shelf-life claims and is it worth the additional investigation? Can the technology satisfy domestic and international food regulations?	*Informed view provided; however, technology is still in development.*
IXON business model has been identified and suitability for further trials with Australian processors/manufacturers has been established.	*Yes - Section 6*
Interested local partners have been identified as potential candidates for the next phase of technology testing.	*Interested parties have been identified as potential candidates.*

Product and Process Validation and Testing: Assessment of product from IXON ASAP processing to determine customer acceptability and understand breadth of application.	*Informed view provided; however, technology is still in development, next available samples have been requested.*
Some initial commercial viability assessments. Develop understanding of process implementation within the local marketplace.	*Toll process insights provided.*

Supporting commentary: the original research questions were structured in the anticipation that the IXON ASAP process was up and running commercially within a limited market; however, as is detailed in the results section the technology is still operating within the pilot phase of its development. Having been in concept and development for 5 years, it is realistically at about stage 4 or 5 of a 9 stage 'Technology Readiness Level' (TRL) process. This concept is introduced and ASAP progress to market is further detailed in the results section.

This review meets the objective of reviewing the technology as it stands today from current available sources and through private direct discussions with the inventors themselves.

3.0 Methodology

This report is the findings of desk literature review, zoom face-to-face interviews with IXON ASAP co-founders themselves compiled with interpretation and insights by Prof. Consulting Group, Founder, Mark Field, and food industry associate Jane Rodway.

As a novel technology the founders have not published peer reviewed papers on the technology yet, preferring to release the scientific papers under patent protection and as they launch commercialised production in 2022.

The face-to-face interviews gave us valuable direct access and a unique opportunity to dig deeper into claims and underlying science over and above the information generally available in the public domain. This provided insights about how the process works, the business model and plans for commercialisation. A technology patent is pending until 2022. In lieu of scientific, peer reviewed published data, we have compiled an understanding of the ASAP process based on scientific desk research, published marketing releases, patent information, diagrams shared by the founders and notes from our zoom calls.

Our connection with the founders was also a good platform to introduce MLA as a thought leader and potential interested party should MLA proceed to the next stages of engagement and investigation.

4.0 Results and Findings

4.1 IXON Food Technology Company and ASAP

The company IXON invented and specialises in Advanced Sous-vide Aseptic Packaging (ASAP) that allows protein to remain stable at room temperature for up to two years. ASAP has been in development since 2017 and over the last two years or so has attracted significant interest within the Asian, European and US food industry as an exciting novel food processing technology.

The technology is currently in the closing stages of a small-scale pilot based in Hong Kong before a planned move to the US next year for scale up and commercialisation. Based on the outcomes of this report, consideration for Australian red meat uptake might now be in scope.

4.1.1 Company Background and ASAP Patented Technology

The ASAP methods were developed by co-founders Felix Cheung and Elton Ho after studying the microbial risks of sous-vide food for a university project. This inspired them to develop the ASAP technology and launch the Hong Kong based IXON Food Technology company in 2017.

The company has applied for patents and trademarks on its proprietary ASAP technology in the United States, Europe, and China. The patent was registered in 2017, published in 2019 and is scheduled for approval in 2022. It exclusively owns the patent of ASAP, as well as technologies surrounding ASAP. This includes technologies related to processing, packaging, analytical, and food hygiene. The patent is referenced below. [1]

The company plans to license and custom-make equipment for food manufacturers affording manufacturers the rights to make and distribute ASAP food products. IXON company states that '*They also assist in product development, product testing, plant design, plant construction, operation management, hygiene maintenance, corporate training, and patent enforcement, so that our partners have little to worry about and are guaranteed commercial success.*'[2]

Subject to patent protection, the founders plan to release scientific data, planning to publish a science whitepaper in Nature Asia magazine in June 2022.

4.1.2 Company Funding and Industry Interest

The co-founders have successfully raised two rounds of seed funding, with a third, series A funding round due to close in June 2021. Seed funding and crowdsourcing raised in the region of USD $35,000 and Series A funding is targeting USD $10 million. Incubator seed funding Techstars Farm to Fork[3] and

[1] https://www.freepatentsonline.com/y2019/0159486.html
[2] Company Registration Profile: https://www.crunchbase.com/organization/ixon-food-technology
[3] https://www.cbinsights.com/company/ixon-funding

crowd sourced funding rounds[4] are referenced below.

Since start up, IXON's ASAP technology has been recognised by several leading food Industry bodies as well as securing seed funding as part of the Techstars incubation programme. Recently IXON ASAP was shortlisted as a finalist for Future Food Asia, named one of the Food Tech 500 pioneers and the Thought for Food Challenge. IXON have also applied for the NASA Deep Space food challenge.

If you would like to learn more references are provided below:

- Deep space food challenge [5]
- Techstars food to fork programme[6]
- Food tech 500[7]
- Hello tomorrow [8]
- Future Food Asia [9]

4.1.3 IXON Food Technology Pilot Partnerships, Plant and Scale Up

Industry Partnerships - include Cargill, Ecolab

IXON is working with a number of well respected industry partners in meat, packaging and technology, including Cargill, Tyson, Amadori (Italy, Chicken), Thai Union (Seafood), Sealed Air, Ecolab, Mitsui Chemicals and SGS.

IXON took part in the 2020 class of Techstars Farm to Fork to speed up the adoption of their technology with large corporations such as program partners Cargill and Ecolab. "During the program, Cargill and Ecolab helped evaluate our food safety protocols, forecast the cost of plant construction, and connect us with prospective investors." cited Felix Cheung. [10]

[4] https://www.kicktraq.com/projects/ixon/ixon-preservative-free-meat-you-can-store-at-room-temp/

[5] https://www.nasa.gov/directorates/spacetech/centennial_challenges/spacefood/index.html
[6] https://www.techstars.com/accelerators/farm-to-fork
[7] https://forwardfooding.com/blog/foodtech500/foodtech-500-2020-finalists/
[8] https://hello-tomorrow.org/
[9] https://futurefoodasia.com/2021/05/ffa2021finalists/
[10] https://www.techstars.com/the-line/startup-profile/ixon-multi-year-food-storage-without-refrigeration-or-preservatives

Current Facility and Plans for Next Stage

The current 80m² pilot facility in Hong Kong is operational for two days per week producing around 50Kg per day utilising a manual process.

IXON is planning to build the next facility in Chicago following its series A round of funding due to close in June 2021. IXON pinpointed the US location as a move closer to the raw material source.

During our discussions IXON founders noted that Australia would be a similarly desirable location for a processing facility as a high quality, high volume beef exporting nation.

Processing Cost and Automation Challenges

One of the biggest hurdles to the technology going mainstream is the automation of the sterilisation/packaging process. "We are currently working with meat processors, food packaging equipment suppliers, and aseptic packaging experts toward building the world's first automated production line for making ASAP products autonomously," [11]says Cheung.

Currently the cost per Kilo out of the 80m² pilot factory is estimated at US$40 per kilo. When the technology is refined Chueng estimates that toll process costs for 1 tonne per day would be USD$2 per Kg or **4 tonnes per day manufacturing USD$1 per kilo**. The cost reduction is not pro-rata due to the variable costs involved for the surface decontamination step.

"We estimated that if the production line processes a metric ton of food per day continuously for five years, the **technology would cost less than US$2 per kilogram of food processed** irrespective of the type of food being processed."[12]

A lab style 80m² pilot facility could be replicated within Australia for around AUD$1million.

Customer Acceptance Challenges

An essential consideration for a successful launch of the ASAP technology will be the Go to Market strategy to raise awareness and educate consumers on the safety and benefits of ASAP. A focus on education and to encourage product trial so consumers can experience the product quality will help to build consumer confidence in this new way of seeing meat. This is applicable for a retail, Business to Business (B2B) or Direct to Customer (D2C) Strategy.

IXON ran some customer panels in January 2020 which included a product tasting and tested their willingness to purchase. Customers rated appearance, taste and texture. Pre-tasting and unprompted average willingness to purchase was 5 out of 10. After an explanation of the ASAP process and product 6 out of 10 customers indicated they would purchase. IXON stated that after the customers tried the product, willingness to purchase improved 3 points to 9 out of 10 customers.

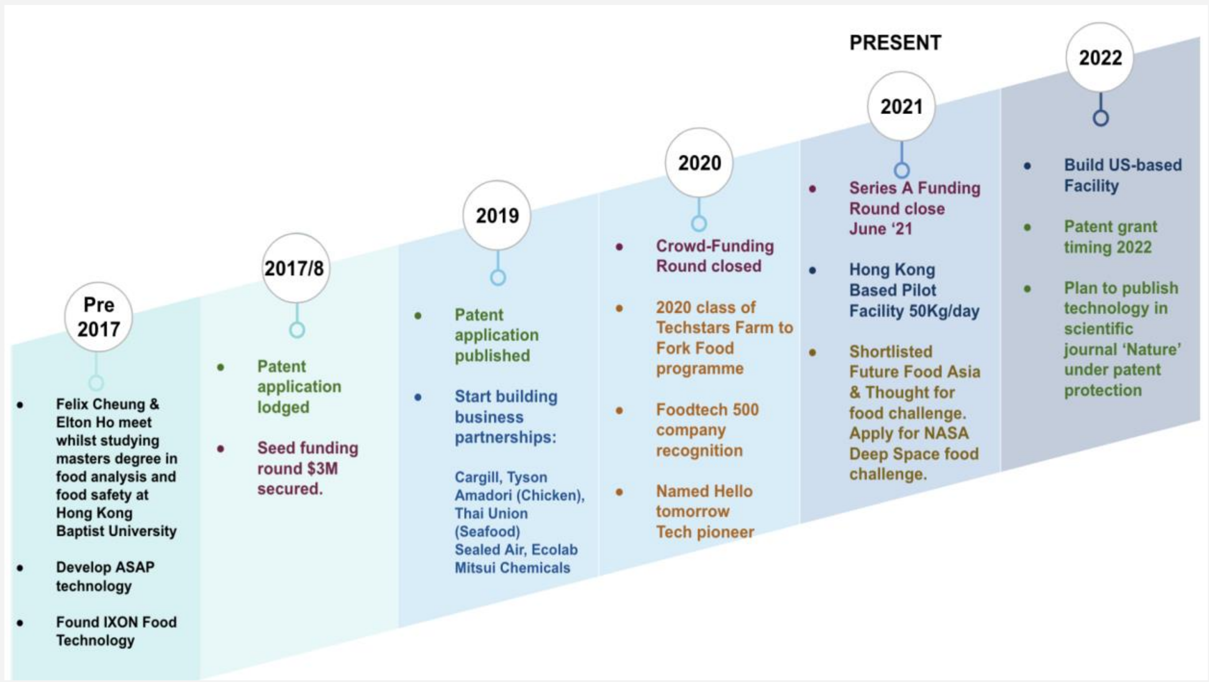
Co-founder Felix Cheung believes that, "as with any ground-breaking technology, you need to educate the public on the underlying science before you can gain consumers' trust. Once you have tried using

[11] https://www.packaginginsights.com/news/ixon-food-tech-eyes-commercialization-of-aseptic-vacuum-packaging-for-meats-seafood-eggs.html
[12] ibid

our products, there is no going back". The project has gained good support and traction through encouraging partners, investors and collaborators to directly experience samples of the product.

4.1.4 Milestones Summary

Summary of Key company and technology development milestones to date:



Source: Author created

4.2 IXON ASAP Features & Benefits Overview

4.2.1 IXON ASAP - Cited Product Features

- Shelf-stable food products that require no refrigeration during storage and transportation and will not spoil even when stored at room temperature for up to 2 years, and even longer if the sterile food package is not compromised.
- Prolong the shelf-life of foods such as meat, seafood, eggs and root vegetables.
- Improve the texture, flavour, moistness, and nutritional values of processed food.
- Ready-to-eat meals that can be eaten with or without warming/reheating.

4.2.2 IXON ASAP - Cited Product Benefits

Quality & Safety	• Better quality ambient products; redefining the quality of shelf stable products to overcome dry overcooked texture associated with canning. • Reduce food safety risk of temperature abuse. • Commercially sterile products suitable for all segments including young, elderly and immunocompromised.
Reduced Costs	• No refrigeration costs - reduced costs of storage & distribution. • Easier shipping access to markets and lower cost shipping and ability to reach more distant markets with 'fresh' products. • Energy efficient - cited as using 30% less energy than canning and 80% less energy than freezing (assuming 12 months of storage). • May allow for longer, less frequent production runs - economies of scale. • Reduce labour costs and consistency of quality for food service as it just requires heating.
Convenience	• Quick and easy to regenerate. • Quality advanced convenience e.g. better quality options for camping, rations, on the go. • Products can be sent through the post. • Convenience and accessibility of canned food but with the eating quality of fresh meat.

Supply & access	● Support access to new markets that lack infrastructure or amenity to the chill chain. ● Support growth of direct online sales. ● Mitigate against risks of disruption in the supply chain, reduce waste. ● Reduce reliance on chilled chains.
Good Food Values	● Better quality and enhanced nutrition versus canned and reported pouch proteins. ● No need for artificial preservatives. ● Product could potentially be transported ambient and retailed chilled to build consumer confidence and acceptance.
Sustainability ***many of the press releases reference sustainability benefits**	● IXON reference that ASAP targets 10 out of 17 United Nations Sustainable Development Goals (SDGs), including zero hunger (SDGs 2), responsible consumption and production (SDGs 12), and climate action (SDGs 13). ● Benefits across food security/equality (supply, access & utilisation), food safety, health and nutrition, food sustainability and energy conservation, "*this is why we built IXON*." ● By eliminating the need for cold-chain distribution, asap gives low-income countries greater access to affordable, high-quality meat products. ● Environmental benefits: uses fewer resources versus chilled. ● Reduces food waste, IXON states currently, 30% of the meat produced globally gets wasted due to expiry date, freezer burns and other storage issues.

4.3 ASAP Technology and Process Details

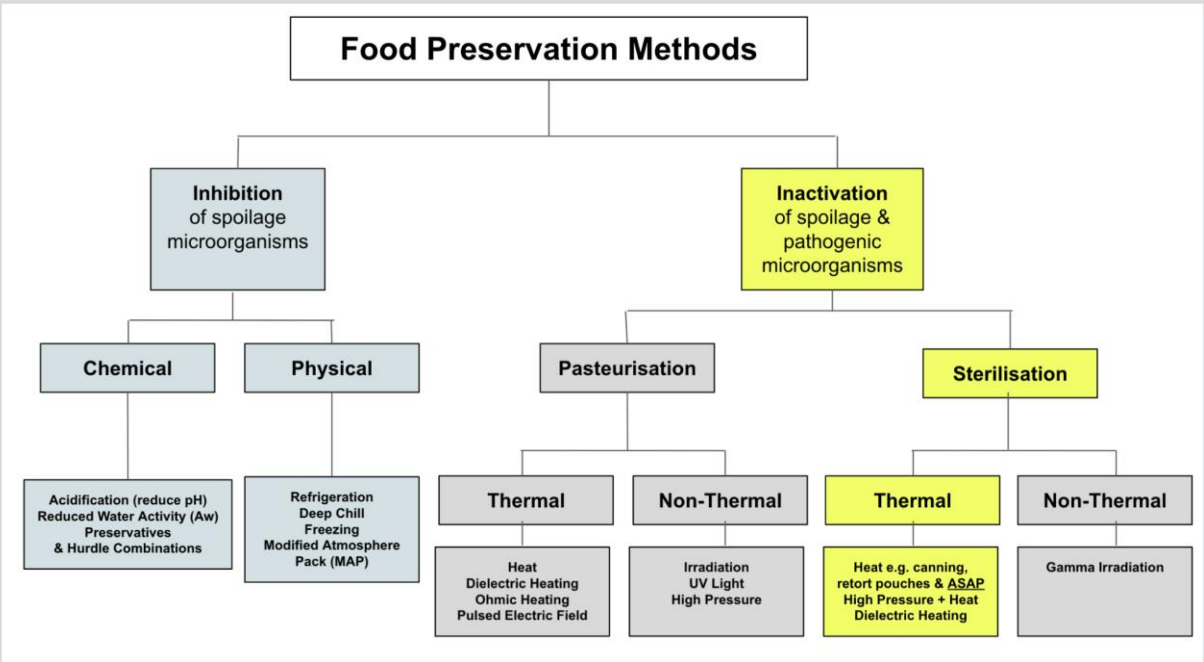
Most packaged foods on supermarkets shelves today have been preserved or modified in some way - using one or more food preservation methods developed over the last century. Canned corned beef, modified atmosphere and vacuum-packaged meats, fermented and brined smallgoods, cook-chill meals and sous vide meats are a few examples.

Food spoilage may be inhibited through chemical means by use of preservatives or drying of foods or physical methods such as temperature. Other products may receive a treatment to inactivate the present microflora such as pasteurisation of milk or cook chill methods to produce meals. A taxonomy of methods is summarised over, with ASAP and similar technologies highlighted in yellow.

ASAP technology is similar to a canning/retort process where heat is applied to inactivate spoilage and pathogenic microorganisms including spore-forming bacteria. ASAP process claims to deliver a commercially sterile product, which is safe to be stored at ambient. According to the WHO/FAO (1993)[13] commercial sterility of low-acid food is defined as:

> *"Commercial sterility means the absence of microorganisms capable of growing in the food at normal non-refrigerated conditions at which the food is likely to be held during manufacture, distribution and storage."*

Similar thermal sterilisation technologies are used widely today across the grocery aisles which including canning (pioneered by Nicholas Appert 1809), Ultra Heat Treated (UHT) Milk (commercialised by Tetra Pack in the 1960's) and retort pouches which were invented in 1978 by the US Army.



Source: Author adaptation of Koutchma (2011)[14]

4.3.1 ASAP Product Components and Thermal Processing

ASAP processed food is separated into three components, then different sterilisation methods are applied to the different components.

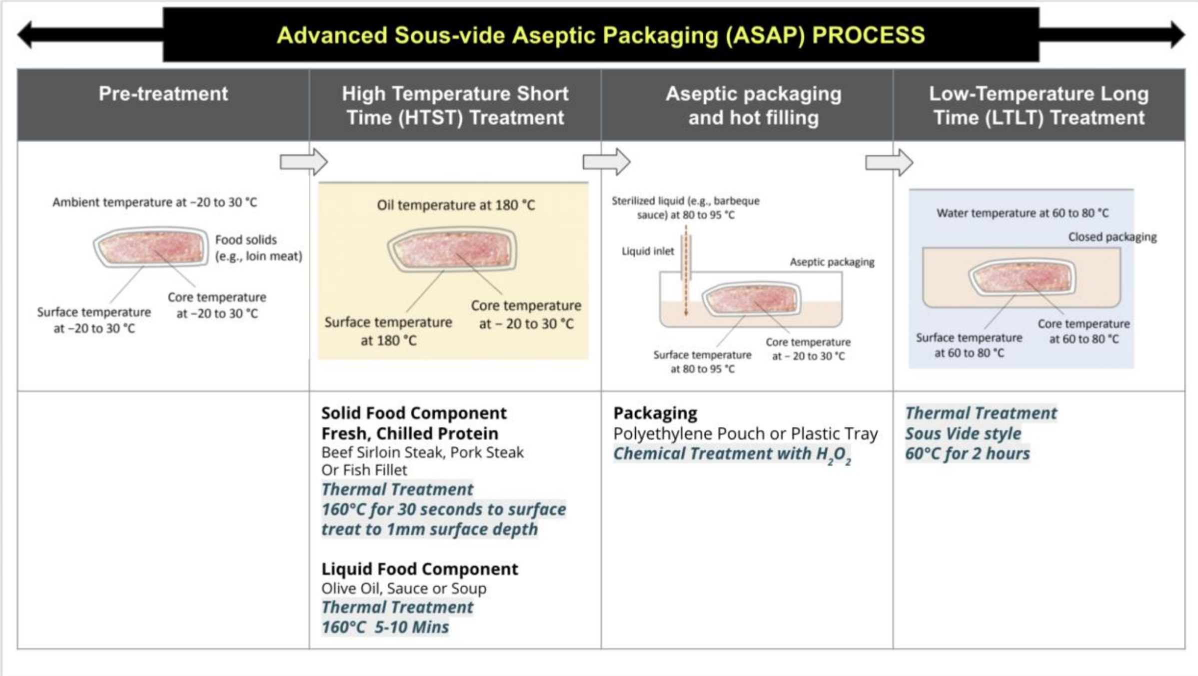
- solid food components (e.g., lamb/pork chop, beef sirloin, root vegetables),
- liquid food components (e.g., olive oil, curry sauce),
- packaging (e.g., polyethylene pouch, plastic tray, glass jar, aluminium can).

IXON confirmed the functions of the liquid component/olive oil:

[13] WHO/FAO (1993) *Codex Alimentarius Commission* CAC/RCP 40-1993

[14] Koutchma, T. (2011) *Novel Food Processing Technologies: Emerging Applications, Research and Regulation*s Guelph Food Research Center

- keeps product moist,
- improves the product visual,
- helps the vacuum process,
- an oxygen and moisture barrier.



Source: Author created from IXON (2021) information and zoom interview

More specifically, details on the different sterilisation stages are detailed within the patent are as follows. [15] *(The authors note that as the process and technology progresses through its development some of the stages and treatments reference below may have been subject to refinement.)*

Solids: *Treated high-temperature, short-time ('HTST') stage (e.g. searing at 181° C. for 10 seconds) is used to kill all bacteria, fungi, and spores on the surface of solid food components whose interior is intact and sterile; (i) Sear the surface of solid food components (i.e. raise the surface temperature) through deep-frying, frying, flaming, grilling, roasting, scorching, or superheated steam at 181° C. for 10 to 120 seconds depending on the temperature, morphology, and type of solid food components in theory, searing at 181° C. for 0.00018 seconds would achieve a 12-log reduction in C. botulinum whose D value at 121° C. is 15 seconds and Z value is 10° C., but for safety reasons, searing at 181° C. for at least 10 seconds is recommended.*

Liquids: *medium-temperature, medium-time ('MTMT') 'retort' treatment (e.g. 121° C. for 20 minutes) is used to eliminate all bacteria, fungi, and spores in liquid food components, with or without particulates.* (ii) Pasteurise (if pH<4.5) or sterilise liquid food components (if pH>4.6)

[15] IXON Patent: https://www.freepatentsonline.com/y2019/0159486.html

inside an autoclave at 121° C. for 20 to 60 minutes depending on the size, volume, and viscosity of the liquid food components.

Packaged product*: a low-temperature, long-time ("LTLT") stage, or "sous vide" treatment (e.g. 60°C. for 2 hours) is used to inactivate enzymes, viruses, and parasites that may or may not be present in solid food components .*

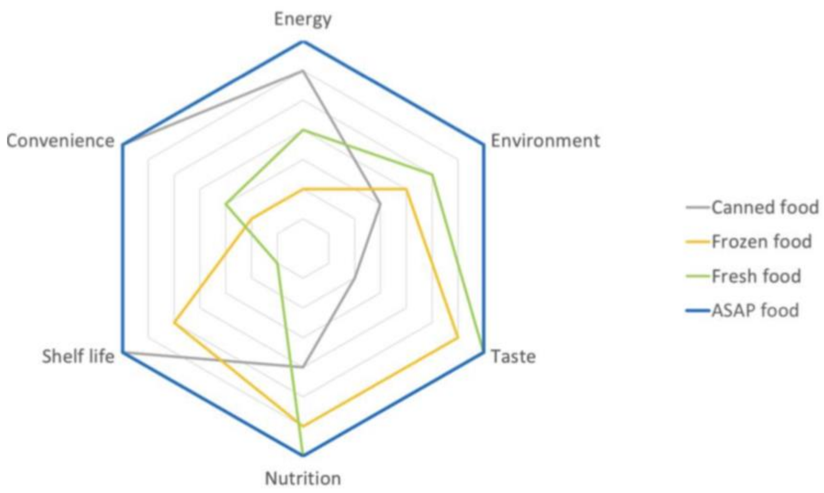
Packaging Process:
(iii) Sterilise packaging inside an autoclave at 121°C. for 15 minutes. [*Authors also referenced hydrogen peroxide decontamination during our conversations with IXON*].
(iv) Place solid food components inside sterile packaging under sterile conditions (e.g. inside a clean bench of ISO class 5 or below).
(v) Hot-fill sterile liquid food components 6 at 80 to 95°C. depending on pH of the liquid food components into the packaging containing the solid food components.
(vi) Hermetically seal the packaging containing the solid food components and the liquid food components with or without a modified atmosphere (e.g. nitrogen).

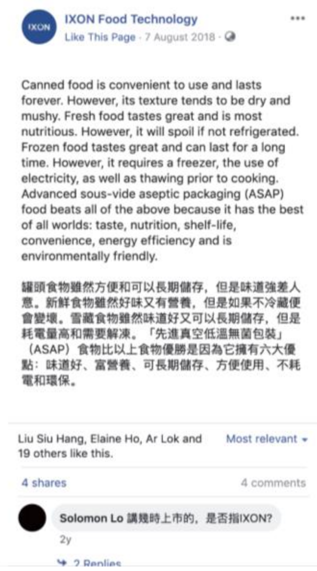
Sous Vide Cook:
(vii) Hold the temperature of packaging containing the solid food components and the liquid food components 6 at 60 to 80°C. Using a digital water bath, incubator, or sous vide oven for 1 to 24 hours depending on the size, load, and type of solid food components.

4.3.2 How IXON ASAP claims to differ from other preservation methods

The inventors claim to achieve commercial sterility by using a combination of packaging processes and gentler processing temperatures than other accepted methods to reduce impacts on quality.

Overleaf is IXON's appraisal of ASAP processes versus canned, frozen and fresh products. Notably large benefits are flagged for Environment, Convenience and Energy input versus conventional preservation methods.





IXON Food Technology
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Canned food is convenient to use and lasts forever. However, its texture tends to be dry and mushy. Fresh food tastes great and is most nutritious. However, it will spoil if not refrigerated. Frozen food tastes great and can last for a long time. However, it requires a freezer, the use of electricity, as well as thawing prior to cooking. Advanced sous-vide aseptic packaging (ASAP) food beats all of the above because it has the best of all worlds: taste, nutrition, shelf-life, convenience, energy efficiency and is environmentally friendly.

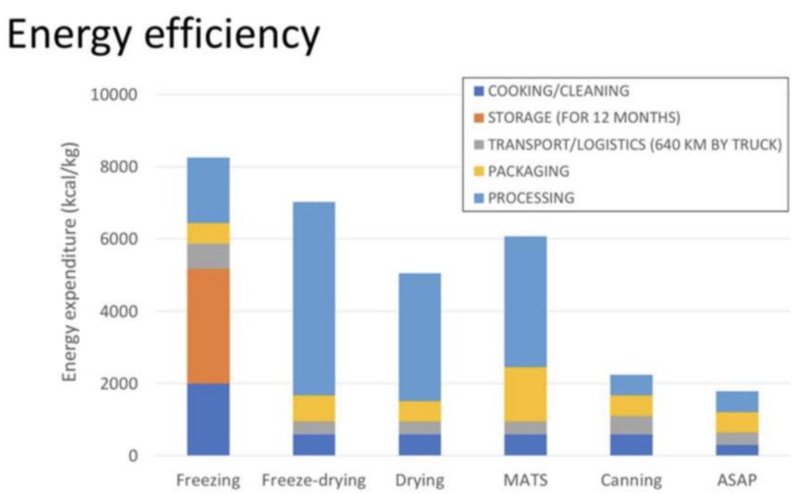
罐頭食物雖然方便和可以長期儲存，但是味道強差人意。新鮮食物雖然好味又有營養，但是如果不冷藏便會變壞。雪藏食物雖然味道好又可以長期儲存，但是耗電量高和需要解凍。「先進真空低溫無菌包裝」（ASAP）食物比以上食物優勝是因為它擁有六大優點：味道好、富營養、可長期儲存、方便使用、不耗電和環保。

Liu Siu Hang, Elaine Ho, Ar Lok and 19 others like this. Most relevant

4 shares 4 comments

Solomon Lo 講幾時上市的，是否指IXON?
2y

And statement as to energy usage between methods:



IXON Food Technology
Like This Page · 18 August 2018

Food is a perishable commodity. Without preservation technologies, food will spoil and become inedible very quickly. Freezing can help prolong the shelf life of food, but the technique consumes a lot of energy. This is true especially in processing (i.e. cooling the food from room temperature to subzero temperatures), storage (i.e. keeping the food at subzero temperatures) and cooking (i.e. defrosting and subjecting the food to high temperatures).

In contrast, advanced sous-vide aseptic packaging (ASAP) only uses a quarter of the energy typically required in freezing. It is by far the most energy-efficient method even when compared to drying and canning. Therefore, the technique is more environmentally friendly and may help mitigate climate change.

食物若沒有適當保存便很容易變壞。冷藏技術雖然能夠延長食物的壽命，但缺點是很費電，尤其是在處理（將食物由室溫降至零下溫度）、儲存（保持食物在零下溫度）和烹調等階段（解凍食物和透過高溫處理食物）。相反地，「先進真空低溫無菌包裝」（ASAP）技術的耗電量只有冷藏技術的四分之一，就算和烘乾或罐頭技術比較，耗電量還是最低。所以ASAP技術不但更加環保，還有可能幫助解決氣候變

(MATS is an abbreviation for Microwave Assisted Thermal Sterilisation.)

Summary comparison of claimed advantages between ASAP and a number of conventional food preservation methods:

Canned or retort food products	● The interior of food solids in ASAP food products is not subjected to high temperatures. Only the surface of solid food components, liquid food components, and packaging are subjected to high temperatures. ● As a result, ASAP food products have texture, flavour, moistness, and nutritional values that are superior to canned and retort food products. ● ASAP products claim to have texture, flavour, moistness, and nutritional values that rival freshly made products.
Frozen or Chilled food products	● ASAP does not require low-temperature cold chain management and in-home/in business equipment for storage.
Sous vide food products	● Sous vide requires refrigeration and shelf-life generally <30 days or can be frozen. ● ASAP food products are sterile and shelf-stable for up to 2 years, and even longer if the sterile food package is not compromised.
UHT aseptic processing	● UHT is designed for use on liquid food products (e.g. milk, juice) or liquids with small particulates (e.g. creamed corn). ● ASAP is designed for use on solids (e.g., pork chops, roast beef) and solid-in-liquid food products (e.g. curry chicken, beef stew). Only the liquid component of food products need to be free-flowing.
Ambient hot filled products e.g. pasta sauces	● In hot-filling, liquid food products are pasteurised and then hermetically sealed in sterile packaging under sterile conditions. The technology only works on acidic liquid food products whose pH<4.5. ● ASAP can be applied on solids and solid-in-liquid products, and the liquid component need not be acidic. ● Good quality MSA meat has a pH 5.3 - 5.7[16]. pH averages of proteins are beef pH 5.5, pork pH 5.9 and Salmon pH 6.29.

[16] https://www.mla.com.au/globalassets/mla-corporate/effect-of-ph-on-beef-eating-quality_sep11.pdf

4.3.3 Shelf Life Microbiological and Organoleptic testing

Organoleptic quality assessments

At the time of the investigation IXON confirmed that they have conducted several customer panels on fresh products as well as sharing samples for industry partner review which have sufficiently impressed to deliver sufficient excitement and investment in ongoing partnerships.

Product and technology validation is recommended including robust product sensory assessment schedules throughout shelf life, for all material ingredient, process and packaging variables and product quality attributes to validate organoleptic quality over life, at a range of temperatures.

For example, oxidative rancidity can be an unacceptable quality issue for fat in meat products.

IXON indicated that the oil in the pack has a function to safeguard products against rancidity and enhance product succulence; and that they have conducted internal product testing to end of life.

Microbiological & Chemical assessments

IXON confirmed they are working with SGS for microbiological test validations; test reports were not available at this stage but would be critical for verifying the process.

4.3.4 Will the technology work from a Microbiological Perspective?

Yes, on the face of it - but peer review of the Scientific literature and process evidence is required.

From a microbiological risk assessment perspective, the process temperature and times would theoretically be sufficient to sterilise the areas of the product exposed to this process assuming moist heating (not dry heat) is applied.

The target pathogenic microorganism of most concern for the process is *Clostridium botulinum* due to its resistance to heat, as well as ability to form spores and release deadly neurotoxins. It gives us some reassurance that this microorganism is referenced in the patent as the target microorganism for the design of the technology.

Skinner et al (2006)[17] reference that commercial sterility is generally expressed as minutes at 121°C in order to destroy heat resistant spores of *C. botulinum*. Commercial sterility is usually expressed in minutes at 121°C, the sterilisation process equivalent time (F_0) given to a particular type of product and food processors employ a critical F_0 value (3.0 minutes) necessary for a 12-log reduction of heat resistant spores of *C. botulinum*.

[17] Reddy, N., Skinner, G., Oh, S. (2006) *Clostridium botulinum* and its control in low acid canned foods, Food Sci. Biotechnol Vol 15, No 4. pp 499-505

Additional sterilisation time may be given to some products for the complete destruction of various bacteria that may have higher heat resistance e.g., marine products.
Greater visibility of the Process and key controls are needed to independently underwrite the validity of the technology to meet its claims:

- The product temperature achieved would be critical.
- Validation and verification of the surface decontamination temperatures and depth.
- Validation for fissures or nicks in the product from butchery.
- Spores of *C. botulinum*, *Bacillu*s spp and thermophiles would need to be proven to be fully inactivated if this product was to be stored at ambient temperature.
- This would require validation of the flash process, the oil sterilisation, the packaging sterilisation and the aseptic sterilisation in place (SIP) processes.

4.3.5 ASAP Technology Readiness Level - still a way away from market

Technology readiness level 4 of 9 (TRLS)

A TRL scale is helpful when considering whether ASAP meets its claims. Technology readiness levels, developed by NASA, is a scale that can be used for estimating the maturity of a given technology for market.[18] TRL 1 is the lowest, indicating the earliest stage of development for a new technology, and TRL 9 is the highest, indicating the technology is fully implemented commercially. The scale is used across industries such as auto, biotechnology and food. There are nine levels, which each represent a stage in the development of technology, from the first thoughts to the final technology.

ASAP is still in development and we rate its progress as TRL stage 4, with stage 5 planned as part of commercial scale up, which is planned from June 2021 and expected to go live in June 2022.

	TRL 1 Basic principles observed	• Identification of new concepts and its integration, expected barriers, and applications. • Identification of materials and technologies based on theory. • Evaluation of potential benefits of the new concept over existing ones.
	TRL 2 Technology concept formulated	• Enhanced knowledge on technologies, materials, and interfaces. • New concept is investigated and refined. First evaluation about the feasibility. • Initial numerical knowledge. Qualitative description of interactions between technologies. • Prototyping approach and preliminary technical specifications for laboratory test are defined.
	TRL 3 Experimental proof of concept	• First laboratory scale prototype or numerical model. • Laboratory tests of the technological element, but not the whole integrated system. • Identification of key parameters characterising the technology. • Verification of the proof of concept through simulation tools and cross-validation with literature data

[18] NASA (2010). Technology Readiness Levels Demystified. https://www.nasa.gov/topics/aeronautics/features/trl_demystified.html

▼	**CURRENT STAGE** TRL 4 Technology validated in lab	• Small-scale prototype integrated with complementing subsystems at laboratory level. • Validation of the new technology through enhanced numerical analysis (if applicable). • Measurable Key Performance Indicators. • Prototype shows stable performance (either TRL4 or TRL5, depending on the technology)
	TRL 5: Technology validated in relevant environment	• Large scale prototype integrated with components of supporting elements and auxiliaries. • Robustness is proven in relevant working environments. Prototype shows stable performance • The process is reliable, and performances live up to expectations • Other parameters concerning scale-up, environmental, regulatory, and socio-economic issues are defined and qualitatively assessed.
	TRL 6: Technology pilot demonstrated in relevant environment	• Demonstration of the technology is fine-tuned to a variety of operating conditions in relevant environment. • The process is reliable, and the performances live up to the expectations • Demonstration of interoperability with other connected technologies. • Manufacturing approach is defined (either TRL6 or TRL7, depending on the technology). • Environmental, regulatory, and socio-economic issues are addressed.
	TRL 7: System prototype demonstration in operational environment	• Full scale pre-commercial system is demonstrated in an operational environment. • Compliance with relevant environment conditions, authorisation issues, local/national standards is guaranteed. • Integration of upstream and downstream technologies are verified and validated. • Manufacturing approach is defined (either TRL6 or TRL7, depending on the technology).
	TRL 8: System complete and qualified	• Technology has been experimented in deployment conditions and proven its functioning in its final form. • Manufacturing process is stable enough for a low-rate production. • Training and maintenance documentation are completed. • Integration at system level is completed. Full compliance with obligations, certifications, and standards of the addressed markets.
	TRL 9: System proven in operational environment	• Technology proven fully operational and ready to be commercialised. • Full production chain is in place and all materials are available. • System optimised for full rate production.

Adapted from TRL scale: s3Food[19]

Despite IXON having a number of technology development stages still to complete, the quality of industry partners combined with the founders' scientific backgrounds reflects well on the approach being taken to design and develop the technology, which is a complex process requiring deep expertise at each stage.

Robust process design verification and management is critical to safeguard the process and its delivery. Partnership support from global leaders in the areas of red meat, packaging and food hygiene will increase the likelihood of success.

[19] https://s3food.eu/technology-readiness-levels/

4.3.6 Does the technology meet regulatory requirements?

Assessed as being at TRL 4, the technology has not progressed far enough to meet regulatory requirements such as FDA (US) approval or Australian New Zealand Food Standard Code requirements.

4.4 Market opportunities for producing ASAP meat in Australia

4.4.1 Target Markets

IXON's market for the technology are red meat processors, fish processors and food manufacturing companies. They cite target end users as "*just about anyone, from foodservice, military, supermarket, outdoor camping companies to everyday consumers*," Cheung says.

They are marketing the product solutions for intermediate goods or semi-finished food products for use in hotels, restaurants, eateries, and food factories. Commercially sterile food products could be supplied to aviation, aerospace, disaster relief, hospital, and military applications as well as supermarket and online retailing.

There is an opportunity to access new markets with ambient products due to lack of cold chain infrastructure and reduced distribution costs. Accessing out of home eating occasions is another opportunity.

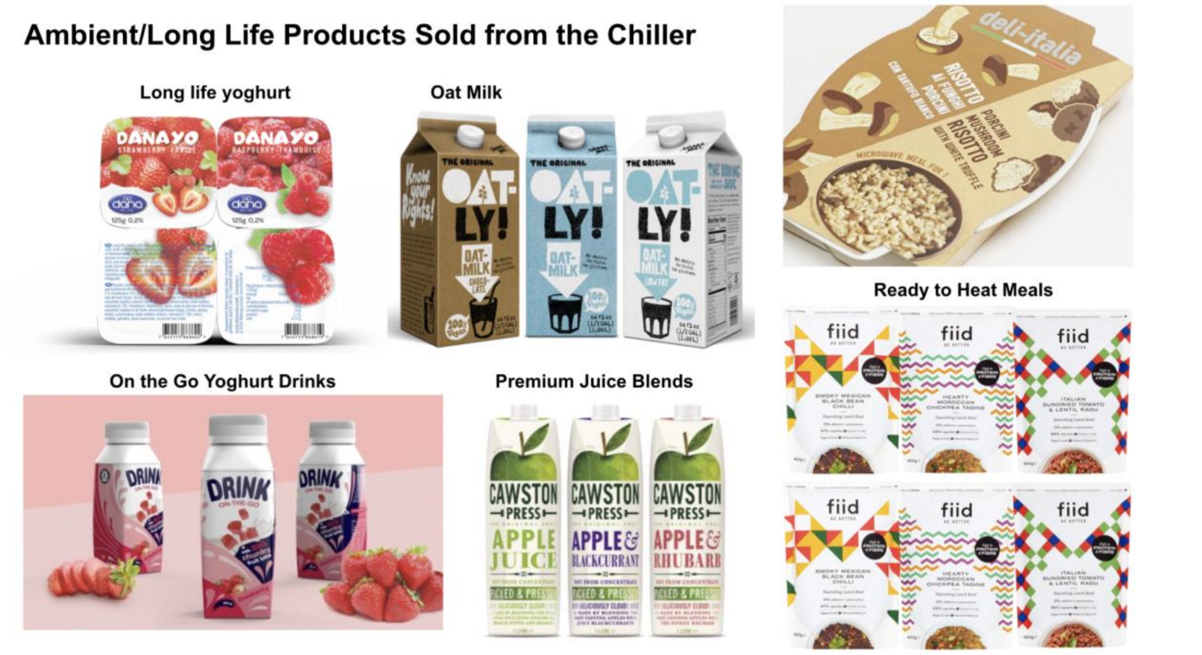
4.4.2 What will customers think? Thoughts on mainstream retail acceptance

More research into target market retail acceptance is recommended to understand customer thoughts and willingness to accept ASAP as an alternative to fresh or ambient protein products. Some challenges may be overcome through product positioning, design, recipe and packaging. Similar challenges were certainly faced by UHT milk and ambient meals at a point in their evolution. Examples are shown below:

Ambient products in market place

There is heightened consumer demand for healthy, clean label ingredients and convenience products. However fresh-looking meat sold on a grocery shelf with 2-year shelf life is such a novel concept that it may present a psychological bridge too far for the current retail customer to accept. Food that spoils may generally be associated with being fresher and more natural than ambient food which is perceived to be more processed.

Ambient food often suffers a poor quality perception versus fresh despite sometimes possessing similar organoleptic qualities to their more perishable counterparts. To overcome this challenge some products are retailed from the fridge for enhanced freshness perception. To encourage initial trial, this may be a retail route consideration for ASAP. Some examples are shown below:



4.5 The Commercial model for ASAP partnerships

Potential benefits to meat processors include opportunities for shipping ASAP-processed meat to international markets ready for further value-adding. During the course of our research the largest primals processed to date were in the region of 5Kg. In addition, the technology would give the retail sector the option to sell red meat portions from either ambient grocery shelves or traditional chilled cabinets.

IXON is planning to partner via a Business to Business toll processing model. They are looking at progressing, building and licensing the ASAP technology and are seeking opportunities to partner with meat processors to build a site with a production line. The patent-pending technology can be licensed, the IXON team plans to deliver a specialist function to complete R&D installation utilising the proprietary technology. The company will help customers develop new products and construct the production line, which includes clean rooms, aseptic packaging equipment, isolators, and decontamination chambers. From a factory build perspective the process specifies an ultra-clean class 1000 clean room, with the packaging process managed within a class 10 aseptic space.

4.6 Photo Gallery

Finished Product - as sold to end consumer

Beef and Pork Steaks - Shelf Stable.

Source: [20]

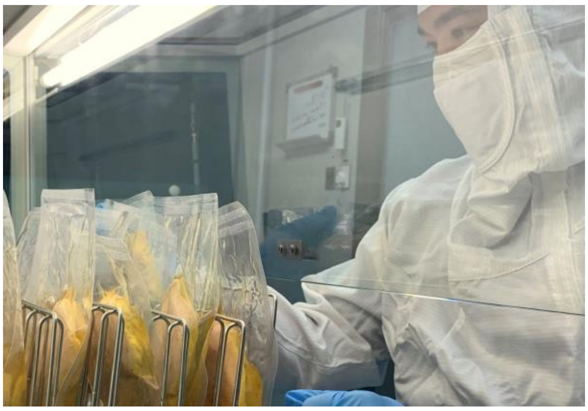
Finished Product- regenerated & plated

Pork Steaks - Shelf Stable.

Finished Product viewed on Zoom call with Co-founders Felix Cheung and Elton Ho

Source: [21]

Product assembly in pilot plant



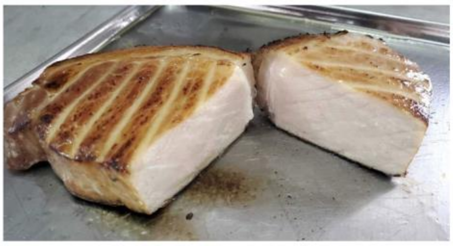
ASAP Pork Chops ASAP Product

Product Sous-Vide Mock Up at Conference

ASAP Salmon Fillet:

[20] https://www.packagingdigest.com/food-packaging/hybrid-packaging-technology-reinvents-sous-vide
[21] Prof zoom call with Co-founders Felix Cheung & Elton Ho - shared with permission

and Flame-seared Reheated End Product



Source: [22]

ASAP Chicken Fillet:

Co-Founder Elton Ho Showcasing Product

5. Conclusion

[22] https://www.kickstarter.com/projects/ixon/ixon-preservative-free-meat-you-can-store-at-room-temp/posts/3020446

IXON's patent-pending ASAP technology (packaging and process) that sterilises fresh meat for long-term, shelf-stable storage is an exciting novel thermal processing technology. IXON Hong Kong is supported by project partnerships with a number of businesses including Cargill, Tyson, Ecolab and Sealed Air lends added legitimacy to the project, which is generating industry attention.

If successfully commercialised, ASAP is an exciting technological advance for food preservation - presenting significant cost, quality and sustainability advantages over traditional food processing methods including canning, retorting, chilled and frozen foods.

Although products have been shipped globally to investors to try, planned commercialisation is around 12 months away. The Go to Market strategy will be critical in educating consumers and end-users of the product's safety and its benefits. ASAP is an exciting and leading-edge technology with real commercial benefit to the primary red meat sector and could benefit other protein sectors once commercially available.

5.1 Key findings

- The technology is available to see and feel, more advanced in its evolution than conceptual or bench top theory, it gives confidence in the evolution of development to see that samples have been produced and shipped internationally.
- Whilst, the scientific articles are not publicly available, the level of funding to date and quality of industry partnerships infer credibility of the claims.
- The level of recognition and awards for the technology is positive.
- Regardless of targeting the food service market or retail - the value opportunities by reducing the need for a fully chilled supply chain are significant.
- The data available whilst conducting the review suggests that the shelf-life claims are theoretically achievable although would certainly warrant further examination as more data becomes available.
- The transition from pilot scale to commercialisation is planned and targeting significant cost of processing reductions to deliver a cost-effective solution for the red meat industry.
- Regulatory acceptance and definitions will be key to support access into some export markets delivering outside the chilled chain.

5.2 Benefits to industry

- The ability to access an in-line processing solution that compliments traditional meat packing technology provides access to new markets with 'fresh or chilled' products.
- Removing the high cost of refrigerated supply chains and enhanced food safety controls should improve profitability of the red meat industry and deliver the additional benefits of an important sustainability message.
- Adoption of the technology could, subject to regulatory alignment, provide access to a global market for the Australian red meat sector.
- Other market opportunities include a D2C model, where as an example international consumers could subscribe to a regular butchers box program of Australian steak.

6. Future research and recommendations

ASAP is gathering momentum and interest globally. We recommend some level of IXON partnership and strategic co-funding investment with a meat processor. By gaining a seat at the table the Australian red meat industry will be represented and engaged in the commercialisation of the technology, securing an advantaged position to unlock the future value potential of ASAP. This action is in-line with the MLA growth and sustainability strategy, the best interests of the red meat sector and meets the evolving needs of our industry and target consumers.

It is our recommendation as the lead research organisation that Prof. CG prepares a phase 2 industry development and commercialisation roadmap. As ASAP progresses through its development and commercialisation programme we recommend the following further avenues of research and involvement:

Future R&D Applications	● When the scientific data is available, recommend third-party review and verification by expert agencies such as CSIRO or Campden (UK). Both Internationally respected in the area of thermal process define, verification and third party certification;
Practical Application	● Further engagement with IXON to make the technology available to the MLA and the red meat industry. ● Assess Product here in Australia (we have requested samples). ● Highly recommend a trip(s) of interested parties to view the Hong Kong process, extend engagement with founders, view the process and further try products. ● Scoping proposal for Australian based pilot facility and industry partners. ● Commence regulatory discussions around technology, its acceptance and timelines for process.
Customer insights	● Direct experience of consumer acceptance of products is essential, research is recommended to understand customer acceptability (both as shoppers and as Food Service end users) and obstacles to acceptance for each target customer segment.
Business case modelling	● More information needed to understand commercial viability of processes when tech development nears market completion. ● NDA disclosure of commercial modelling to date recommended.
Product development	● Pending research findings above - opportunity to work alongside IXON on breadth of technology applications and optimised product formats including positioning, packaging and branding for customer-targeted new line concepts.

Suitability for Further Trials with Australian processors and manufacturers

MLA/Industry involvement is recommended now due to the perceived potential of ASAP to capitalise on being an early adopter and promoter with influence on its application and commercialisation. The benefits of accessing new export markets, reducing food waste and improving the cost and quality of existing product chains are potentially significant.

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