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ASEAN High Value Add Red Meat Opportunities- ASEAN Food Products and Processing

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Disclaimer

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Shortened Forms

ASEAN	Association of Southeast Asian Nations
ASW	ASEAN Single Window
ATIGA	ASEAN Trade in Goods Agreement
B2B	Business to business
B2C	Business to consumer
CP	Cold Plasma Processing
ET	Enzyme Treatment
FD	Freeze Drying
FE	Fermentation Processing
FO	Formulation Processing
GIS	Geographic Information System
GPS	Global Positioning System
HDC	Halal Industry Development Cooperation
HPP	High Pressure Processing
HST	Hydrodynamic Shockwave Treatment
HSR	High speed rail
II	Ionising Irradiation
ISO	International Standards Organisation
JAKIM	Islamic Development Department Malaysia JAKIM
LPI	Logistics Performance Index
Micvac®	Food packaging company
NTP	Non-Thermal Plasma Processing
NTT	Non-Thermal Technologies
OC	Oven Cooking
RFID	Radio frequency identification
SC	Steam Oven Cooking
SV	Sous Vide Processing
UNCTAD	The United Nations Conference on Trade and Development
UPU	Universal Postal Union
WSN	Wireless Sensor Network

Glossary

Amino acids	The building block molecules that make up proteins
Antioxidants	An antioxidant is a substance that inhibits oxidation. Oxidation is a chemical reaction that can produce free radicals, leading to reactions that may damage cells or food. Antioxidants are found naturally in many foods, and may also be added to processed foods to improve shelf life.
ASEAN member countries	ASEAN is a regional grouping that promotes economic, political and security co-operation with ten member countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. 
Bioactive Peptides	Specific protein fragments, or portions of protein chains, that have a positive impact on body function or condition, and may influence health
Clean Label Food	Clean label food is food products that contain simple, easily recognisable ingredients. Typically foods like this are free from ingredients that may have negative consumer perceptions, e.g. anything with an E- number.
Co-products	Byproducts that are formed during production of food products. Typically these items may be discarded, but have inherent value useful for other applications
Dysphagia	Swallowing difficulty due to injury, disease, or loss of muscle tone. This affects the types of foods that can be consumed and is mostly present among the elderly.
Enzymes	Enzymes are biological substances that aid chemical reactions as a catalyst. In the context of food consumption they are substances that can aid digestion, by breaking down food molecules, readying them for transport around the body.
Jerky	Food product consisting of lean meat that has been cut into strips, and then dried to prevent spoilage.
Meat Floss	Food product consisting of shredded, dried meat that has a light fluffy texture, like cotton.

Nem Chua* and *Naem	Fermented meat products, usually presented as sausages
Non-thermal Process	Food processing that does not use heat to produce the product, and includes processes such as fermentation and high pressure processing
Probiotic	Live microorganisms, such as bacteria and yeasts that are associated with health benefits when consumed.
Ready Meals	Pre-packaged complete meals, which only require reheating before being served. The more modern definition can apply to meals that are chilled only, as opposed to frozen meals
Sous Vide	Sous vide (pronounced soo–veed), means under vacuum. It is a cooking technique where vacuum-sealed food is immersed in a water bath and cooked at a very precisely controlled temperature (~45-85°C)
Halal logistics	Halal standards apply to all activities along the supply chain.
Value Add	Value-add is the process of taking a raw food material and changing its form to a higher-value (or premium) product. The value attributed to the product by consumers can come from a range of factors such as convenience, brand, origin, or after sale services etc. Conversely, value maybe reduced due to supply chain disruptions, business to business (B2B) conflict, or government blockages. Value-add processes comprise a broad range of factors, including governance, labour, quality control, logistics and storage. When these factors are managed strategically and efficiently, risk is reduced and the product is more likely to meet consumer expectations and increase or improve trade. Customers (value-chain business partners or collaborators) and consumers are more likely to pay premium prices such as multiples of 3 – 5 times the input commodity price.
E-commerce	E-commerce is the electronic process through which consumers and suppliers engage in transaction activities such as buying, selling, transmitting funds and data over the Internet.
Blockchain	Blockchain is a digital platform that records and verifies transaction across different industries and countries in a transparent and secure manner.

Executive summary

MLA contracted the University of Southern Queensland to undertake foundation insights research relevant to the ASEAN markets to identify high-value growth opportunities that provide competitive advantage for Australian red meat value chains beyond the next 3-5 years. This research is part of the Round 1 Rural R&D for Profit (V.RDP.1000) suite of work.

The analysis of ASEAN high value add red meat products has been divided into four reports and this overarching synthesis. Each report focuses on important economic, social and trade issues in the red meat value chain. **Error! Reference source not found.** lists the reports, with each report hyperlinked through its title.

Themes and trends that influence consumer perceptions of red meat products are covered in the Consumers' health and wellbeing report (2018). Relevant findings from the consumer and wellbeing study are used here to inform product and processing options for ASEAN consumers.

Fresh red meat is not traditionally consumed in most ASEAN countries. Fish and chicken are the most prevalent proteins and are cooked and sold in a wide range of formats; however, this is not the case for red meat within the region. To grow the red meat market in the ASEAN region, a carefully considered strategy for Australian producers and processors of red meat is required to deploy products into ASEAN countries.

Alternative new and improved red meat formats therefore present a unique opportunity, for Australian industry. They could capture a significant segment of the ASEAN market, if they can align

red meat with ASEAN preferences. The strategic value add proposition for the Australian red meat industry is to develop red meat products that are:

1. Meal products that are rapidly processed at lower cost
2. Snack products that use the highly nutritious components of red meat
3. In formats with extended shelf life
4. Wellness-enhancing
5. Convenient to purchase and consume
6. Attractive to ASEAN consumers' tastes.

Products may also include supporting products and servies, such as online purchasing, social media apps that provide cooking and nutritional and advice and packaging and processing that extend shelf life. Deploying red meat products with these characteristics can reach beyond Tier 1 cities in the region, due to the removed need for cold chain logistics, thereby increasing market size.

This report is not a detailed analysis of the economic value add for each product, rather we have identified the products that present the best opportunity to deliver higher value in ASEAN. This report does covers a review of food products that may align with key food and drink trends in ASEAN, which include propositions for lifestyle and functional foods, as well as lifestyle services. A review of contemporary and emerging processing technologies that would enable manufacture of these products is also included. Issues of significance are detailed below.

1.2 Product and processing value propositions

Busy ASEAN consumers need quick, easy to eat snacks and meals to fit within their lifestyle and enhance their health.	There is an increased proportion of the ASEAN region leading busy working lives, where they are constantly eating away from home. The rise of heart disease and diabetes prevalence in ASEAN means healthier foods are needed. Portable, convenient, highly nutritious snacks would be well received by this demographic. Red meat in formats other than 'steak' better suit ASEAN food preferences, and suitable formats include snack bars, broth concentrates and single-serve protein drinks, which are easy to consume while on the move.
Young health conscious consumers demand information about nutrition in their food, and greater connectivity with their food.	Labelling products with 'high in [desired nutrient]' is better received than labelling as 'low in [undesired nutrient]'. Lifestyle apps where they can look up information about their food easily by scanning a code on the product packaging will also support these consumers.
Older consumers prefer traditional foods but require more nutritious versions of these products.	Traditional fermented meats can be produced with modern biotechnology to have desirable flavours, but with better nutritional value. Fermenting to encourage development of bioactive compounds produces products that enhance health.

In-home cooking + app support, for failsafe red meat preparation is great for inexperienced ASEAN cooks	ASEAN consumers mentioned that they are not confident preparing red meat meals and therefore need confidence-boosting support to prepare and consume red meat. They would benefit from having apps that can provide training and cooking lessons along with pre-prepped red meat ready for sous vide cooking. This would encourage them to eat red meat products.
Packaging is the flexible component for red meat meals for ASEAN to allow choice in processing method. It makes red meat more appealing in the region due to appearance and reduced odour	Packaged products can undergo processing via the following modes with a finished ready-to-eat product at the end of the process. • High Pressure Processing [HPP] • Hydrodynamic Shockwave Treatment [HST], • Sous Vide processing [SV] Another advantage is that odour can be reduced, and tenderness increased which better suits the ASEAN palate. The convenience of these products makes them attractive for busy ASEAN consumers.
Contemporary technologies MATS/MAPS and HPP can rapidly produce ready meals for <$1/kg cost	Current and emerging processing technologies can significantly speed up production of red meat meal products with low processing costs, <$1/kg. Such low cost processes include: • High Pressure Processing [HPP] • Microwave Assisted Thermal Sterilisation [MATS] and Microwave Assisted Pasteurisation Systems [MAPS]. MATS/MAPS have only become commercially available in the last 5 years, but can produce ready meals, which are shelf stable for up to 1 year at ambient conditions. This allows further market reach as there is no need for chilled transport.
Non-thermal processes can produce functional snack products worth up to $700/kg of solids	Current and emerging processing technologies can create red meat snack products in alternative formats, such as functional foods and nutraceuticals, with potentially very high value (up to $700/kg of solids). Useful processing technologies for these products include: • Freeze Drying [FD] • Formulation of red meat with nutraceutical type ingredients or functional foods [FO], • Fermentation of meat and meat co-products [FE] • Enzyme treatment to produce bioactive peptides [ET] Some of these processes may be more costly and time consuming but the value return is very high.
Packaging is the flexible component for red meat meals for ASEAN to allow choice in processing method. It makes red	Packaged products can undergo processing via the following modes with a finished ready-to-eat product at the end of the process. The convenience of these products makes them attractive for busy ASEAN consumers.

meat more appealing in the region due to appearance and reduced odour	o High pressure processing. o Hydrodynamic shockwave processing. o Sous vide processing. o Microwave assisted processing.

1. Introduction

This report outlines high value add red meat opportunities deemed suitable for the ASEAN region. These opportunities are the results of investigating the ASEAN region, and include red meat product types along with the processing technologies to produce them. High value add propositions for the ASEAN region address the ASEAN lifestyle, including health and wellbeing of its consumers, which are discussed in detail in the Consumers' health and wellbeing report (2018) and underpin the findings of this report.

The ASEAN region is a young and emergent market and this report focuses on meeting the future needs of the growing ASEAN ten-country market. To address ASEAN growth with red meat opportunities, this report on high value adds red meat opportunities is divided into five key sections. This, the first section introduces the reader to food products and processing for the ASEAN consumer. The second section of this report focuses on red meat opportunities in functional snack product formats and the third section of the report looks into the growing ready-to-eat meals market. An area growing exponentially is the fourth section of this report, which are the complementary services for red meat opportunities. The fifth and final section of the report discusses food processing associated with each of the different types of red meat products and provides a roadmap of potential stakeholders and contacts that may take these propositions further. For more detail on how to operationalise these red meat opportunities refer to the Growth, investment strategy and methodology report (2018) and the Logistics and infrastructure report (2018).

1.3 Red meat consumption

As mentioned in the Consumers' health and wellbeing report (2018), red meat consumption in the ASEAN region is lower than the global average, yet is expecting strong growth in the next thirty years with emergent growth in wealth of its middle class. There are opportunities to grow red meat consumption despite health concerns and protein substitutes of fish, chicken, eggs and vegetable protein. Driving this growth are the increasingly busy lifestyles of developing urbanised populations and the new mega cities mentioned in the ASEAN environment report (2018). Culture and traditions underpin perceptions on red meat 'steak' type of products and the limitations of 'steak' types of red meat products to do with cooking, lifestyle and pricing sensitivities.

We propose there are high value add red meat opportunities when considering a transition away from sales of solely red meat and towards the development and sales of products derived from red meat. Products for the ASEAN region that show the most potential for high value include functional foods, snacks and ready-to-eat-meal products, along with digital services that enable ecommerce. Products that have higher shelf-stability without the need for chilled storage have further reach into the various regions of the ten ASEAN countries.

To meet these opportunities, the red meat industry may decide to consider repositioning red meat products in the ASEAN region, as a significant opportunity exists to change how red meat is consumed and perceived.

2. Functional Snack Products

Functional snack products are products that are smaller than full meals and address mobile lifestyles. These functional snack products are of lower calorific value, and can be individually portioned and packaged, to be consumed away from home or while in motion. They are desirable for their nutritional and health benefits and are appropriate for three key segments outlined in the Consumers health and wellbeing report (2018). The first of these are the young consumers who are body conscious and focused on eating on-the-go products that improve their physical appearance. The second of these are the busy urban workers who are time poor, find it difficult to find time to prepare nutritious meals or snack, and are conscious of maintaining their health and wellbeing. The third cohort is the elderly with diminished appetite who require high nutrient concentration in their food. Meat products in this category could be viewed as meal replacements, or meal supplements.

An emerging area of interest is the development of healthy snack food products from meat co-products that can be a valuable source of proteins, vitamins, minerals and bio-actives to be used as nutritional ingredients in food products (Arihara, 2006; Lafarga and Hayes 2014; Mullen et al. 2017; Schmidt et al. 2006). Also of potential interest are meat products containing probiotics and functional foods (Khan et al. 2017; Neffe-Skocińska et al. 2016).

With Asia, leading the world for new probiotic product launches (Wan 2017) there is growth potential for red meat opportunities. Some of the emerging snack food products have claims attached, such as having health benefits related to reducing diabetes incidence, assisting with weight loss, or assisting the digestive process to improve gut health. The health benefits of these snack products fit the aims of several demographic groups within the ASEAN region. The specific value adds for functional snack product offerings will require further analysis with the Australian red meat industry.

The critical point is to position these snack products as functional foods, geared towards health and wellbeing, and to highlight the nutritional benefits. These types of foods are frequently ten times more expensive than their commodity packaged equivalent. These functional snack products can make use of the 70% of the carcass that is currently considered low value add. There is potential with these functional snack products of improving the value add of the lower-end of the carcass by at least five times.

1.4 Types of functional snack products

A range of snack product types have been explored and proposed to meet different needs. The value contribution of the red meat in these products ranges from $45/kg up to $700/kg as calculated in Appendix 1.

Fermented food snacks and sauces retain traditional appearance and tastes, yet have improved nutritional value. These are appropriate for the elderly consumers who have traditional tastes and desire to maintain or improve their health and wellbeing.

Protein powder, including single serve options, with twist and dispense bottle options, such as Berocca 'Twist N Go'. These are an excellent way to increase protein consumption in the ASEAN region as the powder format increases reach. The health benefits and nutrients are suitable for busy

consumers, and those consumers interested in their physical appearance as well as elderly consumers who need a nutritional boost.

Snack bars, jerky, trail mix and meat floss are products that are easily individually portioned and involves formulating red meat with other nutritious products including grains, fruits and vegetables. These bars and packets are also suitable for busy consumers, those interested in their physical appearance, as well as elderly consumers without dysphagia.

Nutritious broth concentrates are products that are thick liquids, and therefore easy to swallow and digest. Broths are suitable for all of the consumer groups; in particular, the elderly consumers with dysphagia as the broths are easy to digest and are more traditional. Busy consumers and consumers interested in enhancing their physical appearance, desire broths in single shot portions, as they are easily portable and quick to drink, as well as being a highly concentrated source of nutrients. These are suitable as supplementary food products.

Next, the types of functional snack products are discussed in detail beginning with fermented foods.

1.5 Fermented food snacks and sauces

Fermented foods, drinks and sauces (e.g. Vietnamese fish sauce) have long been a part of eating culture in parts of the ASEAN region and are already well accepted. There is growing evidence of the health benefits of such products. Recent research outlining the science behind how such products are beneficial for health finds that a range of healthy bacteria and enzymes are present and promote gut health. In addition, the bioactive peptides and antioxidants can promote health and muscle maintenance (Lafarga and Hayes 2014; Ohata et al. 2016). Beyond complete food products in this category, there are also opportunities to develop isolated nutritional components such as fermented probiotic products, enzymes for digestive health and antioxidants for general health and wellbeing.

Figure 1 illustrates already accepted fermented meat-based food snacks from the ASEAN region. On the left is Vietnamese Nem Chua, which is typically a fermented pork dish. There are beef options. In the middle and on the right are pictures of Thai Naem or fermented sausage products that are typically pork based. The middle picture shows the Naem unpackaged, where on the right, the Naem is packaged. There may be potential to produce beef based fermented sausages.

Figure 1: Fermented food snacks of Beef Nem Chua and Thai Naem

Modern fermented or probiotic food products are experiencing a surge as health products. One such example is kimchi, which generally commands a price of almost $30.00/kg (Peace Love

Vegetables Sauerkraut) and presents a significant value to horticultural produce. Boutique jerky can command up to ~$160/kg ($39.95 for 250 grams of Territory Jerky – see Appendix 1) and this provides further scope to introduce functional fermented meat snacks which may retail for higher than this.

A similar high value add could be possible for fermented meat products with high nutritional value. Significant value adds could be gained if fermented products are produced from the lower value cuts of meat, which account for 70% of the carcass. There is potential to develop fermented meat products for both human and pet consumption. Fermented human food snacks are likely to appeal to upwardly mobile and busy consumers (see more on this consumer in the Consumers' health and wellbeing report 2018).

Fermented meat products for the pet market might be an additional and lucrative option to consider. The Financial Times (2017) reported that the Asia-Pacific region is the fastest growing region for pet ownership, outpacing growth in the western world (>60% increase 2012-2017 to a $US6.6bn market size in Asia/Pacific). Pet owners are likely to seek pet foods with added nutritional value and these can command up to $55/kg (e.g. Vitapet Dog salami snacks). Experiencing the highest growth in dog ownership is Indonesia, which has increased by 130 percent from 2003 to 2017. The highest growth market in cat ownership is South Korea (>600% 2003-2017).

1.5.1 Modern Biotechnology produces healthier fermented foods faster

The technology to produce fermented meat products involves primarily formulation mixing, addition of live culture/probiotic, fermentation, drying, packaging and storage (Freitas de Macedo et. al. 2012). Fermentation periods can vary from a few weeks to several months (fermented sauce) depending upon the product. The use of modern biotechnology techniques, including careful selection of multi-functional microorganism cultures consisting of both bacteria and fungi, can provide the opportunity to develop products with a higher concentration of nutritional components and digestive aids at a faster rate.

1.5.2 Healthier fermented meat products suit traditional ASEAN tastes

A range of healthy fermented meat products that are lower in fat and salt than traditional products with boosted nutritional value. The proposed output of fermented foods aligns nicely with several of Mintel's themes identified in the Consumer's health and wellbeing report (2018), these are 'In tradition we trust', 'time is of the essence', 'waste not' and 'health for everyone'. Of importance with maintaining health 'for everyone' is the rising incidence of non-communicable diseases (such as diabetes). As mentioned in the Consumers' health and wellbeing report (2018), labelling the packaging with a focus on the nutrients the product is high in, will encourage consumption.

As mentioned in the Consumers' health and wellbeing report (2018) fermented meat sauces are a solution that address consumer concerns to do with the odour of meat cooking. Fermented meat sauce with reduced odour using similar technologies to those developed by FoodInnopolis to reduce fish sauce odour are more likely to be accepted by younger consumers. We propose that products like the Nem Chua and the Naem, with modernised, healthier formulations, perhaps in a cube or meatball form would be beneficial, and assist in portion control and portability

1.5.3 Fermented meat development with FDA support will improve market reach

Fermented food snacks and sauces could be produced and developed by smallgoods processors, e.g. Hans Smallgoods or Primo Smallgoods, or SMEs in this sector, such as Territory Jerky. Development of potential products to suit the ASEAN environment could be accomplished in collaboration with a research consortium like FoodInnopolis Thailand, which has both a strong understanding of tastes in the region, as well as a wealth of food biotechnology experience.

To assist in creating awareness of the healthy benefits of fermented food snacks and sauces, the Food and Drug Administration in Malaysia, Singapore and Thailand might be useful. In Thailand, Dr Tipvon Parinyasiri, who is a meat scientist and the Director of the Thai Food Drug and Administration (FDA), may be a useful source of assistance.

1.6 Protein powders

Protein powders are already accepted as a source of protein by consumers who are interested in improving their physical appearance, either as a form to build muscle mass or to reduce weight, and are regularly used in gyms. Currently, the most popular forms of protein powders are whey and soy protein.

Like with fermented foods, snacks and sauces, there is the potential with protein powder to use the lower value part of the carcass and provide high value add red meat opportunities. There are high value red meat opportunities in protein powders, as meat provides a more complete protein than other sources (e.g. whey, soy) as it has a wider range of amino acids that are more utilisable by the human body. The percentage of protein in such powders is also very high (95%), and is the highest concentration of functional protein out of any of the protein powder products on the market.

Beef protein may also be used as an ingredient in healthy snacks, much the same way that soy and whey protein are used (e.g. protein balls). Figure 2 illustrates some examples of beef protein. Beef protein isolates command a price of $45-50/kg (Bulk Nutrients brand and Carnivore brand). For single serve options, sachets could be used or packaging similar to the Berocca Twist ‘N’ Go, which equates to ~$700/kg of solids minus packaging costs ($3.60 /250 mL containing 1 x 5 gram tablet – See Appendix I).

Figure 2: Examples of beef protein powder products

1.6.1 Freeze drying offers new opportunities for meat protein powders

Protein powders are usually sold as isolates, which means the protein component of the raw material, in this case beef, is isolated by filtration and/or ion exchange, as well as possible acid or alkali extraction, followed by drying. Typical processes for drying include spray drying (with high temperatures >100°C). Freeze-drying is growing in popularity due to the ability to retain more of the nutrient value that would be otherwise degraded at high temperature and in a more oxidative environment.

To appeal to consumers who may not like the idea of 'processed food' there could be a market segment devoted to pure meat powder (i.e. freeze dried and ground only).

1.6.2 Single-serve protein powder is good for on-the-go consumption and offers higher value add than bulk packs

Protein powder tubs and single-serve satchels, along with Twist 'N' Go products for consumers on the move. This type of product would appeal to several of the Mintel themes identified in the Consumers' health and wellbeing report (2018), in particular, the 'time is of the essence' segments who lead an active lifestyle as active gym goers, outdoor adventurers, busy workers, or young mothers. Additionally, the 'waste not' and 'health for everyone' could find protein powders appealing for an extra boost of energy to maintain or enhance protein consumption in a healthy diet.

Protein powders have a high reach into the ASEAN market due to the shelf stability of powdered products, as there is no need for cold storage. Further, there is the added advantage of improving nutritional security in needy areas where access to fresh produce can be an issue.

1.6.3 Single-serve protein powder snacks need dispensable packaging for on-the-go markets – food processors and packagers need to develop these together

Meat based protein powders could be produced and developed by existing protein powder suppliers, including Bulk Nutrients and Custom Protein in Australia. Nutradry in Hendra, Qld or Freeze Dry Industries in Yandina, Qld, could carry out freeze-drying. There are further freeze drying processors on the Sunshine Coast as well.

To improve the high value add of meat protein powders there is potential to offer individual serves of the Twist 'N' Go type of packaging and these could be developed by Bayer or Invetech. Another way to improve protein with functional snack products other than fermented foods or protein powders is with protein snack bars.

1.7 Snack bars/jerky/biltong/trail mix/meat floss

High protein snack bars are a useful option for those who wish to have a diet high in this nutrient but do not have time to eat meals rich in cooked protein. Jerky type products that are lower in fat than some traditional jerkies may also be attractive to those after a protein 'hit', but who still want to maintain a healthy calorific intake. Meat floss is a dehydrated, shredded product already present in various parts of the ASEAN region. A candied pork floss product is the most popular throughout the area, and there are also chicken and beef versions.

The advantage of snack bars, jerky, trail mixes or meat flosses are that they are easily portable and are smaller volume than wet protein due to being partially dehydrated. The opportunity to develop savoury snack options with red meat based products may overcome the negative perceptions associated with sweeter snack options (i.e. sugar is 'bad'). Additionally, meat floss can be a garnish, a healthy snack, or an ingredient in formulated products, such as protein balls, children's snacks, or as texturizing and/or the nutritional components in snack bars. Meat protein based snack opportunities may assist in overcoming some of the growing health issues in the region associated with increasing obesity rates and non-communicable diseases (NCDs), e.g. diabetes or heart disease, which are diet related.

Meat protein snack products have the potential to appeal to a variety of 'time is of the essence' consumer types including those consumers who are trying to improve their physical appearance (increase muscle mass or lose weight) and seeking post-workout fuel, or busy workers on the go seeking healthy diet, or outdoor adventurers on the move, or mobile active mothers. The Mintel themes of 'health for everyone' or 'waste not' are also likely to appeal (see the Consumers health and wellbeing report 2018) as part of a balanced and healthy diet for the elderly who are experiencing a diminishing appetite (but not with dysphagia), particularly in ASEAN countries where there is an aging population (e.g. Singapore).

Meat protein snacks such as those shown in Figure 3 meet the desire for foods to be mobile and high in nutrition. Products in this category range in price from >$80/kg (2.50 for 30 g of Doctor Proctor's Biltong) to >$140/kg ($17 for 3 x 40 g Chief bars). These snack food products, like the protein powders, have a greater reach in the ten ASEAN countries, because they are not dependent on cold storage chains and can be transported easily into remote areas of the region (Melia and Lee 2017). From left to right, Figure 3 shows the beef trail mix, the red meat protein bars and the healthy jerky/biltong.

Figure 3: Examples of red meat snack products, including bars, biltong and trail mix.

1.7.1 Formulation and freeze-drying facilitate meat snack product manufacture

Healthy snack options are typically sweet. To promote the heathy image of minimally adulterated components freeze-dried items such as meat pieces and fruit could form part of the snack formulation and add to perceptions of a healthy on-the-go snack. Freeze-drying minimises nutrient degradation as compared to heat drying processes. Further formulation technologies would ensure adequate shelf life while reducing salt and added sugar to position these meat protein snacks as healthy.

1.7.2 Formulating with fruit and healthy ingredients makes meat snacks popular

A high in protein and nutrients range of snack bars, jerky, trail mix, protein balls and meat floss, that are lower in fat, sugar and salt than traditional products, with boosted nutritional value, available in single serve packages, would assist in positioning the meat based protein snacks.

Within these products, there can be the addition of nutritious fruit, such as cranberries and currants—as in the 'Chief' snack bars—, which help aid perception of meat as part of a healthy diet. Consumers in the region are often more comfortable eating red meat if there are other components with it such as vegetables, spices and aromatics to provide additional nutritional value (conversations with Kasetsart University students) and this could be a potential consideration for a more savoury healthy snack product.

1.7.3 SME's are innovative red meat snack developers and online markets increase product reach

Red meat protein snacks could be produced and developed by several SMEs in this sector, similar to what Chief and Doctor Proctor's are already doing in Australia. Production of meat floss has the potential to be produced and developed by freeze-drying companies such as Nutradry and Freeze Dry Industries in Queensland. These snacks could be distributed through online health food shops such as iHerb or through online markets like Alibaba, which are ideal for SMEs. For on the ground distribution, convenience shops like 7-Eleven or PT Blambangan Foodpackers, as both have a wide reach in the ASEAN region.

So far, we have looked at fermented foods, protein powders and protein snack bars with the functional snack products range, the last product within this range are the nutritious broth products.

1.8 Nutritious broth products

Items like soups and broths for nutritional and health benefit are typically well received in the ASEAN region (e.g. chicken broth or ginseng broth) due to the acceptance of their effects on maintenance of good health. There are many nutritional components in bone broth including gelatine—a good source of amino acids—and minerals such as calcium magnesium and phosphorous. Broths may be a food ingredient or a standalone nutritious product.

Liquid products may be more accepted over powders in the region due to their perception as being 'natural' (Singapore insights). Based on discussions with Unilever during in-country research it was acknowledged that liquids would be better received than powders, due to the perception of liquids

being not as highly processed. ASEAN consumers consider fresh produce to be of a higher quality than canned or dried products.

Broths provide an additional benefit as single serve high value add opportunities. Figure 4 shows broth as being promoted as a nutritious 'superfood' which fits in with the ASEAN region's growing need for food products that are beneficial to health. Broth concentrates typically retail for >$130/kg ($35 for a 250 g jar).

Figure 4: Example of broth concentrate products on the market

1.8.1

1.8.2 Concentrated broth processing enhances nutrient extraction

Lower value carcass components (bones) are not widely used in consumer food products. These bones can be valorised in bone broth to produce high value add red meat opportunities. This process typically involves boiling of bones in water, with the addition of acid, such as vinegar, which can aid mineral extraction. The liquid is then concentrated into a viscous broth. Alternatively, some newer processes may freeze dry the bone broth powder (Nutradry) to develop a freeze-dried bone broth liquid.

There could be an opportunity to have an intermediate product with less high temperature processing using vacuum concentration; however, this can be costly to operate on a larger scale.

1.8.3 Single serve broth concentrate has high value add potential

Nutritious beef bone broth could be packaged in large jars, in single serve 'shot' portions of concentrated liquid, or 'twist n go' packaging. Any of these options would be suitable for the three Mintel themes of 'time is of the essence', 'waste not' or 'health for everyone' (see the Consumers health and wellbeing report 2018). The single-serve portions offer the highest value add as the per litre dollar value will be significantly more than that for the larger jars. The single serve provide appeal, as they are portable for consumption at home or 'on the go'.

1.8.4 Stakeholder support

Beef broth is an opportunity that could be produced and developed by several SMEs in this space, similar to what Meadow and Marrow are already doing in Australia. Food processors, such as Bundaberg brewed drinks, could produce this product on a larger scale. Digital distribution could be

through iHerb or through online markets like Alibaba and physical distribution could be through 7-Eleven or PT Blambangan Foodpackers.

3. Packaged meals ready to eat

Products that are pre-packaged, and partially pre-processed are attractive, as they can appeal to consumers who value time – 'time is of the essence' or the 'health for everyone' are key themes identified in the Consumers' health and wellbeing report (2018). As mentioned in this report, many ASEAN consumers are unfamiliar with how to cook red meat and do not like the smell of red meat cooking. Packaged, ready-to-eat meals may address some of these concerns. Also mentioned in the Consumers' health and wellbeing report (2018) is the importance of packaging to enhance the experience and to distract from the smell of meat being cooked. The use of novel packaging can serve to retain and combat the red meat aroma during preparation, and provide confidence that ASEAN consumers can prepare a high quality meal each time. There are a few different options of packaged prepared, ready to eat meals and the first covered in this section is sous vide.

1.9 Vacuum packaging

Vacuum packaging offers opportunities for ready-to-eat meals. Sous vide is traditionally how vacuum packaged foods were prepared. Sous vide, means 'under vacuum' and traditionally, with respect to cooking, refers to first vacuum packaging food and then submerging it in a controlled temperature water bath for cooking at a very controlled temperature, typically ranging from 45-70°C.

Cooking of vacuum-packed food can also be done in a steam oven, and it is a very versatile approach to food preparation allowing production of ambient, chilled and frozen products (chilling and freezing after processing).

With vacuum packaging, two product deployment approaches could be taken. The first is meat and other accompanying ingredients (e.g. sauce, vegetables) could be vacuum packed raw and sold to the customer, ready for them to do their own sous vide cooking at home. The second is vacuum packaging and post-pack processing can be done at a food-manufacturing site. The consumer can then purchase the product for reheating/cooking at the point of consumption. The second approach provides more opportunities for longer shelf life due to superior sterilisation, as well as desirable texture modification (tenderisation).

Vacuum packaging provides opportunities for the packages to be used in other contemporary and emerging processes, such as high pressure processing (HPP), hydrodynamic shockwave treatment (HST) and microwave assisted technologies (MATS/MAPS) Microwave assisted technologies are a very modern technology having only just been commercialised in the last 5 years, and offer processing that creates shelf-stable products for up to 1 year, stored in ambient conditions

Figure 5 illustrates the process pathways from meat to consumer product for vacuum-packed products. Products that are pre-packaged and partially pre-processed like this are attractive, as they can appeal to those cooks who are unfamiliar with cooking red meats, such as beef. The use of novel packaging can also serve to retain and combat the red meat aroma during preparation, and provide confidence that ASEAN consumers can prepare a high quality meal each time.

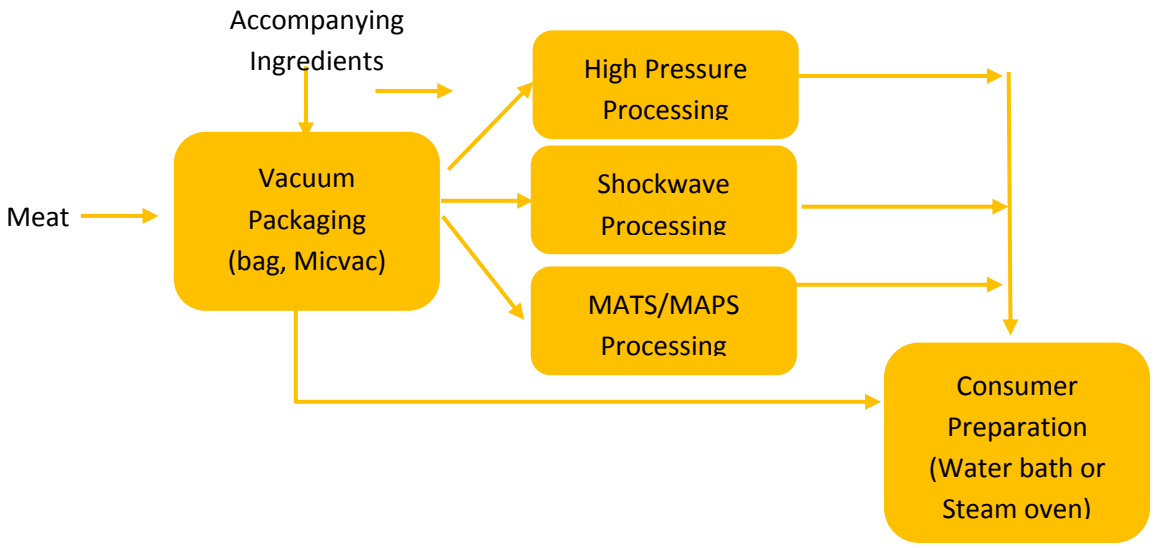


Figure 5: Pathways for vacuum-packed products

Some of the many advantages to using vacuum packing include:

- Better retention of aroma and flavour due to the vacuum packaging.
- Lower temperature cooking than traditional oven or stovetop cooking, preventing overcooking or burning.
- Extended shelf life.
- Softer texture of meat, which provides opportunities to use lower value cuts that can be tenderised through this process.

There are a few opportunities for product type and selection, and the best opportunities depend on acceptability and value addition. The convenience of at-home heating of pre-cooked sous vide meals is suitable for

- inexperienced cooks
- time-poor working professionals
- elderly family members who may no longer be able to cook their own meals due to deterioration of health.

Services and products are needed to support consumers seeking to learn sous vide cooking methods. Services include recipe apps and package instructions for those who are not confident cooks. Such complementary services as these are discussed in detail in section four of this report.

1.9.1 Modern meat processing technologies and appliances offer superior quality and shelf life for ready meals

When addressing sous vide technology, this will depend on the food package type and performance, as well as water bath cooking. These vacuum-sealed packages can also be cooked and/or sterilised via other processes including:

- Steam Oven Cooking (SC)
- Microwave Assisted Thermal Sterilisation (MATS) / Microwave Assisted Pasteurisation Systems (MAPS)
- High Pressure Processing (HPP)
- Hydrodynamic Shockwave Treatment (HST)

MATS, HPP and HST in particular are very modern technologies which can provide extended shelf life at ambient temperatures.

Recent developments in at-home sous vide equipment, as well as the rapid reduction in price in the last five years (approaching $40 per unit), has made sous vide viable as an in-home appliance, and much cheaper than a steam oven or microwave oven. Part of the reduction in appliance pricing has been due to the development of clip-on units to be attached to an existing cooking pot. Figure 6 illustrates three standalone sous vide appliances on the left side of the diagram and six at-home cooking pot clip on appliances to cook vacuum packed meals, which are useful to cook meat.

Figure 6: Sous vide cooking appliances for the home

1.9.2 Vacuum packed ready meals offer versatile meal types for ASEAN tastes

Vacuum packing is a versatile process with the opportunity to develop a range of products for consumers, which are outlined below and include stew or curry products, full or ready-to-eat meals or meat only.

1.9.2.1 Vacuum-packed stew or curry products

Vacuum packed products incorporating both meat and vegetables, such as curries and stews have the advantage of being perceived as part of a healthy balanced diet, as opposed to red meat alone. As mentioned in the Consumers' health and wellbeing report (2018), red meat is perceived as healthier when it is accompanied with other components (vegetables, aromatics and spices). The combination of ingredients is perceived as healthier and more representative of a balanced meal. Components such as aromatics (onion, garlic) and spices are viewed particularly well as providing health benefits, and possibly overcoming some of the issues with red meat and health (e.g. fat content).

The addition of other flavoursome ingredients can also serve to overcome issues consumers may have with strong red meat flavour. Curries and stews cooked using sous vide allows for the usage of lower fat cuts of meat, as the meat becomes very tender. With other cooking methods (e.g. oven or

pan cooking) higher-levels of meat fat are required to improve the tenderness of the meat. Cooking using sous vide offers opportunities to improve cooking confidence with red meat, as sous vide is a bit more foolproof with a good result every time - the meat is cook through evenly and is tender.

Using flavours representative of each part of the ASEAN region aligns with the food trend theme of 'In Tradition We Trust' discussed in the Consumers health and wellbeing report (2018). Leveraging the known flavours of each region and conveying the benefits of using such sous vide on the packaging may improve awareness in considering red meat in cooking. Figure 7 shows two examples of sous vide curries. The first is a green curry and the second is a Thai curry.

Figure 7: Sous vide readymade curry meals

1.9.2.2 Ready-to-eat meals

Vacuum-packed ready-to-eat opportunities address increasing demand of the growing ready-to-eat meal market of chilled raw, packaged or processed frozen options.

The technology advent of flexible packaging technology, including Cryovac's® sealed air Simple Steps® enables cooking in a steam cabinet/oven, while Micvac® post-pack pasteurisation packages allows the package to steam and vent during microwave cooking, thus increasing the options for ready-to-eat meals. To account for different temperature cooking needs, the vegetables, which require higher temperatures to soften adequately, are first cooked at higher temperatures (82°C), and then the temperature is dropped to ~60°C to cook the meat component.

1.9.2.3 Meat only vacuum-packed cooking

Individual portions or collated family size portions can be vacuum packaged and then processed at the temperature desired for cook level type. Meat may vary from rare on the left of Figure 8 to well done, which is on the right of Figure 8. This flexibility enables consumers to select their cooking preference perfectly every time due to the consistency of sous vide cooking method for meat inside

Figure 8: Sous vide red meat cooking guide

and out.

1.9.3 Stakeholder support for vacuum packed meals

As mentioned in the Consumers' health and wellbeing report (2018), affluence influences meat consumption, and meat consumption is perceived as more favourably with affluence. Some perceive eating meat as a treat or to demonstrate wealth, while at luxurious restaurants or at tourist resorts, meat is on the menu.

Potential stakeholders are Minor Food Group Sizzler, the Coffee Club chain, the BBQ Plaza chain restaurants or sit down restaurants in Asia.

There are HPP processors in Australia, such as Austchilli in Bundaberg that could undertake post-pack processing. Other processors include Beston Global Food Company and Australian Country Choice.

Suppliers of components for ready meals, include Cobram Estate (olive oil), Sunrice (rice) and Simplot (wide range of ready meals—Lean Cuisine etc.).

DSTO and CSIRO also have MATS/MAPS facilities, which are currently being developed for production of food via this process in Australia. CSIRO also has the only Shockwave food-processing unit outside of Germany, with the capability to develop shockwave treated meat products.

1.10 Aged care/institutional vacuum packed foods

Those in hospital or aged care environments require particular meal types due to swallowing difficulties caused by injury or illness, termed dysphagia. These are often comprised of texture-modified foods with a paste or puree-like consistency. Meat is one of the components that often requires most of the blending or mincing due to a stronger texture than overcooked vegetables,

which require less blending. Meats cooked with open methods such as oven or pan cooking are often blended with sauces to achieve the correct safe texture.

Aged care is a growing market due to a growing and aging population in some areas of the ASEAN region. There is a push to meet the nutritional needs of this demographic. This is possible through foods that are highly nutritious and palatable to a group who may be missing more solid-textured food.

There are opportunities to enter the market of aged care and institutional foods with ready-meal products and nutritious snacks. The nutritious snacks may be easier to consume for those with low appetite due to their smaller size and they have the highest potential value add.

1.10.1 High pressure technologies are good for aged-care dysphagia foods

Vacuum packaging, along with processes such as high pressure processing or shockwave processing prior to cooking of meat, can provide opportunities to provide ready-to-cook texture-modified meat options that do not require much preparation pre- and post-cook. The application of the high-pressure methods makes it possible to achieve an even more tender texture than sous vide alone. One of the other advantages, particularly for this demographic group, is that higher nutritional value of the food is better maintained through these processes than conventional cooking methods: this is of importance, as food consumption volume can tend to be lower.

In large institutions, this may make preparation and distribution easier and make the meals potentially more flavoursome, as they would not be an open cooked-reheated option, which has the tendency to develop oxidised ‘off’ flavours. Sealing within the package overcomes some of these hurdles, as well as serving to retain moisture within the product—which can help safe swallowing of food. Another advantage is that achievement of consistent texture is more easily achievable through sous vide than traditional open cook methods, due to the well-controlled cooking temperatures and moisture content.

1.10.2 Highly nutritious, easily consumable meat meals for ageing ASEAN residents

Vacuum packed ready-to-eat products for at-home aged care or institutional aged care increases the tenderness, palatability, and ease with which the elderly may consume meat. There are options to include Asian flavours and curries to address the more traditional consumer. Additional aged care outputs are those mentioned previously in the functional snack food section, such as, protein powders for thickened drinks to increase nutrition intake, functional and nutritious snack bars with meat floss to aid digestion, or broth concentrate, which is naturally thickened and may appeal to these consumers in both flavour and nutritional value.

1.10.3 Health care organisations are ideal partners for deploying meat-based aged care/institutional meals

Ramsay Sime Darby Health Care has locations within the ASEAN region, and would be an ideal partner to help deliver and deploy these types of products into the region.

Vacuum-packed meals offer some high value red meat opportunities, similar to the functional snack food products. The sous vide and package meal options are likely to be more successfully received

by the ASEAN market if positioned as complete, convenient, nutritionally balanced, tasty meals, geared towards health and wellbeing of ASEAN consumers.

Vacuum-packed meals are frequently three to five times more expensive than their commodity packaged equivalent. In terms of market reach, distributors such as CP Group and 7-Eleven have the widest ranging reach in the ASEAN region and may serve as interested parties in deploying sous vide and package meat meals through these channels.

4. Services with meat products

When providing services with meat products, this is referred to as augmenting the product and usually consists of services that add value, or increase the value of the physical product. Some of these services accompanying the product are available by subscription, others are free.

The purpose of augmenting meat products is to improve the perceived value of the red meat to the consumer, to enhance consumer confidence, and to improve the red meat customer experience by providing information that assists with understanding, cooking and consuming red meat products. Services may also assist in reducing the negative perceptions that ASEAN consumers have about red meat products. As mentioned in the Consumers' health and wellbeing report (2018), ASEAN consumers consume most of their protein through fish, chicken, eggs and plants. The red meat consumption journey is new to most people in the ASEAN region so a robust supported engagement model is necessary to assist with the transition to integrating red meat as a source of protein in a healthy diet.

To best support ASEAN consumers, an integrated digital approach is warranted. The approach could seamlessly integrate cooking apps that already exist to include red meat recipes, provide new apps to support cooking (e.g. with vacuum packed technologies), integrate QR codes through social media (e.g. WeChat already does this effectively), provide social cooking groups through Facebook, and seek Twitter influencers to tweet about various ways in which to integrate red meat protein into a healthy diet. Social networks, community forums, YouTube and webcasts enable sharing and provide platforms for influencers to share the narrative of integrating red meat protein into a healthy diet.

ASEAN consumers are typically younger and are very active on social media, and food bloggers, in particular, are extremely influential. Social media and decision support lifestyle apps will complement the red meat product delivery. There must be an integrated approach, not just about juicy meat, but nutritional data that can be scanned from packets, and that highlights the 'functional' food attributes of the product. Complementary functional foods such as Goji berries or Queen Garnet Plum can be used to create balanced nutritional products containing super foods.

Applications may deliver one's daily diet, and optimum health and wellbeing, with data captured from each product and tuned for the individual—drink one shot of beef broth at 6pm so that the individual can fine tune and optimise their day; or be confident that their child or parent is eating a balanced diet.

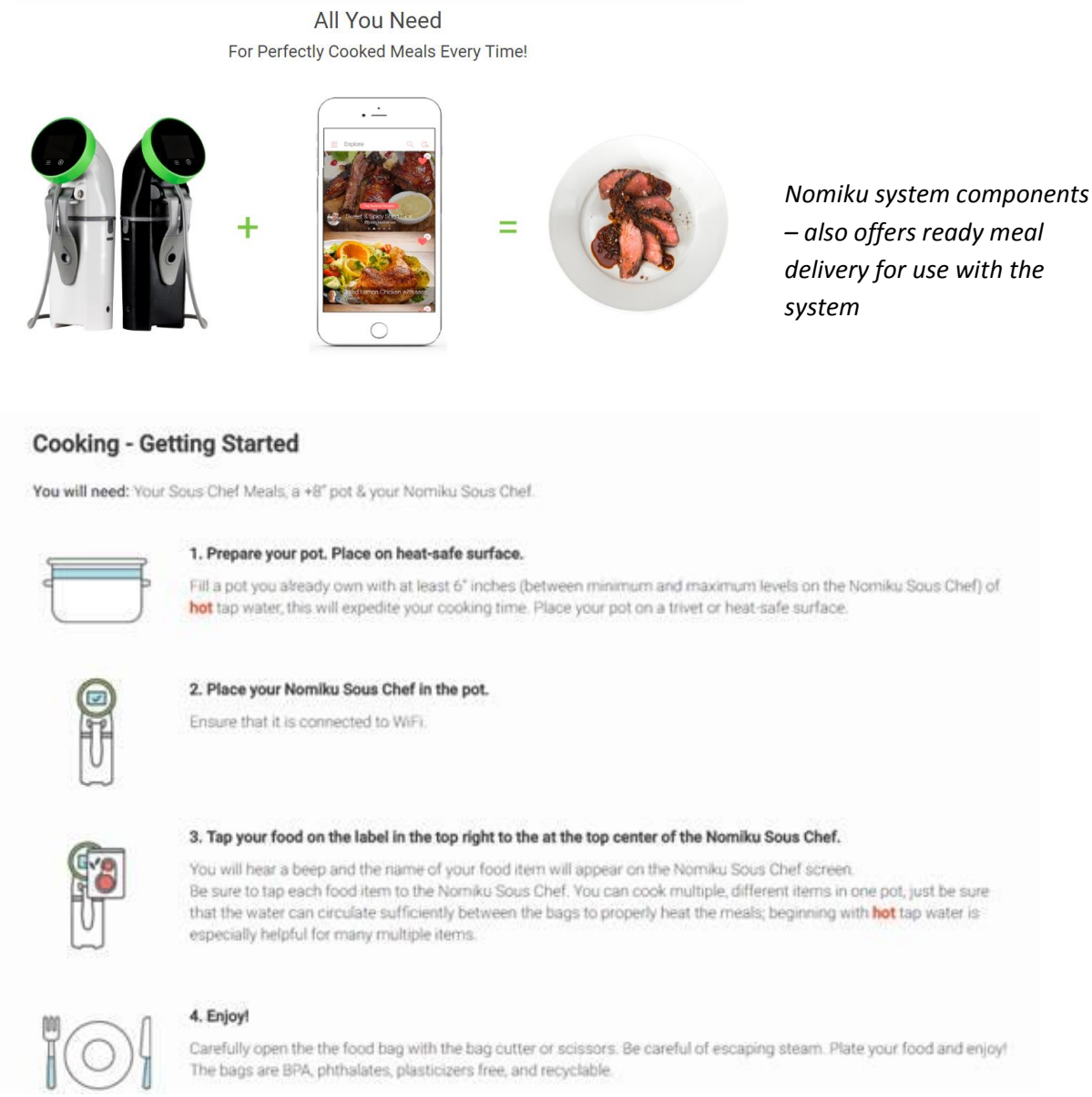
There are opportunities to develop a wide range of culturally specific digital applications and MLA could provide data and resources to inform these apps—much as if the Bureau of Meteorology is resourcing numerous weather applications.

1.11 Apps for supporting meat products

There is technology available for including scannable QR codes and chips within food packaging providing extra information regarding nutritional content, integrity of the package and food preparation instructions.

Technology such as this is useful for busy or inexperienced cooks, or those who are looking to be educated on how to eat a healthy diet. The red meat industry can benefit from providing such services on their packaging linked to digital content within apps or on websites if needed.

Nomiku has been combining technology in the form of Wi-Fi apps, ready meals and sous vide cooking through individual meal component packages with a scannable label that is recognised by the Nomiku machine. Figure 9 demonstrates the link between the sous vide Nomiku device, a smart phone and a beautifully cooked steak.



Nomiku system components – also offers ready meal delivery for use with the system

Figure 9: Sous vide cooking appliance with digital support and apps

1.12 Wearable Technology and Apps

Increasingly integrating wearable technology with apps is a growing aspect of many young consumers' lives. Wearable technology tracks the eating, exercise, sedentary hours and sleeping habits to assist the consumer in improving their lifestyle. Here we discuss building muscle, healthy eating and special dietary requirements as key demographic groups that are likely to be already using wearable technology with integrated apps on their smart phones.

1.12.1 Building muscle

There are over 100,000 apps that focus on building muscle, or muscle and fitness or muscle and diet, which demonstrates the ubiquity of muscle building apps on the market. Many of these apps have exercise plans, diet plans, food tracking and diet tracking ability to enable the user to have information at their fingertips 24/7, whether the apps are on the phone or wearable technology (e.g. a watch). Some of these apps have healthy recipes, meal plans, ideas on how to lose weight or gain mass through food. One of the key foods often cited by these apps as key in preserving and building muscle is beef. There is potential to develop collaborations with these apps and promote Australian beef. There is also potential to develop an Australian beef app aimed at providing beef recipes for those who desire to build muscle.

1.12.2 Healthy eating

There are also more than 100,000 apps on the market that promote healthy eating and work with wearable technology. Many of the low carb diet apps, no sugar diet apps, Atkins diet apps, Paleo diet apps, superfood apps and healthy eating apps promote beef as a superfood or a healthy food. The common theme among these apps is the focus on promoting beef as a functional food. These apps promote beef as a functional food because beef contains vitamins protein, B6, B12, Iron, choline, zinc, phosphorus, niacin, selenium and riboflavin. Together, these nutrients help the beef consumer to maintain brain function, have energy to tackle the day, aid the body to use oxygen, support the nervous system, build bones and teeth, maintain a healthy immune system, preserve and build muscle, protect cells from damage and convert food into fuel. There is potential to develop collaborations with these apps and promote Australian beef. There is also potential to develop an Australian beef app aimed at providing beef recipes for those who desire to build muscle.

1.12.3 Allergies and special dietary requirements

Growing areas of healthy eating apps are those apps that target and assist the user manage their allergies and special dietary requirements. These include consumers who are seeking assistance from apps and functional foods to help them manage various diseases or allergies such as coeliac, diabetes, autoimmune diseases, gluten free, and allergy free entertaining. With many of these allergies and diseases, beef is promoted as a healthy option that can be eaten, and has functional benefits for the consumer. There is potential for Australian beef to be promoted as a healthy solution to assist with autoimmune and other diseases or allergies.

5. Food processing

To integrate red meat as part of a healthy diet, we have already established that a mix of contemporary and emerging food processing methods will be necessary to produce red meat products suitable for a variety of demographic groups that have similar needs and wants. These include the desire for more nutritious ready-to-eat food products, but in some instances, may include different underlying requirements, such as easy to swallow meat products for elderly.

There are a range of non-thermal and thermal processes available for manufacture of the products specified in the Sections on Functional snack products and Ready-to-eat meals. This section of the report introduces some of these and provides information about the strengths and weaknesses of these processes.

The advantages of more contemporary and emerging processing techniques are that a wider range of red meat product formats can be produced, without detrimentally affecting nutritional content. Some emerging processes also produce finished products at a faster rate, and a lower cost (<$1/kg). This is crucial for the production of healthy, nutritious, high value red meat products.

1.13 Processes for developing value add red meat products

Processes of interest for developing high value add red meat products consider that:

- Product types that can be produced using lower cost contemporary technologies, and suit the demographics of young health-conscious consumers, busy consumers, and elderly consumers include:
  - High nutritional products such as broth concentrates, protein powders, snack bars; and
  - Balanced nutritious meals cooked in pack to minimise odour dispersion during cooking, and to enhance odour release during consumption
- Current and emerging processing technologies that can create red meat snack products in alternative formats, such as functional foods and nutraceuticals, with potentially very high value (up to $700/kg of solids). Useful processing technologies for these products include:
  - Freeze Drying [FD]
  - Formulation of red meat with nutraceutical type ingredients or functional foods [FO],
  - Fermentation of meat and meat co-products [FE]
  - Enzyme treatment to produce bioactive peptides [ET]
- Current and emerging processing technologies can significantly speed up production of red meat meal products with low processing costs, <$1/kg. Such low cost processes include:
  - High Pressure Processing [HPP]
  - Hydrodynamic Shockwave Treatment [HST],
  - Microwave Assisted Thermal Sterilisation [MATS] and Microwave Assisted Pasteurisation Systems [MAPS].

1.13.1 Processing technology and product opportunities

The choice of meat processing technologies can affect many characteristics of meat food products including texture, flavour, aroma and nutritional quality. Depending on meat product type, there

are several processing options available to develop healthy, attractive food products for different consumer groups in the ASEAN region.

There are a range of contemporary and emerging processing technologies that can increase red meat product value. These contemporary processes are typically categorised as non-thermal processes or thermal processes. Table 1 provides information on non-thermal contemporary and emerging processes, and Table 2 provides information on thermal processes that are contemporary or emerging. For an analysis of both processes refer to Appendix 2, which is detailed and includes some of the characteristic features, as well as costs, advantages and disadvantages of the various contemporary and emerging non-thermal and thermal processes.

A wider range of product formats beyond just red meat is more accessible through use of some of these technologies. Products such as healthy snack bars, nutritious drinks and concentrates, and protein powders are of higher value (up to $700/kg depending on product format), and processes which produce these, are worth exploring further.

Contemporary and emerging processing non-thermal technologies

Non-thermal processes are attractive, as less nutrient degradation and food oxidation occurs. Thermal processes are desirable for their sterilisation capabilities, but may detrimentally affect some nutrients.

It is worth noting that non-thermal processes are utilised to modify the physical properties of meat including transformation into meat products with new structures, flavours and textures. Fermentation without heat may also be included in this category. Originally, the main purpose of non-thermal processing technologies was to pasteurise foods without application of heat. This serves to minimally process the food and thus retain its fresh characteristics more easily. Table 1 identifies a range of contemporary and emerging non-thermal technologies that are available for red meat processing.

Table 1: Contemporary and emerging non-thermal technologies available for red meat processing

Process Type	**Mechanism of Operation**
Enzyme Treatment (ET)	Direct application of enzymes to the meat surface or formulation. The enzyme acts to degrade myofibrillar protein structures, thus tenderising the meat (Marques et al. 2010).
Fermentation (FE)	Addition of micro-organisms, either specific, or 'wild' to counterbalance populations of pathogenic bacteria. Depending on choice, lactic acid, ethanol, or other compounds are generated affecting flavour, texture, and pH and water activity, thereby preserving the meat.
Formulation of meat co-products with nutritional components—mixing/ comminution (FO)	Incorporation of health boosting components such as probiotics, dietary fibre, and natural antioxidants with potential for some to be derived from the meat itself (Han & Bertram, 2017, Khan et al. 2017, Neffe-Skocińska et al. 2016, Ohata et al. 2016).
High Hydrostatic Pressure Processing (HPP)	Sealed packages of meat are placed in a pressure vessel. Isostatic water pressure applied (Guillou et al. 2017).
Hydrodynamic Shockwave Treatment (HST) Emerging Technology	Sealed packages of meat pass along a conveyor belt into a water tank, where the tank has an applied electric 'shock'. This generates a mechanical pressure pulse that hits the meat package, altering structure and texture (Claus, 2017, Bolumar et al. 2013).
Ionising Irradiation (II)	Use of gamma rays and x-rays to damage microbial DNA. Leads to cell death of microorganisms and sterilisation. (Nam et al. 2017).
Non-thermal Plasma Processing (NTP) AKA Cold plasma processing (CP) Emerging Technology for food	Non-thermal plasma is generated by electrical discharge in gas at low or atmospheric pressure. The plasma is then applied to the food. (Schultz et al. 2015)
Vacuum Packing (VP)	Packaging technology has advanced such that shelf life can be increased. Packaging meat with all air removed by vacuum, adds value by this mechanism.

Contemporary and emerging thermal processing involves heating or cooling of the product. The effect of processing on meat product nutritional content is of prime importance as this influences value.

Some components can be degraded by an increase in temperature, while others become more bioavailable for human digestion. Processes that have higher thermal cooking loss (liquid release) also cause a loss of soluble proteins, vitamins and supplements; however, these could be recaptured for nutraceutical type products.

Table 2 provides details on contemporary and emerging thermal technologies that are available for red meat processing.

Table 2: Contemporary and emerging processing thermal technologies available for red meat processing

Microwave Assisted Processes (MATS/MAPS)	To improve speed of production, the use of microwave technology can be utilised for processing of food. Some modes involve vacuum-packed products submerged in water and then microwave is applied https://www.915labs.com/.
Conventional Oven Cooking (OC)	Meat is placed in a dry oven at temperatures from 150-250°C. Higher temperatures tend to reduce moisture loss due to faster cooking rates and more rapid outer sealing.
Steam Oven Cooking (SC)	Meat is placed in a humid oven at temperatures a little lower than conventional oven cooking. The presence of steam increases cooking rate due to higher heat transfer and helps products retain moisture.
Freeze Drying (FD)	The product is first frozen and then placed in a freeze-dryer where it is subjected to vacuum and sub zero temperatures. This causes the moisture in the product to sublimate—changing from solid into vapour and being removed from the product, without thermal damage to the food.
Sous Vide (SV)	Vacuum-packed meat packages are submerged in a controlled temperature water bath where the temperature ranges from 46-85°C. This is a 'low and slow' cooking process, but creates wonderfully tender textures and rich flavours (Baldwin, 2012).

1.14 Considerations for Halal Processing

There are a range of emerging technologies outlined in Table 1 and Table 2 and it has not yet been considered what implementation of these would mean for Halal status of food. We can observe that Halal status relates to the slaughter process itself, not the post-slaughter processes. This would

indicate that emerging technologies, which are concerned with post-slaughter processing only, could potentially comply with Halal requirements, if associated processing aids (ingredients) are Halal compliant.

1.15 Alternate Processing Pathways for Red Meat

To optimise product value and consumer acceptance, it would be advantageous for the red meat industry to explore utilising part of its raw meat resources to produce the aforementioned high value nutritious products. This would address the issue of diets changing in the ASEAN region because of increased awareness of food nutrition. An approach like this would help to future-proof the industry, as red meat popularity is being affected by the rise of plant protein products.

Figure 10 demonstrates the processing of meat into higher value meat products, and shows there are a wide range of options, particularly for conversion of low value carcass components. Meat cuts that could benefit from added value include the hip, flank, short plate, brisket and chuck, as well as offal and other co-products. The focus here will be on potential technologies for production of the products proposed.

A strategic approach where a small percentage of red meat raw product is diverted to create functional food products and snacks, instead of meat for meals, would be sufficient to return significant value to producers. There are two product streams that can be produced with an approach like this, which are:

- Vacuum packed (VP) red meat products for meals; and
- Red meat snacks and nutritional products.

Two alternate processing paths can be utilised also, which include red meat material solely transformed; and also red meat that is formulated with other ingredients (FO) and then transformed.

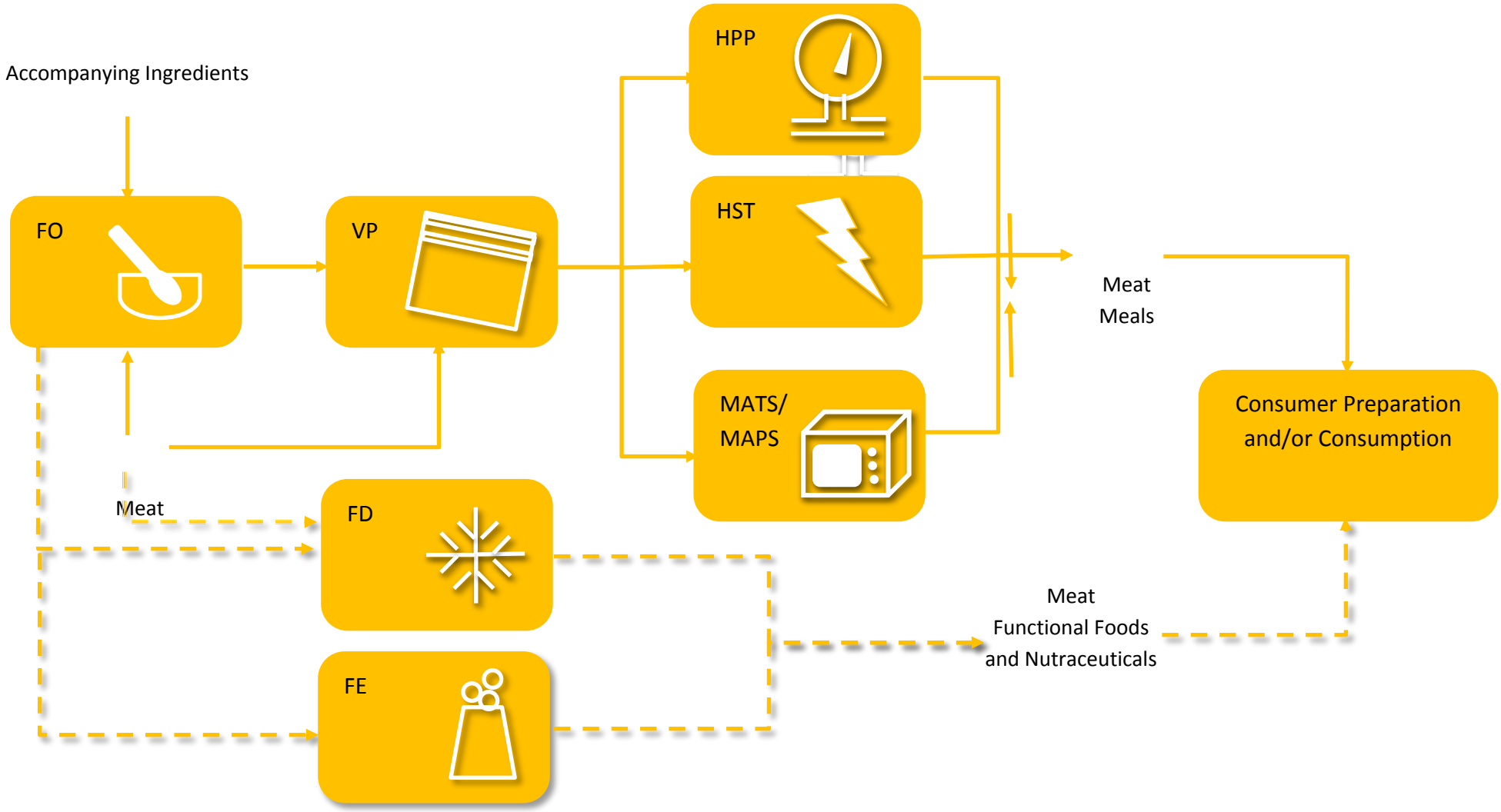


Figure 10: Processing pathways to high value add red meat products

Dotted lines indicate process pathways that create the highest value products. These pathways are ripe for further investment and exploration.

1.15.1 Considerations for cost of production and value addition/product gains

When considering the added value of red meat opportunities, the various costs and gains are weighed up and factored into decision-making. Considerations for the cost and gains of production include:

1. ***Process Costs***
    a. Capital costs.
    b. Processing time.
    c. Energy Usage.
    d. Bill of materials (input raw materials and yields).

2. ***Product gains for higher value meat products***
    a. Improved food safety.
    b. Enhanced nutritional content.
    c. Desirable texture and flavour.
    d. Targeted usages and occasions that are not being met by current products/services.

All of these characteristics need to be considered within the overarching goal of adding value to meat products for the ASEAN region. Processes that optimise the balance between process time and energy usage will be looked upon favourably for economic reasons, along with those processes that destroy pathogenic bacteria and improve nutritional content, texture and appearance for enhanced consumer perception through use of sustainable practices. This, in turn, would increase the likelihood of purchase.

1.15.2 Current product prioritisation roadmap

Based on the summaries in we can do some simple evaluation via rankings of ease of implementation, cost of implementation and potential value added. Underlying these factors are the following considerations:

1. ***Ease of Implementation***
    a. Presence or absence of existing commercial equipment
    b. Footprint
    c. Utilities required
    d. Sufficient knowledge of optimal processing parameters
    e. Australian vs ASEAN based
2. ***Cost of Implementation***
    a. Capital Cost
    b. Operating costs
        i. Energy

ii. Labour
iii. Consumables – e.g. packaging
iv. Ingredients

3. Potential value added

a. Value compared to basic meat commodities
b. Perceived value due to health food benefits
c. Potential product uptake, translated to sales volume

1.15.3 High value add red meat processes

Table 3 provides information on the non-thermal processes for production of ASEAN high value red meats. Based on the rankings in Table 3 and Table 4, the processes with the potential for high value add include enzyme treatment (ET), formulation (FO), fermentation (FE) and freeze drying (FD) as these processes have the potential for production of lifestyle and functional snack products.

Table 3: Evaluation of non-thermal processes for production of ASEAN high value red meat products

Factors for Ease of Implementation	**HPP**	**HST**	**NTP/ CPP**	**II**	**ET**	**FO**	**FE**
Commercial Food-Grade Equipment Availability	√	X	X	√	√	√√√	√√
Capital Cost	$$$	$$$	NA	$$	$$	$	$$
Operating Cost ($/kg)*	$	$	NA	$	$$	$$	$$
Best Shelf life and stability (days)	35	30-35	14	70		540	120
Potential Value Add	$$	$$	$$	$$	$$$	$$$	$$$

HPP – High Pressure Processing

HST - Hydrodynamic Shockwave Treatment

NTP / CP – Non-Thermal Plasma processing / Cold Plasma processing

II – Ionising irradiation

ET – Enzyme Treatment

FO – Formulation

FE – Fermentation

Table 4: Evaluation of thermal processes for production of ASEAN high value red meat products

Factors for Ease of Implementation	**MATS / MAPS**	**OC**	**SC**	**FD**	**SV**
Commercial Food-Grade Equipment Availability	√	√√√	√√√	√√	√√√
Capital Cost	$$$$	$	$	$$$	$$
Operating Cost ($/kg)*	$	$$	$$	$$$	$$

Best Shelf life and stability (days)	365	7	7	365	30
Potential Value Add	$$	$	$	$$$	$$

MATS / MAPS – Microwave Assisted Thermal Sterilisation / Microwave Assisted Pasteurisation Systems

OC – Oven Cooking

SC – Steam Oven Cooking

FD – Freeze Drying

SV – Sous Vide Cooking

1.15.4 Lower operating costs and moderate value add meat processes

Those processes with the lower operating costs and moderate value add include high pressure processing (HPP), hydrodynamic shockwave treatment (HST), and microwave assisted technologies (MATS/MAPS). These processes can be utilised to produce products for the ASEAN market, such as functional snack food products and ready-meals.

There are various food processors, developers and distributors who could help bring the products and processes mentioned here to the ASEAN market. It is recommended that contact be made with these potential stakeholders to progress product development and deployment.

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Appendix I: Meat solids value in proposed red meat products

Assumptions used in calculations:

1. Value of meat component is approximately *total retail price x meat content percentage* (obviously this may be modified for true value)
2. Value of product packaging ranged from 1-50% of the product value for sensitivity analysis
    a. Processing and transport costs not incorporated as they are proprietary, but could be built into the higher percentages to provide an indication
3. Bold large font values are best case per kg price
4. Protein content on nutrition panels was used to equate to meat content, where applicable
    a. Chief Bars were a meat content guess based on their nutrition panel protein content of 33% (assuming dried down beef is close to 100% protein and no other protein components present - almonds may confound this)
5. Water was ascribed Nil value for Twist 'N' Go product

Product Type	Solids mass, i.e non-water mass (kg)	Potential Meat-Derived Content (%)	Retail Price ($)	Pricing Source	Pricing Access Date	Packaging portion of Retail price (%)	Packaging Price ($)	Meat solids price ($)	Meat solids (kg)	Value of Meat solids ($/kg)
Berocca Twist 'N' Go	0.005	100	3.6	https://www.woolworths.com.au/shop/productdetails/335749/berocca-performance-drink-orange-twist-go	5/04/2018	1	0.036	3.564	0.005	**712.80**
Berocca Twist 'N' Go	0.005	100	3.6			10	0.36	3.24	0.005	648.00
Berocca Twist 'N' Go	0.005	100	3.6			20	0.72	2.88	0.005	576.00
Berocca Twist 'N' Go	0.005	100	3.6			30	1.08	2.52	0.005	504.00
Berocca Twist 'N' Go	0.005	100	3.6			50	1.8	1.8	0.005	360.00
Territory Jerky	0.25	100	39.95	http://territoryjerky.com.au/#bulk-packs-anchor	5/04/2018	1	0.3995	39.551	0.25	**158.20**
Territory Jerky	0.25	100	39.95			10	3.995	35.955	0.25	143.82
Territory Jerky	0.25	100	39.95			20	7.99	31.96	0.25	127.84
Territory Jerky	0.25	100	39.95			30	11.985	27.965	0.25	111.86
Territory Jerky	0.25	100	39.95			50	19.975	19.975	0.25	79.90
Beef Protein Isolate	1	100	45	https://www.bulknutrients.com.au/products/beef-protein-isolate.html	5/04/2018	1	0.45	44.55	1	**44.55**
Beef Protein Isolate	1	100	45			10	4.5	40.5	1	40.50
Beef Protein Isolate	1	100	45			20	9	36	1	36.00
Beef Protein Isolate	1	100	45			30	13.5	31.5	1	31.50

Beef Protein Isolate	1	100	45			50	22.5	22.5	1	22.50
Chief Bars (3 pack)	0.12	33	17	https://eatlikeachief.com/product/sample-pack-beef/	5/04/2018	1	0.17	16.83	0.0396	**140.25**
Chief Bars (3 pack)	0.12	33	17			10	1.7	15.3	0.0396	127.50
Chief Bars (3 pack)	0.12	33	17			20	3.4	13.6	0.0396	113.33
Chief Bars (3 pack)	0.12	33	17			30	5.1	11.9	0.0396	99.17
Chief Bars (3 pack)	0.12	33	17			50	8.5	8.5	0.0396	70.83
Beef Biltong - Dr Proctor's 10 pack	0.3	100	30	https://doctorproctors.com.au/product/beef-biltong-chilli-2/	5/04/2018	1	0.3	29.7	0.3	**99.00**
Beef Biltong - Dr Proctor's 10 pack	0.3	100	30			10	3	27	0.3	90.00
Beef Biltong - Dr Proctor's 10 pack	0.3	100	30			20	6	24	0.3	80.00
Beef Biltong - Dr Proctor's 10 pack	0.3	100	30			30	9	21	0.3	70.00
Beef Biltong - Dr Proctor's 10 pack	0.3	100	30			50	15	15	0.3	50.00
Beef Protein Isolate	2.2	100	189	https://www.fruugoaustralia.com/amix-beef-monster-2-kg-200-g-free-sport-proteins/p-7767143-16598165	6/04/2018	1	1.89	187.11	2.2	**85.05**
Beef Protein Isolate	2.2	100	189			10	18.9	170.1	2.2	77.32
Beef Protein Isolate	2.2	100	189			20	37.8	151.2	2.2	68.73
Beef Protein Isolate	2.2	100	189			30	56.7	132.3	2.2	60.14
Beef Protein Isolate	2.2	100	189			50	94.5	94.5	2.2	42.95
Meadow and Marrow Broth Concentrate	0.26	95.3	35	https://meadowandmarrow.com.au/products/bone-broth-concentrate-natural	6/04/2018	1	0.35	34.65	0.24778	**133.27**
Meadow and Marrow Broth Concentrate	0.26	95.3	36			10	3.6	32.4	0.24778	124.62
Meadow and Marrow Broth Concentrate	0.26	95.3	37			20	7.4	29.6	0.24778	113.85
Meadow and Marrow Broth Concentrate	0.26	95.3	38			30	11.4	26.6	0.24778	102.31
Meadow and Marrow Broth Concentrate	0.26	95.3	39			50	19.5	19.5	0.24778	75.00
Broth of Life Powder	0.09	67	40	https://www.brothoflife.com.au/collections/broth-stock/products/fodmap-beef-broth	6/04/2018	1	0.4	39.6	0.0603	**440.00**
Broth of Life Powder	0.09	67	40			10	4	36	0.0603	400.00
Broth of Life Powder	0.09	67	40			20	8	32	0.0603	355.56
Broth of Life Powder	0.09	67	40			30	12	28	0.0603	311.11
Broth of Life Powder	0.09	67	40			50	20	20	0.0603	222.22

Appendix II: Advantages/Disadvantages of processing technologies and potential products

Process Type	Advantages and Disadvantages	Potential Product Types Made
High Hydrostatic Pressure Processing	✓ Kills bacteria ✓ Tenderises meat ✓ Appearance relatively unchanged ✓ Higher pressures can lead to shorter process times ✓ Production cost per pound weight could be as low as $US0.04, but is based on their energy prices; in AUD is approximately $0.25/kg ✓ Maintains fresh-like characteristics under minimal processing conditions of lower temperature and pressure X Lots of packaging usage, but no different to current packaged products X Capital cost high (>$US1m) X Operating costs ~$US0.5m/year (Koutchma, 2014), however this may be a scaling issue as cost per weight is low.	• Aged care softened food • Pre-processing for sous vide to shorten cooking time
Hydrodynamic Shockwave Treatment	✓ Rapid and continuous process (20-30 seconds per package) confirmed by direct discussion with Tomas Bolumar ✓ Tenderises meat, potentially to a very soft texture ✓ Kills bacteria and sterilises meat ✓ Maintains fresh-like characteristics – minimal processing X Capital cost high ($0.5 m) X High energy → and potential high-energy costs – must be balanced against shorter processing time. X Lots of packaging usage, but no different to current packaged products	• Aged care softened food • Tender cuts for treat type products—special occasion meals • Pre-processing for sous vide to shorten cooking time

Process Type	Advantages and Disadvantages	Potential Product Types Made
	X Insufficient data for operating cost determination at this point—needs process optimisation data first → CSIRO.	
Non-thermal Plasma Processing	✓ Kills bacteria and fungi ✓ Moderately short time 10-20 minutes. ✓ Potential to be developed into a home unit, like a microwave oven. ✓ Disruptive technology for traditional thermal processes (Keener and Misra, 2016)	• Ready meals • Airline food • Controlled portion sized meat • Prime meat cuts
Ionising Irradiation	✓ Well-established ✓ Kills bacteria and sterilises meat X May affect meat colour, particularly red meat (Brewer, 2004) X Negative perception X Energy inefficient	• Prime meat cuts • Controlled portion sized meat • Ready meals • Airline food
Enzyme Treatment	✓ Very effective tenderising method ✓ Treatment can be long (4 hours), but could be suitable for pre-transport application. ✓ Opportunities for manufacture of bioactive peptides for health as nutraceuticals X Cost of the enzyme would affect viability X Some enzymes not suitable for use ○ Papain from papaya plant as well as Bromelain from pineapple over-tenderises (mushy texture which might be good for aged care food), not inactivated during typical cooking temperatures ○ Actinidin from kiwifruit may be an allergen ○ Some enzymes adversely affect juiciness	• Aged care food • Nutraceutical products
Formulation of co-products with	✓ Simple to do, with many studies conducted on health benefits ✓ Potentially positive 'boutique product' perception	• Aged care food • Fermented snack foods

Process Type	Advantages and Disadvantages	Potential Product Types Made
nutritional components—mixing/ comminution	✓ Idea for SME product development ✓ Cachet associated with added nutritional value would add value to the price. X Possible negative connotation as processed food X Food labelling compliance for fortification	• Beef jerky type products
Fermentation	✓ Fermented food is popular in many parts of the ASEAN region ✓ A lot of technical knowledge (FoodInnopolis) ✓ Beneficial for gut and general health, more so than cured products which involve salts ✓ Provides opportunity to develop healthy meat products to appeal to many target demographics ✓ Good for the healthy ageing initiative ✓ Fits in with the 'Time is of the Essence' theme, in terms of slow, healthful food process, that also provides convenient quick snacks ✓ FoodInnopolis has the Bioresources Centre which has a strong focus on food fermentation X Some processes can take a very long time X Need to be extremely careful with food-safe compliance.	• Nutraceuticals • Functional Foods • Antioxidant enriched meat products • Fermented meat sauce • Probiotic dry fermented products (Neffe-Skocińska et al. 2016, Ohata et al. 2016)
Microwave Assisted Processes	✓ Alternative to canning ✓ Faster process times ✓ Factories emerging right now ✓ Additive free food ✓ Being explored by Australian Defence and Amazon as a viable manufacturing process ✓ Longer shelf-life while maintaining quality	• Aged Care food • Ready Meals • Online retailed products

Process Type	Advantages and Disadvantages	Potential Product Types Made
	✓ FDA Approved already ✓ Low $/kg cost for manufacturing - <$0.50/kg – on par with HPP. X Capital cost high $US4.5 m ex. works (current quote from 915labs) X Some negative perception of microwave processing X Still being established in Australia, but a medium-term horizon	
Conventional Oven Cooking	✓ Very well established and understood ✓ Equipment is easily accessible ✓ Equipment cost not excessive X Potentially not significant value addition X Can be easy to toughen meat if not done correctly X Usually fatty meats do well due to increasing juiciness, but this is perceived as detrimental to health (Pathare and Roskilly, 2016)	• Roast meat type products for airline food
Steam Oven Cooking	✓ Very well established and understood ✓ Equipment is easily accessible ✓ Can use leaner meats as fat is not needed to keep the meat juicy → healthier ✓ Present in commercial kitchens, and now also products available for home ✓ Equipment cost not excessive	• Aged care food • Fine dining options • Airline food
Freeze Drying	✓ Maintains nutrient levels due to low temperature drying and no heat damage ✓ More stable product due to low water activity ✓ Existing processors (Nutradry, Hendra, Qld; Freeze Dry Industries, Yandina, Qld) ✓ Potentially extremely high value product >$80/kg for broth powder from Nutradry and bodybuilding meat protein powder is $70-90/kg and $6.15 for a 64 g meat trail mix bar X Time-consuming X Expensive process to run X Energy-intensive (Duan et al. 2016)	• Protein powders for fortification to combat malnourishment • Protein powders for bodybuilders • Meat-derived ingredients for protein bars and trail mix • Meat powders for aged care thickened drinks

Process Type	Advantages and Disadvantages	Potential Product Types Made
		• Bone broth powders and concentrates with high nutrient levels
Sous Vide	✓ Already perceived positively in parts of the ASEAN region (Singapore notes) ✓ Process encourages retention of nutrients ✓ Process enhances and retains flavours ✓ Process helps retain moisture ✓ Longer shelf-life than ready meals ✓ Value addition previously seen to be +1 Euro/pound of raw material → ~$AUD 3/kg ✓ Available reports on manufacturing projections for Asia-Pacific to 2022 X Time-consuming, but may not be an issue as it fits with the 'slow food' theme. X Energy costs X May still need to sear the (blanched) meat cut afterwards X Congelated juices/fat within the pack	• Flavoursome meat products for young health-conscious sophisticates looking for tasty healthy food • Aged care soft food • Airline food