



final report

Project code: A.BIM.0028
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Date submitted: January 2011
Date published: June 2011

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Evaluation of synergies between Meat & Livestock Australia and Dairy Australia in bioactives / bioscience programs

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

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January, 2011

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Purpose: This project investigated the current and proposed bioactives strategies of Meat & Livestock Australia (MLA) and Dairy Australia (DA), with the aim of identifying potential synergies in collaborating, at both an industry and enterprise level.

Acknowledgment of funding sources:

Food Innovation Partners acknowledge the financial support for this project from Meat & Livestock Australia and Dairy Australia.

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Abstract

Bioactives in the context of the meat and dairy sectors of the food industry are defined as animal or plant derived molecules and compounds which have regulatory functions in humans beyond normal and adequate nutrition. These molecules can interact with living tissue and act as active ingredients in functional foods, nutraceuticals, functional cosmetics and pharmaceutical products.

Bioscience is defined as an area of scientific study that relates to living things, for example biology or biochemistry. Within the food industry a wide range of functions for bioactive compounds have been described, including antimicrobial properties, blood pressure-lowering effects, cholesterol-lowering ability, antithrombotic and antioxidant activities, enhancement of mineral absorption/bioavailability, cytochrome immunomodulatory effects, and opioid activities etc.

Both Meat & Livestock Australia and Dairy Australia invest significant resources in the bioactive/bioscience sector and potential cost reductions could be realised through greater coordination and collaboration between the two organisations. This collaboration could include capability building in the academic and commercial sector, as well as the development of improved evaluation methodologies and commercialisation strategies. Project A.BIM.0028 “Evaluation of synergies between Meat & Livestock Australia and Dairy Australia in bioactives/bioscience programs” is intended to deliver recommendations for possible opportunities for further discussion and collaboration between the Meat & Livestock Australia and Dairy Australia in the bioscience/bioactives field to drive increased value for the respective industries and stakeholders.

This project investigated the current and proposed bioactives strategies of Meat & Livestock Australia (MLA) and Dairy Australia (DA), with the aim of identifying potential opportunities and synergies to collaborate, both at an industry and enterprise level. The project compared the strategies and processes employed to date by each industry, and considered the lessons that could be learned from successes and failures in commercialising bioactives and makes a series of recommendations focused on industry collaboration.

This study recommended collaboration in the following areas;

- Bioscience/bioactive capability and industry characteristics,
- Tools and processes to assist firms in assessing bioactive/bioscience opportunities,
- Bioactive market research and industry analysis,
- Business models for creating and sustaining value in the market, and
- Precompetitive collaborative research themes.

Finally this study also proposes that the meat and dairy industries work closer together on industry driven bioscience and bioactive projects through the development of syndicate or consortium projects and a potential future Bioscience/bioactives Centre.

Executive summary

Meat & Livestock Australia (MLA) and Dairy Australia (DA) invest significant resources in the bioactive/bioscience sector and potential cost reductions could be realised through greater coordination and collaboration between the two organisations. This collaboration could include capability building in the academic and commercial sector, as well as the development of improved evaluation methodologies and commercialisation strategies. This project A.BIM.0028 “Evaluation of synergies between Meat & Livestock Australia and Dairy Australia in bioactives/bioscience programs” delivers a series of recommendations for possible opportunities for further discussion and collaboration between the Meat & Livestock Australia and Dairy Australia in the bioscience sector: to drive increased value for the respective industries and stakeholders.

The objectives of project were to review and compare the current and proposed bioactives and bioscience strategies of Meat & Livestock Australia and Dairy Australia. This study would provide for the meat and dairy industries with the following;

1. Document lessons learned from the commercialisation successes and failures of bioactive products in both the dairy and meat industries,
2. Identify potential synergies around MLA’s and DA’s bioactive/bioscience platform, and
3. Identify potential opportunities and synergies to collaborate, both at an industry and enterprise level and recommend opportunities for collaborative efforts on pre-competitive bioactives / bioscience initiatives.

This study considered in broad terms lessons learnt and opportunities for collaboration in the following areas;

- Bioactives and bioscience strategies at the industry and firm level,
- Bioscience capability,
- Industry characteristics,
- Tools and processes to assist firms in assessing bioactive/bioscience opportunities,
- Bioactive market research and industry analysis,
- Business models for creating and sustaining value in the market, and
- Precompetitive collaborative research themes.

The study identified twelve key recommendations for future collaboration that would assist in the effective delivery of industry strategies. This study also proposes that the meat and dairy industries work closer together on industry driven bioscience and bioactive projects through the development of syndicate or consortium projects and a future Bioscience/bioactives Centre.

Recommendation 1: Develop and establish a dairy-meat industry professional exchange program for senior innovation and research managers to foster knowledge and skill development and cross fertilisation.

Recommendation 2: Dairy Australia develop and publish a bioactives compendium for the dairy industry similar to the one developed for the meat industry by MLA. The compendium would provide detailed information concerning the many different bioactives that could be commercially exploited from the dairy industry's waste streams. The compendium would cover;

- An overview of Australian Bioactives Industry,
- Bioactives regulatory framework,
- Bioactive extraction and purification technologies,
- Bioactive product data sheets, and
- Bioactive cost estimates.

This information would be useful for dairy companies that are not already involved in bioactive exploitation and for bioactive opportunities that are yet unexploited. Commercial-in-confidence issues will need to be considered to protect the existing opportunities being exploited at a firm level.

Recommendation 3: Dairy Australia conducted workshops with companies on opportunities and processes for the commercialisation of bioactives.

- To bring the industry up to date with the DA bioactives program and market opportunities,

- To increase the industry's awareness of the issues involved in commercialisation bioactives sector,

- Information on regulatory requirements and issues, and

- Workshops involve companies from both the meat and dairy industry.

Recommendation 4: Meat & Livestock Australia and Dairy Australia co-invest in market research and industry analysis projects and activities.

Recommendation 5: Meat & Livestock Australia and Dairy Australia collaborate to develop processes and tools that assist to define the business proposition and the business model: the way in which firms could create and capture value.

Recommendation 6: Meat & Livestock Australia and Dairy Australia co-invest in research and development of novel next generation separation and concentration technologies with relevant commercial application.

Recommendation 7: Meat & Livestock Australia and Dairy Australia co-invest in research to develop new and novel encapsulation technologies as delivery mechanisms within food structures that protect bioactives during processing and consumption.

Recommendation 8: Meat & Livestock Australia and Dairy Australia co-invest in research to develop biomarkers for potential human health effects and rapid systems for assessing efficacy.

Recommendation 9: Meat & Livestock Australia and Dairy Australia take an active role in Monash University's Centre for Green Chemistry in relation to bioscience and bioactives, on behalf of the meat and dairy industries.

Recommendation 10: The meat and dairy industries co-invest in understanding safety issues associated with consumption or application of extracted bioactives in order to address possible future consumer concerns.

Recommendation 11: Meat & Livestock Australia and Dairy Australia facilitate the development of bioactives and bioscience syndicate projects.

Recommendation 12: Meat & Livestock Australia and Dairy Australia undertake a detailed scoping study to determine the need for and feasibility of a Bioscience/bioactives Centre for the meat and dairy industries and develop the business case.

The next steps are for each of the two organisations, Meat & Livestock Australia and Dairy Australia to assess the value of the findings of this study and make a clear decision to develop a collaborative relationship in the area of bioscience and bioactives.

This project has been undertaken through the meat and dairy industry bodies sharing of commercially-in-confidence material with Food Innovation Partners and this report has endeavoured to maintain the integrity of all commercial sensitivity information.

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1 Background

Bioactives in the context of the meat and dairy sectors of the food industry are defined as animal or plant derived molecules and compounds which have regulatory functions in humans beyond normal and adequate nutrition. These molecules can interact with living tissue and act as active ingredients in functional foods, nutraceuticals, functional cosmetics and pharmaceutical products.

A wide range of activities has been described, including antimicrobial properties, blood pressure-lowering (ACE inhibitory) effects, cholesterol-lowering ability, antithrombotic and antioxidant activities, enhancement of mineral absorption/bioavailability, cytochrome immunomodulatory effects, and opioid activities etc.

A report on dairy-derived bioactive ingredients, "The World Market for Dairy Bioactive Ingredients 2009-2012", estimates the current global market size of dairy bioactives to be more than 30,000 MT with an approximate value of AUD 700 million and is growing by 10-20% p.a. The market for dairy bioactives is being driven by the broader nutrition industry, i.e. infant formula, sports nutrition, dietary supplements, clinical nutrition and functional foods. (1)

Meat & Livestock Australia and Dairy Australia both have strategic priorities for value adding to their respective industries. Within these strategic objectives, bioscience and bio-processing are seen as key platforms to deliver on these opportunities. Both organisations have so called "waste streams" (e.g. whey and offal); ancillary material streams that are a by-product from the processing of the core product milk and meat. It is these waste streams that contain valuable components and have been the subject of investigation for possible new products and business streams. The models, systems and technologies required to capitalise on these opportunities are expected to be similar and included;

- Identification and characterisation of active components or fractions,
- Identification of relevant target markets,
- Identification of suitable extraction and refinement strategies,
- Identification of suitable feedstock for extraction of components (or fractions),
- Evaluation of the opportunity taking into account possible extraction costs and component value,
- Development of appropriate business models for capturing the value of the bioactives,
- Identification of appropriate strategies to protect the IP (e.g. patenting),
- Collaboration with commercial parties to develop relationship for future uptake and subsequent commercialisation of opportunities.

Some of the bioactive/bioscience opportunities involve similar extraction methodologies, mode of action and capabilities to realise their commercial potential.

The dairy industry in Australia is about 10-15 years ahead of the red meat industry with respect to commercialisation of high value bioactive components extracted from what used to be regarded as waste streams. Much of the growth has been in the area of nutraceutical and functional foods. The functional foods market is estimated to be more than \$30billion per year and there are several examples of Australian dairy companies successfully engaging this market.

Both Meat & Livestock Australia and Dairy Australia invest significant resources in the bioactive/bioscience sector and potential cost reductions could be realised through greater coordination and collaboration between the two organisations. This collaboration could include capability building in the academic and commercial sector, as well as the development of

improved evaluation methodologies and commercialisation strategies. This project is intended to deliver recommendations for possible opportunities for further discussion and collaboration between the Meat & Livestock Australia and Dairy Australia in the bioscience/bioactives field to drive increased value for the respective industries and stakeholders.

This project investigated the current and proposed bioactives strategies of Meat & Livestock Australia (MLA) and Dairy Australia (DA), with the aim of identifying potential opportunities and synergies to collaborate, both at an industry and enterprise level. The project compared the strategies and processes employed to date by each industry, and considered the lessons that could be learned from successes and failures in commercialising bioactives. The project has also attempted to identify opportunities for collaborative pre-competitive research.

2 Project objectives

The objectives of this project are to review the current and proposed bioactives and bioscience strategies of Meat & Livestock Australia and Dairy Australia to;

1. Document lessons learned from the commercialisation successes and failures of bioactive products in both the dairy and meat industries,
2. Identify potential synergies around MLA's and DA's bioactive/bioscience platform, and
3. Identify potential opportunities and synergies to collaborate, both at an industry and enterprise level and recommend opportunities for collaborative efforts on pre-competitive bioactives / bioscience initiatives.

A list of some of the key documents accessed and utilised is shown in Section 6: Reference List.

3 Methodology

This project was undertaken by following the basic methodology of reviewing and comparing the existing and proposed strategies in the bioactives and bioscience themes, reviewing projects and activities already undertaken: to identify important lessons learnt that can be shared and identify areas where the two organisations could collaborate in the future. The outcomes of this project are presented as a series of recommendations for possible future collaboration.

Extensive information on the bioactives and bioscience programs, both public and commercial-in-confidence was collected from Meat & Livestock Australia and Dairy Australia. This information was in the form of;

- Organisational and industry strategy documents, including Annual Reports and Operational Plans,
- Project reports,
- Workshop reports,
- Intellectual Property portfolio listings,
- Industry bulletins,
- Market opportunity reports, and
- Other relevant documents.

The collated documents were extensively reviewed and the bioactive and bioscience program objectives, strategies, activities and processes compared.

1. Review Dairy Australia's Bioactives strategies, activities and outcomes,
2. Review Meat & Livestock Australia's Bioactives strategies, activities and outcomes,
3. Compare the overall direction, strategies and effectiveness of each organisations bioactive/bioscience program,
4. Identify lessons that can be learnt and shared around the success and effectiveness of strategies and actions,
5. Develop collaboration strategies and actions for future shared bioscience platforms and produce a series of recommendations,
6. Facilitate discussions between Dairy Australia and Meat & Livestock Australia to identify opportunities to collaborate in pre-competitive activities.

4 Results and discussion

The initial stage of this project was to compare the way in which the two industries manage their bioscience /bioactive strategies and an assessment of the factors that may impact on the effectiveness of these industry strategies. Also consideration was given to the differences in bioscience/bioactives strategies, across and between industries but at the firm level.

4.1 Bioactives/bioscience strategies

4.1.1 Meat industry

The Australian meat industries peak body, Meat & Livestock Australia (MLA) has recognised the importance of value adding to the industry through the commercial exploitation of bioactives. This has been articulated within MLA’s Annual Operational Plan under the imperative, “Growing Demand” and the objective “Developing New Products”.

The profitability of the red meat industry is critically dependent on deriving extra value from lower-value meat cuts and from the non-meat parts of the animal, such as skins, offal and blood products. All parts of the animal contribute to increased revenue per carcass and profit. To achieve this value must be added in the eyes of the consumer across the wide continuum of value-added products – from consumer meals at one end to high value pharmaceutical ingredients at the other. In 2010-11, MLA aims to assist the industry to identify market opportunities for lower-value meat cuts and co products, develop the capability to access novel markets and value chains and develop advanced technologies which can provide the industry with a competitive advantage to increase revenue per carcass.

MLA’s objectives for the bioactives theme as stated in their Operational Plan will be achieved through the following strategies;

Strategy	Key Initiative
1. Identify and evaluate emerging trends for new Products.	<ol style="list-style-type: none"> 1. Maintain and develop improved resources to facilitate the commercial evaluation of new product and technology opportunities 2. Raise industry awareness of emerging trends, opportunities in new products and value-adding technologies, 3. Undertake detailed cost-benefit analyses to quantify industry benefit to be derived from increased effort and activity in value adding
2. Develop technologies to improve the range of applications of co-products as commercial ingredients	<ol style="list-style-type: none"> 1. Improve the functionality of the top five bioactives in order to differentiate the products in the world market, 2. Develop more cost effective purification technologies for Australian bioactives

MLA has undertaken a range of activities within their bioactives strategy. These include;

- Industry workshops on exploiting bioactive opportunities,
- Development of a Bioactive Compendium,
- Bioactive Industry Bulletins,
- Bioactive market studies,
- Value chain gap analysis,
- Market failure studies,
- Bioactives feasibility studies and
- Commercial-in-confidence firm projects.

4.1.2 Dairy industry

The Australian dairy industry also has a strategic goal of exploiting bioactives and developing the industry's bioscience capability. The bioactives/bioscience theme falls within Dairy Australia's strategic objective "Value Chain Innovation" and is articulated in their annual operating plan as follows;

Program/sub-program/	Strategic priority	Outcomes. What was achieved in 2009/10
<p>Bioscience Strategic priority 1: Improve margins and growth opportunities</p>	<p>Development of commercially differentiated and protectable high value product opportunities from dairy components.</p> <p>Active use of Dairy Australia-funded assistance to exploit specialised components by dairy processors.</p> <p>Alignment of approach to, and funding of, bioscience along the dairy supply chain.</p> <p>Positive health and nutritional messages from dairy components science.</p>	<p>Bioactive components associated with weight management and immune function progressed to developmental stage with commercial parties. Patents filed for both potentially high value dairy component opportunities.</p> <p>Negotiated and initiated evaluation of dairy components with oral antimicrobial efficacy. Includes two patents assigned across to Dairy Australia.</p> <p>Negotiated assignment of a part owned patent in cell expression area. Led a commercial review that indicated little value in progressing allowing Dairy Australia to cease further expenditure.</p> <p>Improved Dairy Australia's intellectual property management capability by developing a best practice model for intellectual property management.</p> <p>Research completed and communicated to industry on a rapid method for identification of dairy components that improve muscle health.</p>

Dairy Australia's Bioscience program delivers under their broad business goal of maintaining and developing high margin markets, channels and products. It consists of strategies for promoting the health and nutritional benefits of dairy products, and ingredients, while enhancing skills and capability. Bioscience and biotechnology are key platforms to unlocking and delivering further health benefits inherent in milk. Bioscience provides for the identification of components as well as their impact, while biotechnology provides novel processing opportunities for both current and new products.

The program continues to assess its IP portfolio which includes dairy derived ingredients with health benefits in the area of oral, gut and weight management. The current focus is towards commercialisation of the most promising discoveries from earlier investments, which also includes the bioactive research made through the CRC for Innovation Dairy Products which has now concluded.

DA's commercialisation strategy has been focused on multiple component streams (or "fractions") that provide inherent benefits over single compounds. Benefits include reduced chance for copy through recombinant technology, cheaper extraction (no need to purify to a single compound), quicker development times and synergistic effects from a specific mix of components (providing a more 'natural' and increased benefit when compared to an individual compound). This strategy aligns with the nutraceutical market.

DA has stated that bioscience, which includes the 'omic' sciences such as genomics, proteomics and metabolomics is core to uncovering many more benefits of milk and its bioactives. The increased scientific understanding will allow for flow on marketing effects down the value add chain, all the way from the pharmaceutical end through to commodity products.

Dairy components already make up around 13% of the nutraceutical market, which in turn is around 20% (at ~\$7,000m/y) of the total food ingredient market. These include high valued products such as; whey protein hydrolysates, lactoferrin and casein phospho-peptides. Murray Goulburn, Tatura Milk Industry and Warrnambool Cheese and Butter Factory are example of companies active in this area where their key strategy has been to ensure engagement with the ingredient companies that use their products.

Dairy Australia's bioscience program is investing in bioactives that have functional on eye health, anti-cancer, oral health, weight control, gut health, muscle development and bone health. The program is improving its overall effectiveness through process such as modelling, protecting, reviewing and communicating the benefits of bioscience to industry. (Key activities include this project, identifying synergies with MLA and listing opportunities in the value add area yet to be developed, but available to the industry).

Like MLA, DA has undertaken a range of activities within their bioactives strategy. These include;

- Bioactive discovery research,
- IP assessments,
- Bioactive market studies,
- Bioactives feasibility studies,
- Commercial-in-confidence commercialisation projects and
- Commercial-in-confidence firm projects.

4.1.3 Firm level

At the firm level, individual companies have different strategies in the bioscience area and for the utilisation of bioactives. There is no consistent understanding of the sector at the firm level with companies ranging from extensive successful exploitation of bioactives directly into the market place to simply selling unprocessed bioactive ingredients or worse passing the stream direct to waste treatment.

The Australian dairy industry has many examples of commercial companies that have identified, extracted and developed a business stream from bioactive components from their process “waste” streams. Murray Goulburn established a subsidiary company to commercialise these dairy opportunities. MG Nutritionals was established in 2003 to prospect for bioactive components, develop the value chain and establish a viable market for their products in the food and nutraceutical sectors. Their products include lactoferrin, colostrum, growth factor rich fractions, calcium, milk salt flavour enhancer, and specialised milk proteins. (www.mgc.com.au/index.php/our-products/mg-nutritionals)

Tatura Milk Industries Limited (TMI) is a public unlisted company with shareholding held by supplying dairy farmers. The company was established in 1907 and is located at Tatura in regional Northern Victoria. TMI manufactures quality Australian dairy ingredients for the global market. Approximately 70,000 tonnes of manufactured products are produced per annum using state of the art technologies and systems. Along with fresh milk TMI produces and sells Infant formula & follow-on Powders, adult nutritional powders, lactoferrin, colostrum, hyper immune colostrum and proteins high in selenium. <http://www.tatmilk.com.au>

On the other hand the meat industry has not had the same degree of success. The meat industry has largely perceived itself as a commodity trader rather than a producer of a range of value added products. Examples in the meat industry of companies who have a successful business stream from the commercial exploitation of bioactives in the industry “waste” stream are limited.

An example of a meat processing company involved in bioactives is Australian Country Choice (ACC). The range of bioactives ACC is involved in is limited and focused on products that only require limited primary processing before being sold into the bioactives market where other companies in the supply chain add value through additional processing. Example product streams are bovine foetal blood and blood products, gall stones, pericardia and bulk gall.

Commercialisation of meat industry bioactives has largely been undertaken by bioscience companies one step further along the value chain; that do not have direct meat processing involvement. But there are examples of meat companies developing a business stream in bioactives, but this is usually a primary processed product such as foetal calf serum. For the dairy industry it is generally the dairy processing companies that are driving the commercialisation of dairy bioactives.

These bioscience or meat value adders take the co-product outputs from abattoirs and convert them to either ingredients or final products for the target markets of interest. For example Maverick Biosciences Pty Ltd (www.maverickbio.com) produces and exports

bioactives to over 15 countries globally, for manufacturers of pharmaceuticals, vaccines, medical device, nutraceutical and collagen based products. The company sources its minimally processed bioactive material from a number of abattoirs it has agreements with; then undertakes additional processing to produce a value added product. The company's offering includes blood products (plasma, serums, etc) device tissues (pericardium, amnion), collagen materials (tendon, bone cubes, hide splits, corium) and tissue and glands from many species.

4.2 Capability

This study found important significant differences between the meat and dairy industries in terms of ability to commercialise bioactive/bioscience products and service. Generally, dairy companies have had greater commercial success at creating income streams from the commercialisation of bioactives than meat processing companies. There are a number of possible underlying reasons why the dairy industry has been more successfully at commercialising bioactive/bioscience products and services. Possible attributes are;

1. *Higher numbers and level of skilled professionals in senior roles within companies in the dairy industry.*

Traditionally the meat industry has sourced its senior staff and managers from within the sectors own employment pool rather than from the wider food industry. While on the other hand the dairy sector regularly experiences a higher level of migration of skilled professionals between the wider food industry and the industry. Potential employees have usually considered the meat industry as a hard and dirty environment to work in. The attractiveness of the dairy industry in relation to the meat industry has led to the migration of senior managers; including R&D who has a more extensive science based tertiary training. This characteristic has provided an environment in the dairy industry that understands the science under-pinning the bioactives field, including the bioactive compounds and the technologies required to produce a marketable product and the efficacy associated with consumption.

2. *Technology intensive dairy industry.*

The dairy industry has a long history of developing, adopting and operating advanced processing technologies such as separation, UHT plants and membrane filtration etc by comparison to the meat industry was has been in the past largely a manual or manual assisted operation with technology an ancillary function: such as packaging technologies.

MLA has in place a strategy for development of innovation managers with individual companies. This "Red Meat Industry Professional Development Program" has been developed to increase the professionalism and innovative capacity of both individuals and companies.

Increasing innovation within a company will impact directly on the overall performance, profitability and competitiveness of the business and the industry. This program will contribute to increasing the numbers and level of professionals in senior roles in the meat industry, including those with science and technology training. With improved capability the industry will be better placed to exploit opportunities around bioactives.

There may also be an opportunity to have cross fertilisation of knowledge, skills and processes by developing a dairy-meat industry secondment program, specifically in the area of bioactives/bioscience.

Recommendation 1: Develop and establish a dairy-meat industry professional exchange program for senior innovation and research managers to foster knowledge and skill development and cross fertilisation.

4.3 Industry characteristics

There are differences around the industry and firm's level of processing before selling into the market. The meat industry typically sells a primary product while the dairy companies generally undertake secondary and tertiary processing to sell either a bioactive ingredient or a finished functional food or pharmaceutical product. For example, Murray Goulburn through its subsidiary MG Nutritionals owns the brand Ascend: a range of sports products for training and recovery based on the bioactive extraction from milk waste streams.

Another fundamental difference that has an influence on the development of bioactive opportunities is the differences in the processing line between dairy and meat. The dairy industry is largely based around a liquid commodity as opposed to a solid commodity such as meat. This may appear as irrelevant, but this has allowed the dairy industry to adopt chemical engineering processes and technologies similar to a petroleum refinery. Dairy bioactives are typically isolated from a liquid stream, in this case milk and so the fundamental processing technologies used are fluid based. On the other hand the meat processing industry can be considered as the disassembly of a solid unit in a batch like process. This criteria does not lend itself readily to in-line extraction of bioactives as the molecules are typically bound within the meat or offal components of an animal.

4.4 Tools and processes

Both the Australian dairy and meat industries have an industry support mechanism through Dairy Australia (DA) and Meat & Livestock Australia (MLA) respectively. As detailed earlier MLA has a clear strategy to develop technologies to improve the range of applications of co-products as commercial ingredients. This is a two pronged strategy,

Improve the functionality of the top five bioactives in order to differentiate the products in the world market,

Develop more cost effective purification technologies for Australian bioactives.

The Australian meat industry has to date been reluctant to develop business opportunities based upon bioactive ingredients, possible due to the perceived lack of knowledge of processing techniques and technologies utilised in the sector. In an attempt to address this, MLA have focused significant time and resources to encourage and guide the industry to better understand the opportunities and how they can be exploited. MLA has developed for industry a suite of resources to support the development of the bioactives opportunities. This type of material could also assist the dairy industry to further develop their bioactives industry.

4.4.1 Bioactives compendium

MLA has written and published a bioactives compendium for the meat industry that provides detailed information concerning the many different bioactives that could be

commercially exploited from the industry's waste streams. The compendium covers the following topics around bioactives in relation to the meat industry;

- An overview of Australian Bioactives Industry,
- Bioactives regulatory framework,
- Bioactive extraction and purification technologies,
- Bioactive product data sheets, and
- Bioactive cost estimates.

Recommendation 2: Dairy Australia develop and publish a bioactives compendium for the dairy industry similar to the one developed for the meat industry by MLA. The compendium would provide detailed information concerning the many different bioactives that could be commercially exploited from the dairy industry's waste streams. The compendium would cover;

An overview of Australian Bioactives Industry,
Bioactives regulatory framework,
Bioactive extraction and purification technologies,
Bioactive product data sheets, and
Bioactive cost estimates.

This information would be useful for dairy companies that are not already involved in bioactive exploitation and for bioactive opportunities that are yet unexploited.

Commercial-in-confidence issues will need to be considered to protect the existing opportunities being exploited at a firm level.

4.4.2 Bioactives opportunity workshops

MLA has also undertaken a series of industry workshops involving discussions with processors and bioactives value adders (1) (2). The workshops attempted to address the issues around exploiting bioactives opportunities, discussing markets and opportunities for collection of bioactives from the meat industry, overcoming hurdles including regulatory impositions and maximizing competitive advantages. The specific objectives of the workshop were:

1. To bring the industry up to date with the MLA bioactives program and results to date,
2. To increase the industry's awareness of the issues involved in entering the bioactives sector,
3. To demystify regulatory compliance, and
4. To raise awareness of the importance of competitive advantage in selecting bioactive projects.

MLA has also produced a series of bulletins for the meat industry that provide information supporting a bioactives commercialisation strategy. These bulletins are intended to complement the Nutraceutical Bulletin in reviewing additional potential products and market opportunities for red meat co-products as a source of bioactives (3). These bulletins attempt to identify and discuss several bioactives for which a global market exists, and in which an Australian product may be competitive. They also explore the factors associated with particular bioactives which may allow firms to capture market share with appropriate technical and market development.

Recommendation 3: Dairy Australia conducted workshops with companies on opportunities and processes for the commercialisation of bioactives.

To bring the industry up to date with the DA bioactives program and market opportunities,
To increase the industry's awareness of the issues involved in commercialisation bioactives sector,
Information on regulatory requirements and issues, and
Workshops involve companies from both the meat and dairy industry.

4.5 Market research and industry analysis

A critical step in deciding whether a company is to proceed with the commercialisation of bioactives is to understand the market opportunity and the required steps in the value chain.

Dairy Australia already provides its industry with significant global market analysis reports and data of dairy bioactive opportunities. DA is able to access additional information through its relationships with different International dairy network resources.

The meat and dairy industry have an opportunity to collaborate in the identification and assessment of opportunities for bioactives products and services not covered in previous industry specific reports. These sorts of precompetitive market research and industry analysis reports would identify market opportunities, competitors, competitive advantage, distribution, quantities, format and value.

Recommendation 4: Meat & Livestock Australia and Dairy Australia co-invest in market research and industry analysis projects and activities.

4.6 Business models

Critical to the successful exploitation of dairy and meat bioactives is the development of appropriate business models. A business model is the way in which the commercialiser will make money in the market place for a specific product or service.

Commercial companies can create and capture value from new bioactives and processes in three basic ways: through incorporating the product or service in their current businesses, through licensing to other firms or through launching new ventures that exploit the product or service in other markets.

The functions of a business model are as follows:

- Articulate the value proposition (the value created for users by the offering based on the product or service)
- Identify market segments. Users to whom the product or service is useful and the purpose for which it will be used
- Define the structure of the commercialiser's value chain which is required to create and distribute the offering and determine the assets needed to support the firm's position in this chain
- Specify the revenue generation mechanism for the commercialiser
- Describe the position of the commercialiser within the value network, linking suppliers and customers

- Formulate the competitive strategy by which the commercialiser will gain and hold advantage over rival solutions
- Assess capability required to achieve commercialisation, and
- At a firm level, the critical issue will be the economic return and the payback period on the investment

There is an opportunity for MLA and DA to collaborate to develop tools and processes as templates for designing value chains and business models for bioactive ingredients to enable quicker assessment of commercial viability of opportunities.

Recommendation 5: Meat & Livestock Australia and Dairy Australia collaborate to develop processes and tools that assist to define the business proposition and the business model: the way in which firms could create and capture value.

4.7 Precompetitive research

This study has identified a number of potential research themes that the meat and dairy industries could also collaborate pre-competitively on. These themes are detailed below and could involve co-investment from MLA and DA; as well as commercial companies and research organisations with relevant capability.

Already there are some research organisations that are bringing their capability together in collaboration, focused on bioscience and bioactives. CSIRO, Monash University and the University of Melbourne have combined their research capability and capacity to develop novel separation science for the production of bioactive molecules for the food and pharmaceuticals industries.

4.7.1 Separations and concentration technologies

Separation of bioactives is usually achieved through the application of chromatography techniques. Ion exchange chromatography uses ion exchange mechanism to separate compounds. It is usually performed in columns. Ion exchange chromatography uses a charged stationary phase to separate charged compounds including amino acids, peptides, and proteins. In conventional methods the stationary phase is an ion exchange resin that carries charged functional groups which interact with oppositely charged groups of the compound to be retained.

Size-exclusion chromatography (SEC) separates molecules according to their size. Smaller molecules are able to enter the pores of the media and, therefore, molecules are trapped and removed from the flow of the mobile phase. The average residence time in the pores depends upon the effective size of the molecules. However, molecules that are larger than the average pore size of the packing are excluded and thus suffer essentially no retention.

Since starting out in its infancy as an analytical method, one of chromatography's biggest challenges has been in scale up. As processes move out of the lab and into a production setting, the batch nature of traditional column-based systems starts showing their significant constraints. As the material to be processed becomes larger, the labour-intensive requirements of column-based chromatographic applications have effects that increase costs and the potential for production errors and contamination. Both of these chromatography technologies and the many variants have been developed to become a continuous process via a moving bed arrangement with multiple columns.

A newly emerged separation technology known as Molecularly Imprinted Polymers (MIPs) is used to specifically bind and enrich medium and small sized molecules. Molecularly Imprinted Polymers act by specific binding of the molecule they are made to bind. The specificity is established by the production procedure. The molecule of interest is mixed with functional monomers. The monomers bind to the target molecule via for example hydrogen bonds, electrostatic interaction or hydrophobic interactions. A cross linking molecule is added and by illuminating or heating the reaction mixture a polymerisation process is started, linking the cross linkers to the monomers and to each other and locking the structure around the target molecule. The target molecules are then washed away, leaving hollow spaces in a sponge like polymeric network. The hollow spaces are able to encase and rebind the target molecule or in this case bioactive if encountered.

The CSIRO Food Futures National Research Flagship and Monash University Centre for Green Chemistry have collaborated to develop knowledge and capability in highly selective Molecularly Imprinted Polymer (MIP) and Stimuli Responsive Polymer (SRP) separation technologies. These bioactives separation technologies have been developed using green chemistry approaches, enables much greater purity and selectivity of commercially valuable products, as well as the improved removal of contaminants, without the use of traditional polluting solvents.

This collaboration has led to the development of the Advanced Separation Technologies Commercialisation Program (ASTCP). A commercially focused program providing industry with cost effective processes that can be employed to manufacture value-added ingredients, improved quality products and to selectively remove contaminants from waste streams with the potential to reduce impact on the environment.

Concentration of bioactives on the other hand is traditionally achieved using membrane processes such as reverse osmosis, ultrafiltration, microfiltration, nanofiltration, and pervaporation. Most of the applications involve the selective removal of water from a liquid preconcentration process step. Other applications are to separate molecules on their size, for example, flavours, colorants, pectins, and protein fractions, to purify enzymes, to separate micro-organisms, or to keep enzymes in a bioreactor while reaction products migrate through a membrane.

There is an opportunity for the meat and dairy industry to collaborate in the precompetitive development of existing and next generation separation and concentration technologies. For instance both MLA and DA could co-invest in separation and concentration research through CSIRO's Advanced Separation Technologies program or through the Monash University's, Green Chemistry Centre.

Recommendation 6: Meat & Livestock Australia and Dairy Australia co-invest in research and development of novel next generation separation and concentration technologies with relevant commercial application.

4.7.2 Bioactive functionality and efficacy,

Research scientists are developing knowledge and technological solutions to incorporate bioactives into foods so that their beneficial, health-promoting properties are maximised without reducing the sensory attributes and quality of foods. The focus of this research is on how the inherent qualities of the food and aspects of the processing environment can affect the bioactivity and subsequent bioavailability of the bioactive components after consumption.

The challenges for researchers are:

- choosing suitable food formats
- choosing the most appropriate processing conditions
- protecting bioactives where necessary
- maintaining the food quality, such as preventing adverse effects on texture and organoleptic properties, such as smell and taste.

Many bioactive food components can be rendered useless by reactions with oxygen or other food components under certain processing conditions. For these 'active' components to be effective for health-promoting benefits, they need delivery systems that protect them until they reach the part of the digestion process where they will be most beneficial. One strategy is to protect bioactives through microencapsulation technologies. Microencapsulation involves creating a thin film made of proteins and carbohydrates to trap bioactives inside. The resulting 'capsule' is only a few microns in diameter. The film must protect the bioactives during food processing, storage and cooking; the bioactive is then available after food consumption and digestion.

Recommendation 7: Meat & Livestock Australia and Dairy Australia co-invest in research to develop new and novel encapsulation technologies as delivery mechanisms within food structures that protect bioactives during processing and consumption.

A critical factor for successful commercialisation of animal or plant bioactives is ensuring its functionality and efficacy. Screening methods should be developed for the measurement of long term effects in order to ascertain effects of food components that are claimed to promote good health. In this context, relevant indicators or biomarkers that can predict potential benefits relating to a target function in the body have to be identified. A valid biomarker must be representative of the effect brought about by the bioactive food component. Markers could be obtained in vivo (serum, faecal, urinary) as well as in vitro (cytochemical).

Research in the area of bioactive functionality and efficacy is also an opportunity for pre-competitive collaboration between the meat and dairy industries. Research projects could be conducted to develop biomarkers and rapid systems for assessing efficacy.

Recommendation 8: Meat & Livestock Australia and Dairy Australia co-invest in research to develop biomarkers for potential human health effects and rapid systems for assessing efficacy.

4.7.3 Sustainability

The likely impact of climate change on agricultural production and the cost and availability of raw materials are still poorly understood. Modelling has predicted an increased likelihood of reduced water availability, greater temperature fluctuations and extreme weather events. This would have a substantial impact on the production of key food crops with consequences for food and feed production. To contribute to the sustainability of the meat and dairy industries, firms need to maximise their sustainability as businesses.

For opportunities around the commercialisation of bioactives this means ensuring the bioscience processes and technologies involve the application of 'green chemistry' principles. Green chemistry is central to the development of chemical products and processes which require less energy; generate less waste; use less organic solvents or no solvent at all; replace hazardous substances or materials with benign alternatives; permit molecular recycling of the products; and build into their molecular structure the capability that they can be environmentally degraded to harmless materials.

Monash University has recognised the importance of this developing research field and through the financial support of the ARC Special Research Centre program created the Centre for Green Chemistry. Involvement of the meat and dairy industries in the Centre for Green Chemistry will contribute to the transfer of knowledge to industry of sustainability processes and techniques.

Recommendation 9: Meat & Livestock Australia and Dairy Australia take an active role in Monash University's Centre for Green Chemistry in relation to bioscience and bioactives, on behalf of the meat and dairy industries.

4.7.4 Safety and adverse effects

There has been industry and consumer caution that food components may have chronic rather than acute effects on health. When assessing bioactives that could provide beneficial effects, one must also take into account the possible adverse effects that might be exerted by the respective peptides themselves or their by-products that would inevitably be contained in such foods. Such safety requirements include the absence of toxicity, cytotoxicity and allergenicity. Traditionally the consumer safety of food ingredients has been the responsibility of commercial companies. But it is important that industry has a broader and more holistic view to gain an understanding of potential long term effects of refined bioactive compounds or unforeseen reactions with other molecules within a particular food matrix.

Recommendation 10: The meat and dairy industries co-invest in understanding safety issues associated with consumption or application of extracted bioactives in order to address possible future consumer concerns.

4.8 Syndicate projects and Bioscience/bioactives Centre

There exists an opportunity for a dairy-meat industry collaboration to go beyond the scope of precompetitive collaborative projects. Potentially the two industries could cooperate in a number of ways;

1. Syndicated precompetitive research projects and
2. Bioscience Centre for meat and dairy Industries.

Syndicate projects are where a number of organisations or companies co-invest in a specific project that is non competitive in the market place. An example would be a research project to identify and develop relevant biomarkers that can predict potential benefits relating to a target bioactive function in the body and validate their effectiveness. Another syndicate project maybe the development of novel next generation separation and concentration technologies with relevant commercial application. These syndicate projects potentially could involve MLA, DA, commercial firms and research organisations.

A more structured collaboration could be established through the creation of a Bioscience/bioactives Centre for the meat and dairy industries. Such a Centre would have a virtual structure providing the following functions;

- Conduct precompetitive research and development in separations and concentration technologies, bioactive functionality and efficacy, sustainability and safety and adverse effects.
- Facilitate the access to bioscience and bioactives research and development capability for commercial firms;
- Encourage collaborative investment in pre-competitive or broadly-based research objectives;
- Facilitate access to government support programs for both firms and research organisations;
- Facilitate the commercialisation, dissemination of research outcomes, technical know-how and knowledge related to bioscience and bioactives;
- Facilitate the addressing of regulatory issues associated with commercialisation of bioactives in the food and pharmaceutical industries.

Recommendation 11: Meat & Livestock Australia and Dairy Australia facilitate the development of bioactives and bioscience syndicate projects.

Recommendation 12: Meat & Livestock Australia and Dairy Australia undertake a detailed scoping study to determine the need for and feasibility of a Bioscience/bioactives Centre for the meat and dairy industries and develop the business case.

5 Conclusions and Recommendations

The comparison and evaluation of the bioactives/bioscience strategies of Meat & Livestock Australia and Dairy Australia identified a number of opportunities and synergies to collaborate at an industry and enterprise level. This is presented in the form of a series of recommendations for possible future collaboration.

Recommendation 1: Develop and establish a dairy-meat industry professional exchange program for senior innovation and research managers to foster knowledge and skill development and cross fertilisation.

Recommendation 2: Dairy Australia develop and publish a bioactives compendium for the dairy industry similar to the one developed for the meat industry by MLA. The compendium would provide detailed information concerning the many different bioactives that could be commercially exploited from the dairy industry's waste streams. The compendium would cover;

- An overview of Australian Bioactives Industry,
- Bioactives regulatory framework,
- Bioactive extraction and purification technologies,
- Bioactive product data sheets, and
- Bioactive cost estimates.

This information would be useful for dairy companies that are not already involved in bioactive exploitation and for bioactive opportunities that are yet unexploited. Commercial-in-confidence issues will need to be considered to protect the existing opportunities being exploited at a firm level.

Recommendation 3: Dairy Australia conducted workshops with companies on opportunities and processes for the commercialisation of bioactives.

- To bring the industry up to date with the DA bioactives program and market opportunities,
- To increase the industry's awareness of the issues involved in commercialisation bioactives sector,
- Information on regulatory requirements and issues, and
- Workshops involving companies from both the meat and dairy industry.

Recommendation 4: Meat & Livestock Australia and Dairy Australia co-invest in market research and industry analysis projects and activities.

Recommendation 5: Meat & Livestock Australia and Dairy Australia collaborate to develop processes and tools that assist to define the business proposition and the business model: the way in which firms could create and capture value.

Recommendation 6: Meat & Livestock Australia and Dairy Australia co-invest in research and development of novel next generation separation and concentration technologies with relevant commercial application.

Recommendation 7: Meat & Livestock Australia and Dairy Australia co-invest in research to develop new and novel encapsulation technologies as delivery mechanisms within food structures that protect bioactives during processing and consumption.

Recommendation 8: Meat & Livestock Australia and Dairy Australia co-invest in research to develop biomarkers for potential human health effects and rapid systems for assessing efficacy.

Recommendation 9: Meat & Livestock Australia and Dairy Australia take an active role in Monash University's Centre for Green Chemistry in relation to bioscience and bioactives, on behalf of the meat and dairy industries.

Recommendation 10: The meat and dairy industries co-invest in understanding safety issues associated with consumption or application of extracted bioactives in order to address possible future consumer concerns.

Recommendation 11: Meat & Livestock Australia and Dairy Australia facilitate the development of bioactives and bioscience syndicate projects.

Recommendation 12: Meat & Livestock Australia and Dairy Australia undertake a detailed scoping study to determine the need for and feasibility of a Bioscience/bioactives Centre for the meat and dairy industries and develop the business case.

In conclusion, the next steps are for each of the two organisations, Meat & Livestock Australia and Dairy Australia to assess the value of the findings of this study and make a clear decision to develop a collaborative relationship in the area of bioscience and bioactives.

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