



Australia's National
Science Agency

Protein

A Roadmap for unlocking technology-led growth
opportunities for Australia

Executive summary | 2022





Sponsors





Foreword

Australia has long history in agriculture, and around the world we are recognised as leaders in agricultural excellence. CSIRO's own history in agriculture spans more than 100 years, from ridding the land of prickly pear back in 1926, to helping transform our cattle industry through introduction of the Brahman breed, to now developing nutritious grains that combat chronic disease.¹

Today Australia has an opportunity to leverage its agricultural strengths to grow our economy in new markets, to extend our leadership in existing industries, and to sustainably produce and export more food to meet a growing global demand for protein.

By 2050, the Food and Agriculture Organisation estimates we will need to produce 60 per cent more food to feed an expected 9.7 billion people. Currently, 75 per cent of the world's food is produced from five animals and 12 plants.² This concentration makes our food system more vulnerable to threats like disease, pests, and weather. It also presents a tremendous opportunity when you consider the vast biodiversity and nutrient dense foods on the planet that could be incorporated into our diets.

Protein is vital to our health, and as global populations grow and consumer preferences change, we will need to produce more of it, more sustainably, from more sources. But we can't just do what we've done before – we need solutions from science to help create these new markets.

As this *National Protein Roadmap* details, the solution is in agricultural and foodtech innovation to develop new and improved protein-based food products, and new ways to get more value from our traditional animal protein sources. As with any great innovation, it starts with a clear market vision of a better future for Australia, and targets our science at giving Australia an unfair global advantage.

Building on our strengths in agriculture and our reputation as a clean, safe, and high-quality food producer, Australia has a huge opportunity to become a global leader in high quality, value-added protein. We estimate this is nearly an additional \$13 billion market opportunity that will complement – not compete – with our traditional animal protein industries.

1 CSIRO (2020) BARLEYmax. Viewed 14 February 2022 <<https://www.csiro.au/en/research/production/food/BARLEYmax-BUcase-study>>.

2 Searchinger T and Hanson C (2014) Closing the 'Food Gap' Means Renewing the Global Commitment to Crop Breeding . Viewed 14 February 2022, <<https://www.wri.org/insights/closing-food-gap-means-renewing-global-commitment-crop-breeding>>.



Australia is already a significant global producer of premium protein products – like our beloved steaks, lamb, prawns, and barramundi – and there are opportunities to enhance our leadership. Our beef is so highly sought after in export markets that food fraud could impact our growth. This *Roadmap* outlines the opportunity to build on the premium status of our beef with technology to verify the provenance of a product at any point along the supply chain and uncover impersonators.

But the protein market opportunity cannot be met by animal proteins alone. Australia already has strong cropping industries that our science can leverage to grow our plant-based protein output, and if we invest in our manufacturing capability, we can supercharge that growth. We export more than 70 per cent of the bulk protein commodities we produce – like grains, legumes, and meat – and ironically buy them back as finished products. We could capture significantly more value if we invest in our processing and manufacturing facilities to convert these into higher value products for international markets, just as we've demonstrated already creating companies like v2food to bring plant-based protein products onto the mainstream market.

Finally, this *Roadmap* also outlines other protein opportunities for Australia, like sustainable aquaculture with a new white-flesh fish industry, and non-traditional forms of protein like cultivated meat and yeast-based precision fermentation-derived products.

There is room for growth across all protein sectors, but we will need to work together to achieve our goals. In 2021, together with our partners at the Department of Industry, Science, Energy and Resources; Meat & Livestock Australia; the Grains Research & Development Corporation and others, CSIRO launched a Future Protein Mission to co-develop new products and solutions to help our protein industries reach their full potential.

Australia has often been called the food bowl of Asia, but it's time to become the delicatessen of the world – the source of high value, high profit, premium and trusted food products that others strive to copy, but simply can't match. Wouldn't it be great for Australia to be a world leader in food innovation? It's now up to us all to help bring that vision to life, and this *Roadmap* outlines the key science and technology focus areas which will be the building blocks of our success.

Dr Larry Marshall
Chief Executive, CSIRO

Size of the prize for Australian protein



**10.47 million
more
consumers**

For Australian protein products between 2018 and 2030



**65 million
tonnes**

Total domestic and export demand for Australian protein products in 2030



**8.65 million
tonnes**

Additional demand for Australian protein products in 2030 compared to 2018

Source: AgriFutures (2020) The changing landscape of protein production.

Demand is significant and can only be met through a combination of animal proteins, plant proteins and novel protein production systems.

Australian protein industries at a glance

492,000 kt

of animal-based protein consumed globally.³



5,000 kt meat



> 4 billion eggs



≈ 9 billion L milk produced in Australia.⁴

≈ 260 kt



of fisheries products (including fish, crustaceans and molluscs) produced in Australia.⁴

> \$21 billion

in exports of Australian animal-based proteins, including dairy and live exports.⁴

28,000 businesses

in Australian animal-based protein industries.⁵



≈ 210,000 employed

in Australian animal-based protein industries.⁶

≈ \$10 billion

in exports of grains, oilseeds and pulses.⁷



≈ \$3 million

in exports of plant-based protein alternatives.⁸



≈ 550 employed

in the Australian plant-based protein alternatives industry.⁸

3 OECD (2021) OECD Agriculture Statistics. Viewed 11 January 2021, <https://stats.oecd.org/BrandedView.aspx?oeed_bv_id=agr-data-en&doi=4bde2d83-en>. Covers beef and veal, pork, poultry, sheep and fish.

4 See Appendix B protein snapshots.

5 Counted as businesses with one or more employees operating in livestock farming, fisheries and aquaculture, hunting and trapping, meat and seafood product processing and manufacturing, and dairy product processing and manufacturing. ABS (2021) Counts of Australian Businesses, including Entries and Exits. Viewed 11 January 2022, <<https://www.abs.gov.au/statistics/economy/business-indicators/counts-australian-businesses-including-entries-and-exits/latest-release>>.

6 Counted as 'sheep, beef cattle and grain', 'dairy cattle', 'poultry', 'other livestock', 'aquaculture', 'fishing' and 'hunting and trapping' industries. Australian Bureau of Agricultural and Resource Economics and Sciences (2020) Agricultural commodities and trade data - Australian economy - farm sector.

7 Australian Bureau of Agricultural and Resource Economics and Sciences (2021) Agricultural commodities June quarter 2021: Value of agricultural, fisheries and forestry exports (fob), Australia.

8 Food Frontier (2021) 2020 State of the Industry Australia's Plant-Based Meat Sector.



Technology-led opportunities for Australia

	Current state	Conservative 2030 scenario		Ambitious 2030 scenario
Total Australian protein sector (domestic + exports)	\$56 billion	\$76 billion	Additional technology-led opportunity	\$89 billion
Roadmap opportunities	\$16.7 billion	\$22.1 billion	\$13 billion	\$34.9 billion
Integrity systems for red meat exports	\$15.3 billion*	\$16.5 billion	\$570 million	\$17.1 billion
Plant-based products	\$140 million	\$3.0 billion	\$6 billion	\$9.0 billion
Red meat for health and wellness markets	\$1 billion	\$1.4 billion	\$3.8 billion	\$5.1 billion
Precision fermentation	Negligible	\$750 million	\$1.45 billion	\$2.2 billion
White flesh fish	\$300 million	\$460 million	\$1.04 billion	\$1.5 billion
Insect protein sources	Negligible	\$12 million	\$32 million	\$44 million
Total jobs in Roadmap opportunities		4,490 jobs	9,860 jobs	14,350 jobs

Note: Four additional opportunities have been qualitatively explored in this roadmap but their economic size and potential growth have not been quantitatively assessed.

Sources: Estimate of current state for the Australian protein sector is taken from FIAL (2019) Protein Market: Size of the Prize Analysis for Australia; estimate of conservative scenario in 2030 for the Australian protein sector is taken from AgriFutures (2020) The changing landscape of protein production. All other estimates are CSIRO calculations.

*Estimate of current state for integrity systems for red meat exports is the current revenue Australia earns from red meat exports with its current integrity systems in place, estimates of conservative and ambitious scenarios in 2030 for integrity systems for red meat exports are the estimated 2030 export revenue from red meat exports with low (conservative) and high (ambitious) enhancement of these systems to enable traceability and verifiable credentials.



Executive summary

Our objectives

To create almost an additional \$13 billion in science and technology driven protein opportunities for Australia by 2030, products and ingredients must meet or exceed consumer needs and the industry should focus on value-adding in areas where Australia has a competitive advantage.

To become a global leader in high quality, value-added protein, the focus should be on product quality and attributes, including health, welfare and environmental credentials.

Purpose of roadmap

To develop, in collaboration with stakeholders, a blueprint to guide investments in science, technology and infrastructure initiatives that contribute to the protein industry's productivity and profitability, sustainability, regional prosperity and global competitiveness.

Why now for protein?

Growing global protein demand, changing consumer preferences, and increasing investment and innovation are all driving an intensified focus on the protein industry. Now is the time to build a sustainable and resilient Australian food system that delivers protein for discerning local and global consumers.

Why Australia?

Australia is well positioned to capitalise on the growing protein opportunity to become a global leader through growth and expansion of established products and markets, and the sustainable development of novel and differentiated protein products. The nation's agriculture and food industry is supported by a strong history of research and production excellence, proximity to growing Asian markets, a reputation for producing premium and safe food products, strong biosecurity, and commitments towards growth and development of sovereign value adding capabilities.

Strategic science and technology focus areas

1 Strengthening product integrity and market access

Continuing to invest in the essential R&D and infrastructure that underpin the global competitiveness of Australian protein products and ingredients. This will ensure Australian manufacturers have the systems needed to demonstrate and communicate the positive attributes of their products, whether through food safety measures, supply chain traceability, or compliance with local or international trading partner standards and regulations. This will in turn reduce technical trade barriers, position Australia favourably in trade negotiations and support Australia's preferential access to key markets, such as **expanding Australian red meat exports into new geographies**. Although product integrity and market access are key strategic focus areas across Australia's protein industry, this roadmap specifically explores **integrity systems in the red meat sector**.

2 Optimising quality and cost competitiveness

Continuing to invest in the essential R&D and infrastructure that underpin the quality⁹ and cost competitiveness of Australian protein products and ingredients. This will ensure Australian manufacturers have the inputs needed to produce higher value products and that Australian protein is preferred by customers and consumers. While quality and cost optimisation is important across the protein industry, this report explores **plant-based protein ingredients** and **crop breeding and pre-breeding**.

3 Maximising resources and circularity

Transforming what is currently considered low value or waste into high value products and ingredients and incorporating circularity principles into the supply chain. This will capture value and increase producer and processor profitability through product and market diversification. Examples of opportunities to transform waste and lower value by-products into higher value products include **red meat co-products** for health and wellness markets and **insect protein** sources for food and feed.

4 Enabling the scale-up of high growth sectors

Identifying sectors that are currently relatively small in Australia but have high growth potential and supporting their scale-up. This will capture additional value and increase profitability, alongside more mature existing sectors. Examples of high growth sectors include local, sustainable **white flesh fish** and **plant-based products**.

5 Developing novel production systems

Identifying new methods for producing protein through targeted investments in R&D and infrastructure. This will involve having a focused and targeted investment portfolio aimed at capturing value, optimising resources and leveraging Australia's comparative advantages. Examples of novel production opportunities include **precision fermentation** and **cultivated meats**.

The science, technology and infrastructure investment priorities identified for each of these opportunities are shown in Table 1.

⁹ In this context, quality means meeting or exceeding customer expectations regarding the properties and attributes of food items, including its appearance, texture, flavour, nutritional content and its ethical and sustainable production.

Ecosystem priorities

In addition to the strategic science and technology areas, this roadmap also sets out five priorities to guide activities for whole of ecosystem benefit and to monitor progress. For each priority, areas of consideration are identified.

<p>Producers, communities and regions</p> 	<p>Producers, communities and regions recognise the role that the protein industry plays in food production and economic prosperity; and see being part of the Australian protein industry as attractive now and into the future.</p>	<ul style="list-style-type: none"> • Support primary producers with technology adoption, data and insights • Develop an appropriately skilled workforce • Engage and co-develop with Australian First Nations Peoples • Support the development of regional communities to support agriculture • Stabilise high-protein crop price and demand
<p>Customers and consumers</p> 	<p>Customers and consumers are engaged and seek high value, high quality, and trustworthy Australian products.</p>	<ul style="list-style-type: none"> • Conduct consumer sentiment and sensory research • Develop consumer communication and engagement plans for non-traditional proteins • Early community engagement for cultivated meat • Support consumer acceptance of insect proteins
<p>Environment</p> 	<p>Australian protein production increases while also protecting ecosystem health and biodiversity, and meeting consumer and market expectations for sustainability and biosecurity.</p>	<ul style="list-style-type: none"> • Sustainability considerations for red meat production • Whole-of-food-system view of healthy sustainable diets • Consumer access to lower environmental impact food products and knowledge • Understand impact through Life Cycle Analysis
<p>Coordination and collaboration</p> 	<p>The Australian protein industry sees the significant global opportunity for all types of protein and is coordinated and collaborative in pursuing this opportunity.</p>	<ul style="list-style-type: none"> • Establish dedicated industry development for novel protein production • Learn from international protein industry development (policy and scale-up) • Engage with industry incumbents • Share knowledge across industry • Develop new business models and supply chains • Coordinate and collaborate for animal protein product integrity • Support cross-sector collaboration • Facilitate the development of protein innovation clusters and accelerators
<p>Policy and regulation</p> 	<p>The Australian protein industry is well supported by policy and regulations that enable the industry to compete globally and deliver high quality products to local and export markets.</p>	<ul style="list-style-type: none"> • Deliver streamlined compliance for protein exporters • Review process for aquaculture farm licenses • Provide regulatory clarity for new and novel foods • Enable a safe but proactive regulatory environment for precision fermentation • Develop science-informed food safety standards for cultivated meats • Develop insect industry guidelines • Continue policy and government infrastructure support

Table 1: 2022-2030 science technology and infrastructure investment priorities for identified opportunities

SCIENCE AND TECHNOLOGY FOCUS AREA	INDUSTRY OPPORTUNITIES	2022-2030 SCIENCE, TECHNOLOGY AND INFRASTRUCTURE INVESTMENT PRIORITIES
Strengthening product integrity and market access	1: Integrity systems in the red meat sector	<ul style="list-style-type: none"> • Verify the biological and geographical origin of production • Research and infrastructure to help establish and utilise data from production systems • Design new systems-based compliance • Conduct preventative risk assessments • Support compliance infrastructure
	2: Expanding Australian red meat exports into new geographic markets	<ul style="list-style-type: none"> • Support the development of logistics and cold chain management • Research to support new product innovation • Maintain and enhance reputation for clean, safe and natural products
Optimising quality and cost competitiveness	3: Plant-based protein ingredients	<ul style="list-style-type: none"> • Optimise fractionation technology • Secure capital for infrastructure • Obtain market information for plant-based products • Set supported production targets • Support research infrastructure development • Research to support technology and process development for protein extraction
	4: Crop breeding and pre-breeding	<ul style="list-style-type: none"> • Develop supply chain infrastructure • Invest in R&D programs
Maximising resources and circularity	5: Red meat co-products for health and wellness markets	<ul style="list-style-type: none"> • Remap the carcass • Research to understand new product markets and value chains • Research to understand customer needs and willingness to pay • Process engineering for co-product collection and transformation • Support evidence-based claims • Develop and demonstrate origin marker technology
	6: Insect protein sources for food and feed	<ul style="list-style-type: none"> • Investigate feasibility of co-location and sharing • Research to support insect waste management potential • Research to understand the nutritional profile of insects • Support progressive insect infrastructure scale-up • Support regulatory process development for insects

Key: ● Traditional protein ● Plant protein ● Non-traditional protein

SCIENCE AND TECHNOLOGY FOCUS AREA	INDUSTRY OPPORTUNITIES	2022-2030 SCIENCE, TECHNOLOGY AND INFRASTRUCTURE INVESTMENT PRIORITIES
Enabling the scale-up of high growth sectors	7: Scaling up local, sustainable white flesh fish production	<ul style="list-style-type: none"> • Investment in cross-sector infrastructure and services • Identify suitable white flesh fish species • Understand consumer expectations for aquaculture • Research to support aquaculture production enhancement • Research to understand and address aquaculture-environmental interactions and climate impacts
	8: Plant-based products	<ul style="list-style-type: none"> • Scaling up processing infrastructure • Services and skills to support food manufacturers and start-ups • Investment in collaborative R&D and prototyping facilities • Establish domestic ingredient supply chains • Invest in plant-based product R&D
Developing novel protein production systems	9: Precision fermentation	<ul style="list-style-type: none"> • Investigate and support pilot scale facilities • Support collaboration with adjacent sectors and infrastructure for precision fermentation scale-up • Services for precision fermentation scale-up • Research to support microorganism engineering and strain development and optimisation • Research to support feedstock selection, optimisation, and process improvement • Research to understand manufacturer and consumer needs • Life Cycle Analysis to understand impact • Research to understand nutritional profile of precision fermentation products • Precision fermentation product development
	10: Cultivated meats	<ul style="list-style-type: none"> • Optimise cell culture media • Identify cell sources for cultivated meat • Cultivated meat product development • Research to support food safety • Research to inform bioprocess development • Research to understand consumer preferences

As Australia's national science agency and innovation catalyst, CSIRO is solving the greatest challenges through innovative science and technology.

CSIRO. Unlocking a better future for everyone.

Contact us

1300 363 400
csiro.au/contact
csiro.au

For further information

CSIRO Agriculture and Food
Future Protein Mission
Michelle Colgrave
+61 7 3214 2697
csiro.au/about/challenges-missions/future-protein-mission