LIBRARY OF PARLIAMENT
BIBLIOTHÈQUE DU PARLEMENT

HillStudies

In-depth reads on Canadian topics

EXPANDING PROTEIN OPTIONS: EMERGING SCIENCE AND POLICY IMPLICATIONS

Publication No. 2025-07-E

30 May 2025

Kelsey Brennan

Research and Education

AUTHORSHIP

30 May 2025 Kelsey Brennan

ABOUT THIS PUBLICATION

Library of Parliament HillStudies provide in-depth studies of policy issues. They feature historical background, current information and references, and often anticipate the emergence of the issues they examine. They are prepared by Research and Education, which carries out research for and provides information and analysis to parliamentarians, Senate and House of Commons committees and parliamentary associations in an objective, impartial manner.

Expanding Protein Options: Emerging Science and Policy Implications
(HillStudies)

Publication No. 2025-07-E

Ce document est également publié en français.

CONTENTS

EXECUTIVE SUMMARY

Population and income growth are leading to an increasing demand for animal proteins. However, there are concerns related to the world's capacity to meet that growing demand, as well as to the environmental and health effects of diets high in animal proteins. These factors have spurred interest in alternative protein sources such as plant-based, insect and cultured (or lab-grown) proteins. Each of these protein sources presents unique benefits, challenges and policy implications for Canada.

Animal proteins are derived from livestock farming, aquaculture, fishing, hunting and trapping activities. Animal protein production, particularly large-scale livestock farming, is associated with environmental harms such as greenhouse gas emissions and unsustainable freshwater usage. Moreover, high consumption of animal proteins, particularly red and processed meats, is linked to a higher risk of cardiovascular disease. However, by using pastureland to store carbon, responsible livestock farming can contribute to environmental sustainability. Also, fishing, hunting and trapping are culturally significant activities, particularly among many Indigenous peoples.

Plant proteins include legumes, nuts, seeds and meat substitutes like tofu. Plant proteins are generally more environmentally sustainable than animal proteins, with lower demands on land, water and energy use, and lower greenhouse gas emissions. While a balanced plant-based diet can help lower the risk of cardiovascular disease, certain plant-based diets may lead to nutrient deficiencies.

Insects such as crickets and beetles are high in protein and make for an environmentally efficient food source, requiring fewer resources to produce than animal farming. However, there are concerns regarding their safety for human consumption, particularly related to allergies, and they face low levels of consumer acceptance.

Cultured proteins are produced from animal cells in labs. Cultured protein production could lead to reduced environmental impacts compared to conventional farming. They also offer the potential for increased food security: because cultured proteins are produced in labs, they are not subject to the climate variations that often influence animal and plant protein production. However, the energy required to produce cultured proteins is relatively high, and they face challenges related to consumer acceptability.

To feed a growing population in need of protein, governments, private companies and other industry stakeholders are looking to a variety of sources. Changing the proportion of different protein sources in the diets of Canadians, whether due to environmental concerns, changing demand, health concerns or other factors, will

likely have policy implications related to public health, climate change, employment, and research and development.

EXPANDING PROTEIN OPTIONS: EMERGING SCIENCE AND POLICY IMPLICATIONS

1 INTRODUCTION

In 2022, the world population reached 8 billion, and it is expected to grow to nearly 10 billion by 2050.[1] This population growth, coupled with income growth, is expected to increase the consumption of animal proteins such as meat, eggs and milk. The Organisation for Economic Co-operation and Development (OECD) projects that the global consumption of meat will increase 12% by 2033 compared to the 2021–2023 average.[2]

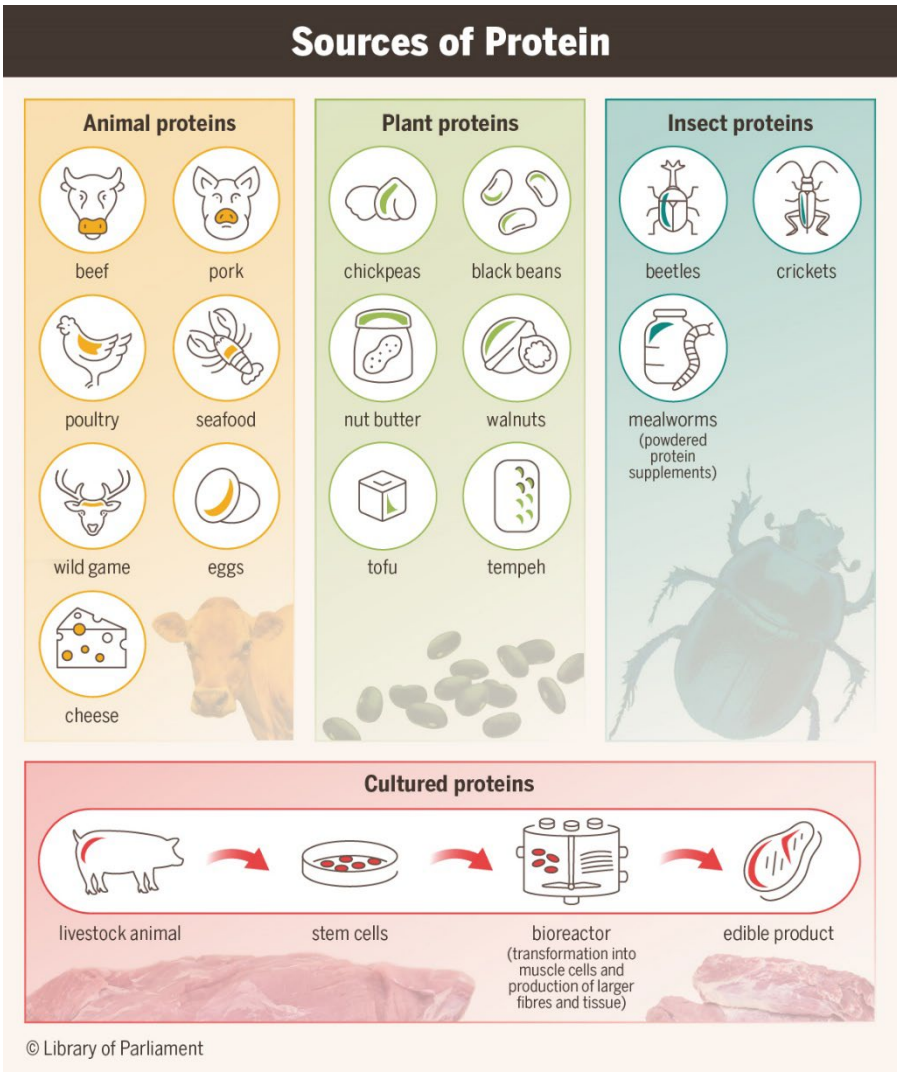
The increasing demand for animal proteins, combined with concerns over the potential environmental and health implications of consuming diets high in animal proteins, has led to an increasing interest in supplementary or alternative sources of protein such as plant proteins, insect proteins and cultured, or lab-grown, proteins. The OECD has indicated that food systems globally face a "triple challenge": ensuring food security and nutrition, providing livelihoods to farmers and others employed in the food chain, and supporting environmental sustainability.[3]

The different sources of protein mentioned in this HillStudy have their own advantages and drawbacks, as well as implications for Canadian government policies and programs pertaining to health, employment, innovation and the environment.

2 SOURCES OF PROTEIN

Protein is a fundamental requirement of a healthy diet, contributing to muscle and bone development and maintenance.[4] Protein needs are likely to be met through a combination of protein sources, such as those illustrated in Figure 1.

Figure 1 – Sources of Protein



Sources: Figure prepared by the Library of Parliament using information obtained from Government of Canada, "Cooking with plant-based protein foods," *Canada's food guide*; and Hanna L. Tuomisto, "The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products?," *EMBO reports*, Vol. 20, No. 1, 14 December 2018.

In Canada's Dietary Guidelines, Health Canada recommends consuming foods rich in protein regularly, including "legumes, nuts, seeds, tofu, fortified soy beverage[s], fish, shellfish, eggs, poultry, lean red meat including wild game, lower fat milk, lower fat yogurts, lower fat kefir, and cheeses lower in fat and sodium."[5] The guidelines encourage consuming plant proteins more often than other sources of protein, and lowering intakes of processed meat and foods high in saturated fat, such as red meat and full-fat dairy products.

2.1 ANIMAL PROTEINS

In its report entitled *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, the Council of Canadian Academies (CCA) stated that Canada's meat industry contributes "significantly to Canada's exports and processing sector," with annual sales totalling over $35 billion in 2021.[6]

Animal proteins come from livestock farming and aquaculture, as well as hunting, fishing and trapping activities. In 2021, the OECD reported that food derived from animals accounts for "[a] third of global protein intake and 17% of calories."[7]

Many studies maintain that animal proteins derived from livestock farming and aquaculture, particularly when conducted at large scale, contribute to environmental harm, including greenhouse gas emissions, deforestation, biodiversity loss, unsustainable freshwater usage, the eutrophication of aquatic ecosystems (i.e., excessive concentrations of nutrients in water), and soil acidification.[8] The OECD estimates that approximately 8% of human-generated greenhouse gas emissions are due to livestock.[9] However, some researchers have argued that the environmental impacts of producing different animal proteins vary, with beef farming associated with particularly large greenhouse gas emissions and land use compared to pork and poultry farming.[10] Scientific advancements in livestock production can also help mitigate environmental harm. For example, the Canadian Food Inspection Agency released a consultation report in 2024 regarding a new livestock feed ingredient with the potential to reduce methane emissions from cattle farming by modifying gastrointestinal processes within livestock, with most of the stakeholders consulted supporting its use.[11]

Furthermore, it has been suggested that livestock farming can play an important role in sustainable agricultural systems.[12] For example, pastures store large quantities of carbon in their soil, and mixed livestock and crop rotation systems can protect against soil erosion by using cover crops for animal feed and recycling nutrients as fertilizer for subsequent crops.

In addition, livestock farming, along with hunting, fishing and trapping activities, can contribute to species management and environmental monitoring, and promote cultural engagement and healthy behaviour.[13] Statistics Canada and the CCA have both discussed how hunting, fishing and trapping are particularly important cultural activities among Canada's many Indigenous groups and contribute to promoting food security, food sovereignty, and improved physical and mental health outcomes among participants.[14]

According to the OECD, "[u]nder-consumption of animal proteins is linked to malnutrition and stunting with serious health outcomes globally."[15] However, they also report concerns about the health implications of diets high in animal proteins. For example, overconsumption of red and processed meat can lead to an increased risk of developing cardiovascular diseases.[16]

Recent years have also seen reports of cases of novel pathogens or zoonotic viruses being transmitted from livestock or harvested animals to humans.[17] Researchers have also found that antibiotic use associated with livestock farming, particularly at industrial levels, accounts for a large proportion of all antibiotic use and can, when overused, promote antimicrobial resistance.[18] The World Health Organization considers antimicrobial resistance "one of the top global public health and development threats."[19]

A study examining the willingness of older consumers in the European Union to accept alternative protein sources found a generally low willingness to change protein consumption behaviour.[20] That unwillingness can be attributed, at least partially, to challenges associated with changing habits, concern over higher food prices associated with protein alternatives, a lack of familiarity with other proteins, and a lack of knowledge on how to prepare meals with unfamiliar ingredients.[21]

2.2 PLANT PROTEINS

Plant proteins include a variety of foods, such as legumes, nuts, seeds and seaweed, as well as meat substitutes like tofu and tempeh, which are both derived from soybeans. Plant-based meat substitute brands, such as Beyond Meat and Impossible Foods from the United States, have emerged and gained increasing public recognition in recent years. Mushrooms are sometimes considered as part of this category, although they are not technically plants, but fungi.

Canada's plant protein sector is significant. The CCA reports that Canada is "a leader in the export of protein-rich crops, including wheat, soy, oats, chickpeas, fava beans, dry peas, and canola."[22]

A 2023 article from the *European Heart Journal* reported that a balanced plant-based diet can have health benefits related to lowering the risk of cardiometabolic disease such as type 2 diabetes; however, the article went on to note that certain plant-based diets can lead to health risks, such as those related to nutrient deficiencies.[23] Further, evidence from a study from the United States' Centers for Disease Control and Prevention demonstrates that cardiometabolic disease rates vary significantly based on other factors that are not subject to behavioural changes, such as racial and ethnic identity.[24]

When considering all stages of the supply chain, from farm to fork, the production of plant proteins is generally considered to be more environmentally sustainable than the production of animal proteins, with lower demands on land, water and energy use and lower greenhouse gas emissions, although there is variation depending on the type of animal or plant protein produced (e.g., beef production is particularly resource intensive).[25]

2.3 INSECT PROTEINS

Many species of insect, such as beetles and crickets, are suitable for human consumption. Insect proteins also have the potential to support livestock farming and aquaculture as a source of feed, and they are increasingly being used to feed pigs and salmon.[26] For example, in 2022 the Canadian Food Inspection Agency approved black soldier fly larvae as animal feed.[27]

Insects have a high protein content by weight and are cultivated using low levels of land and water resources. This process results in lower greenhouse gas emissions than the production of animal proteins.[28] Insects can also feed on organic waste, reducing the impact of environmental pollution.[29]

However, insects do present some food safety concerns. For example, it has been reported that some edible insects, such as those used in the food dye carmine, which is made from the bodies of female cochineal insects, can cause allergic reactions.[30] Insect proteins also have the lowest consumer acceptance levels of the protein sources discussed here, although consumption is greater among certain ethnicities and cultural backgrounds.[31]

2.4 CULTURED PROTEINS

Cultured proteins are animal products created in a controlled laboratory environment using stem cells collected through an animal biopsy. Other terms used to describe these types of protein are “cultivated,” “clean,” “slaughter-free,” “in vitro,” “lab-grown” and “synthetic.” The process can be used to develop both meat and animal by-products such as dairy.

Research to date has found that cultured protein production, while limited, has produced less methane than conventional cattle farming to generate the same amount of meat.[32] More generally, as cultured proteins have not yet reached the market, it is difficult to know what the overall environmental impact of their production at scale will be, but there are early indications that they may use significantly less land and water than traditional livestock farming.[33] Cultured protein production does require significant amounts of energy, however, and the source of this energy (i.e., renewables versus fossil fuels) may dictate whether it is responsible for higher or lower carbon emissions than traditional animal protein production (which already varies depending on the species being farmed).[34]

Cultured proteins are produced in a sterile lab environment, reducing the need to use antibiotics and any exposure to potential pathogen contamination.[35] Cultured proteins also have the potential to address food security concerns derived from environmental factors, as they can be produced indoors during unfavourable external weather conditions, such as droughts, flooding and hailstorms.[36] According to

Statistics Canada data from 2021 to 2022, food insecurity, or the inability to acquire or consume sufficient quantities of nutritious food in socially acceptable ways, affected 16.9% of Canadians.[37] However, food insecurity does not affect all Canadians equally. Rates of food insecurity are higher for the following groups:

- those living in poverty (34.0%) compared to those not living in poverty (15.0%);
- those in lone-parent families (34.0%) compared to couples without children (11.1%); and
- Indigenous people aged 15 years and older (excluding those living on reserve or in the territories) (28.6%) compared to non-Indigenous people aged 15 years and older (15.7%).[38]

There is ongoing discussion as to how cultured proteins fit into religious dietary restrictions, such as halal in Islam and kosher in Judaism.[39] Cultured proteins also face challenges around being considered "unnatural" in comparison to other sources of protein.[40]

3 POLICY IMPACTS

3.1 FOOD REGULATION

Health Canada and the Canadian Food Inspection Agency are responsible for overseeing the safety and nutritional quality of food sold in Canada, in accordance with the *Food and Drugs Act*, the *Food and Drug Regulations* and the *Safe Food for Canadians Act*.[41] With respect to protein products, particularly alternatives to animal protein, these legal instruments:

- prohibit food from being labelled, packaged, sold or advertised in a false, misleading or deceptive manner in regard to its character, value or composition;
- set out how simulated meat products should be labelled;
- define terms such as meat and milk;
- outline content requirements for simulated meat products; and
- define novel food and outline requirements for the sale and advertising of such food, including that manufacturers or importers of novel food notify the Minister of Health in writing of their intentions prior to bringing the novel food to market.

Health Canada uses the term "cellular agriculture" to describe the "production of food usually derived from animals (meat, seafood, eggs, milk products) using cell culture methods instead of live animals."[42]

3.2 PUBLIC HEALTH

The Government of Canada has played a key role in raising public awareness about food safety standards and healthy eating, through such initiatives as the previously mentioned Dietary Guidelines. When it comes to protein sources, *Canada's food guide*, produced by Health Canada, has identified the roles that different types of protein play in a healthy diet and their relative impacts on different health risk factors.[43]

Some observers of public health campaigns have noted that "particular social groups (e.g., women, ethnic minorities) often become the target of food-safety campaigns and other state interventions."[44] Campaigns tailored to specific audiences may appeal to social norms, such as those related to the person in a household who is responsible for food shopping and preparation, or that make reference to cultural eating practices, such as halal dietary rules governing the preparation of beef, poultry and lamb for human consumption.[45] When properly designed, these campaigns can ensure that diverse groups feel represented by and included in public health messaging. Thus, there is a greater likelihood that they will adopt the practices highlighted by that messaging. However, targeted messaging may also promote stereotypes when used inappropriately.

3.3 CLIMATE CHANGE AND EMISSIONS REDUCTIONS

As mentioned previously, the production of different proteins results in different carbon and methane emissions. A 2021 article on cultured meat compared the varying environmental impacts of animal proteins, plant proteins and cultured meat. In reviewing research on the topic, the author concluded that beef generally has the highest environmental impacts related to greenhouse gas emissions, eutrophication and land use, compared to other livestock animal proteins (pork and chicken), plant proteins and cultured proteins. However, the energy required to produce cultured proteins was found to exceed that needed to produce all other protein sources examined. Similarly, the greenhouse gas emissions associated with the production of cultured proteins also exceeded those linked to the production of all other protein sources examined except beef. It should be noted that these estimates assumed no reduction in the greenhouse gas emissions related to energy production over time, such as through increased adoption of renewable energy sources.[46]

In 2022, the agricultural sector accounted for 10% of Canada's total greenhouse gas emissions.[47] However, agricultural soil also absorbs and stores a significant amount of carbon, with Canada's 2030 Emissions Reduction Plan reporting that in 2019, approximately 6% of the total annual greenhouse gas emissions from the agricultural sector were offset by carbon stored in agricultural soil.[48]

The agricultural sector is particularly vulnerable to the impacts of climate change, including increased frequency of droughts, floods and severe storms, which may

affect its ability to meet rising consumer demand for animal proteins and other food products.[49] This vulnerability could serve as a motivation for exploring other protein options, such as cultured proteins. In the words of one researcher, "[s]ince cultured meat can be produced indoors during unfavorable external conditions, such as natural disasters, it may lower global food insecurity."[50]

3.4 EMPLOYMENT

Agriculture and Agri-Food Canada reported that, in 2023, Canada's agriculture and agri-food system employed 2.3 million people, with primary agriculture – work performed within the boundaries of a farm, nursery or greenhouse – employing 247,200 people and animal production employing 106,700.[51] Meanwhile, the food and beverage processing sector – transforming raw food and substances into new products – employed 322,600 people.[52] Statistics Canada provided a further breakdown of food manufacturing employment in 2022, reporting that:

- 10,737 persons were employed in animal food manufacturing;
- 27,424 persons were employed in dairy product manufacturing;
- 64,059 persons were employed in meat product manufacturing; and
- 20,264 persons were employed in seafood product preparation and packaging.[53]

More generally, employment in primary agriculture tends to be concentrated in rural areas in certain parts of the country, such as the Prairies, Quebec and southern Ontario, where the local economy is dependent on it. Almost half of agricultural employment is on a seasonal basis, with a high reliance on temporary foreign workers to meet labour needs, especially during the growing season of May to November.[54]

Some foreign jurisdictions, such as Italy and Florida, have enacted policies that restrict the development of alternative proteins, such as cultured proteins, because of concern for a loss of employment in the primary agricultural sector.[55]

While the development of alternative proteins will no doubt create new jobs, these will likely require different skills and may be located in different regions than where meat and dairy are currently produced.[56] For example, Protein Industries Canada, a not-for-profit organization supporting plant protein development as one of Canada's Global Innovation Clusters, has estimated that their projects could support 10,800 direct and indirect jobs by 31 March 2031.[57]

3.5 FEDERAL INVESTMENT IN SCIENCE AND INNOVATION

The OECD reported in 2021 that "public funding for agricultural [research and development] has been falling in real terms over the past decade in high-income countries."[58]

Agriculture and Agri-Food Canada's Strategic Plan for Science, released in 2022, identified four priority areas "to ensure a sustainable, resilient, and profitable agriculture and agri-food sector by 2050 in four priority areas":

- mitigating the impacts of and adapting to climate change;
- increasing the resiliency of agro-ecosystems;
- advancing the circular economy through value-added opportunities; and
- accelerating digital transformation in the agricultural and agri-food sectors.[59]

For example, cellular agriculture and insect farming were identified as promising innovations that support the circular bioeconomy, an economic model that encourages sustainable resource utilization in part through the reuse and transformation of waste, such as the use of agricultural by-products in insect farming. The OECD, meanwhile, has promoted research and development on livestock and crop breeding to "accelerate the productivity and climate resilience of both crop and animal agriculture in the decades to come."[60]

Protein Industries Canada supports research and innovation related to agriculture and the development of plant-based meat alternatives and new food products.[61] In February 2023, Protein Industries Canada received a renewed investment of $150 million from the Government of Canada, bringing its total funding from 2018 through to 2028 up to $353 million.[62]

Cultured protein, meanwhile, is still in the early stages of commercialization and will require additional research and development before it becomes widely available at the retail level.[63] Furthermore, given the costs of product development and the lack of an established market, it may take time for some cultured protein businesses to turn a profit. For example, an early prototype of a cultured burger developed in 2013 estimated that it cost approximately US$325,000 to produce a single burger.[64] Federal research and development funding programs, such as the National Research Council of Canada Industrial Research Assistance Program and the Venture Capital Action Plan, could play a role in supporting further growth in the cultured protein industry.[65]

As the CCA notes, "[t]echnological advancements that diversify Canada's protein portfolio may support innovation and increase food system resilience and choice for consumers."[66]

NOTES

1. United Nations, *Population*.

2. Organisation for Economic Co-operation and Development (OECD) and Food and Agriculture Organization of the United Nations (FAO), *OECD-FAO Agricultural Outlook 2024–2033*, 2 July 2024.

3. OECD, *Making Better Policies for Food Systems*, 2021, p. 9.

4. Government of Canada, *Protein*; and Council of Canadian Academies (CCA), *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 43.

5. Government of Canada, *Canada's Dietary Guidelines: Section 1 – Foundation for healthy eating*.

6. CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 44.

7. OECD, *Making Better Policies for Food Systems*, 2021, p. 174.

8. Piotr Rzymski et al., "COVID-19 Pandemic Is a Call to Search for Alternative Protein Sources as Food and Feed: A Review of Possibilities," *Nutrients*, Vol. 13, No. 1, 5 January 2021; Alessandra C. Grasso et al., "Older Consumers' Readiness to Accept Alternative, More Sustainable Protein Sources in the European Union," *Nutrients*, Vol. 11, No. 8, 15 August 2019; Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021 (PubMed); Hanna L. Tuomisto, "The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products?," *EMBO reports*, Vol. 20, No. 1, 14 December 2018; Jihee Hwang et al., "Factors Affecting Consumers' Alternative Meats Buying Intentions: Plant-Based Meat Alternative and Cultured Meat," *Sustainability*, Vol. 12, No. 14, 14 July 2020; Zuhaib Fayaz Bhat and Hina Fayaz, "Prospectus of cultured meat – advancing meat alternatives," *Journal of Food Science and Technology*, Vol. 48, No. 2, 30 December 2010; and OECD, *Making Better Policies for Food Systems*, 2021.

9. OECD, *Making Better Policies for Food Systems*, 2021.

10. Hanna L. Tuomisto, "The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products?," *EMBO reports*, Vol. 20, No. 1, 14 December 2018; and Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021.

11. Government of Canada, *What we heard report: Proposed new livestock feed ingredient – 3 Nitrooxypropanol (3-NOP)*.

12. Hanna L. Tuomisto, "The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products?," *EMBO reports*, Vol. 20, No. 1, 14 December 2018.

13. Ibid.

14. Mohan B. Kumar et al., *Harvesting activities among First Nations people living off reserve, Métis and Inuit: Time trends, barriers and associated factors*, Aboriginal Peoples Survey, Statistics Canada, 16 April 2019; and CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 46.

15. OECD, *Making Better Policies for Food Systems*, 2021, p. 175.

16. Ibid.; and Zuhaib Fayaz Bhat and Hina Fayaz, "Prospectus of cultured meat – advancing meat alternatives," *Journal of Food Science and Technology*, Vol. 48, No. 2, 30 December 2010.

17. Zuhaib Fayaz Bhat and Hina Fayaz, "Prospectus of cultured meat – advancing meat alternatives," *Journal of Food Science and Technology*, Vol. 48, No. 2, 30 December 2010; Piotr Rzymski et al., "COVID-19 Pandemic Is a Call to Search for Alternative Protein Sources as Food and Feed: A Review of Possibilities," *Nutrients*, Vol. 13, No. 1, 5 January 2021; and Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021.

18. OECD, *Making Better Policies for Food Systems*, 2021; Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021; Christopher J. Bryant, "Culture, meat, and cultured meat," *Journal of Animal Science*, Vol. 98, No. 8, 3 August 2020; Zuhaib Fayaz Bhat and Hina Fayaz, "Prospectus of cultured meat – advancing meat alternatives," *Journal of Food Science and Technology*, Vol. 48, No. 2, 30 December 2010; Piotr Rzymski et al., "COVID-19 Pandemic Is a Call to Search for Alternative Protein Sources as Food and Feed: A Review of Possibilities," *Nutrients*, Vol. 13, No. 1, 5 January 2021; and Silvia Malagoli, "Italy is set to ban lab-grown meat – here's why it should think again," *The Conversation*, 14 April 2023.

19. World Health Organization, *Antimicrobial resistance*, 21 November 2023.

20. Alessandra C. Grasso et al., "Older Consumers' Readiness to Accept Alternative, More Sustainable Protein Sources in the European Union," *Nutrients*, Vol. 11, No. 8, 15 August 2019.

21. Ibid.; Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021; and July Nguyen et al., "Alternative protein consumption: A systematic review and future research directions," *International Journal of Consumer Studies*, Vol. 46, No. 5, 1 March 2022 [SUBSCRIPTION REQUIRED].

22. CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 44.

23. T. Wang et al., *Benefits and Drawbacks of Vegetarian and Vegan Diets: Key Points*, *European Heart Journal*, Volume 44, Issue 36, 21 September 2023.

24. Alain K. Koyama et al., "Prevalence of Cardiometabolic Diseases Among Racial and Ethnic Subgroups in Adults – Behavioral Risk Factor Surveillance System, United States, 2013–2021," *Centers for Disease Control and Prevention Morbidity and Mortality Weekly Report*, Vol. 73, No. 3, 25 January 2024.

25. Piotr Rzymski et al., "COVID-19 Pandemic Is a Call to Search for Alternative Protein Sources as Food and Feed: A Review of Possibilities," *Nutrients*, Vol. 13, No. 1, 5 January 2021; Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021; and Hanna L. Tuomisto, "The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products?," *EMBO reports*, Vol. 20, No. 1, 14 December 2018.

26. Piotr Rzymski et al., "COVID-19 Pandemic Is a Call to Search for Alternative Protein Sources as Food and Feed: A Review of Possibilities," *Nutrients*, Vol. 13, No. 1, 5 January 2021; and CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 55.

27. CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 55.

28. Piotr Rzymski et al., "COVID-19 Pandemic Is a Call to Search for Alternative Protein Sources as Food and Feed: A Review of Possibilities," *Nutrients*, Vol. 13, No. 1, 5 January 2021; H. C. D. Tuhumury, "Edible insects: Alternative protein for sustainable food and nutritional security," *IOP Conference Series: Earth and Environmental Science*, Vol. 883, No. 1, October 2021, p. 6; Alexandra E. Sexton, "Eating for the post-Anthropocene: Alternative proteins and the biopolitics of edibility," *Transactions of the Institute of British Geographers*, Vol. 43, No. 4, December 2018 [SUBSCRIPTION REQUIRED]; Hanna L. Tuomisto, "The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products?," *EMBO reports*, Vol. 20, No. 1, 14 December 2018; and Shahida Anusha Siddiqui et al., "Consumer Acceptance of Alternative Proteins: A Systematic Review of Current Alternative Protein Sources and Interventions Adapted to Increase Their Acceptability," *Sustainability*, Vol. 14, No. 22, 18 November 2022.

29. Shahida Anusha Siddiqui et al., "Consumer Acceptance of Alternative Proteins: A Systematic Review of Current Alternative Protein Sources and Interventions Adapted to Increase Their Acceptability," *Sustainability*, Vol. 14, No. 22, 18 November 2022.

30. H.C.D. Tuhumury, "Edible insects: Alternative protein for sustainable food and nutritional security," *IOP Conference Series: Earth and Environmental Science*, Vol. 883, No. 1, October 2021, p. 6.

31. Ibid.; Piotr Rzymski et al., "COVID-19 Pandemic Is a Call to Search for Alternative Protein Sources as Food and Feed: A Review of Possibilities," *Nutrients*, Vol. 13, No. 1, 5 January 2021; Alessandra C. Grasso et al., "Older Consumers' Readiness to Accept Alternative, More Sustainable Protein Sources in the European Union," *Nutrients*, Vol. 11, No. 8, 15 August 2019; July Nguyen et al., "Alternative protein consumption: A systematic review and future research directions," *International Journal of Consumer Studies*, Vol. 46, No. 5, 1 March 2022 [SUBSCRIPTION REQUIRED]; Christopher Bryant and Julie Barnett, "Consumer Acceptance of Cultured Meat: An Updated Review (2018–2020)," *Applied Sciences*, Vol. 10, No. 15, 28 July 2020; and CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 55.

32. Silvia Malagoli, "Italy is set to ban lab-grown meat – here's why it should think again," *The Conversation*, 14 April 2023; Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021; and Hanna L. Tuomisto, "The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products?," *EMBO reports*, Vol. 20, No. 1, 14 December 2018.

33. Ibid.; Piotr Rzymski et al., "COVID-19 Pandemic Is a Call to Search for Alternative Protein Sources as Food and Feed: A Review of Possibilities," *Nutrients*, Vol. 13, No. 1, 5 January 2021; Christopher J. Bryant, "Culture, meat, and cultured meat," *Journal of Animal Science*, Vol. 98, No. 8, 3 August 2020; Christopher Bryant and Julie Barnett, "Consumer Acceptance of Cultured Meat: An Updated Review," *Applied Sciences*, Vol. 10, No. 15, 28 July 2020; and CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 55.

34. Silvia Malagoli, "Italy is set to ban lab-grown meat – here's why it should think again," *The Conversation*, 14 April 2023; Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021; and Hanna L. Tuomisto, "The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products?," *EMBO reports*, Vol. 20, No. 1, 14 December 2018.

35. Silvia Malagoli, "Italy is set to ban lab-grown meat – here's why it should think again," *The Conversation*, 14 April 2023; and Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021.

36. Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021; Piotr Rzymski et al., "COVID-19 Pandemic Is a Call to Search for Alternative Protein Sources as Food and Feed: A Review of Possibilities," *Nutrients*, Vol. 13, No. 1, 5 January 2021; and Hanna L. Tuomisto, "The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products?," *EMBO reports*, Vol. 20, No. 1, 14 December 2018.

37. Statistics Canada, "Canadians are facing higher levels of food insecurity," *StatsCan Plus*, 16 May 2024.

38. Ibid.

39. Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021, p. 52; and Christopher J. Bryant, "Culture, meat, and cultured meat," *Journal of Animal Science*, Vol. 98, No. 8, 3 August 2020.

40. July Nguyen et al., "Alternative protein consumption: A systematic review and future research directions," *International Journal of Consumer Studies*, Vol. 46, No. 5, 1 March 2022 [SUBSCRIPTION REQUIRED]; Christopher Bryant and Julie Barnett, "Consumer Acceptance of Cultured Meat: An Updated Review (2018–2020)," *Applied Sciences*, Vol. 10, No. 15, 28 July 2020; and Jihee Hwang et al., "Factors Affecting Consumers' Alternative Meats Buying Intentions: Plant-Based Meat Alternative and Cultured Meat," *Sustainability*, Vol. 12, No. 14, 14 July 2020.

41. *Food and Drugs Act*, R.S.C. 1985, c. F-27; *Food and Drug Regulations*, C.R.C., c. 870; and *Safe Food for Canadians Act*, S.C. 2012, c. 24.

42. Government of Canada, *Cellular agriculture*.

43. Government of Canada, "Make it a habit to eat vegetables, fruits, whole grains and protein foods," *Canada's food guide*.

44. Alexandra E. Sexton, "Eating for the post-Anthropocene: Alternative proteins and the biopolitics of edibility," *Transactions of the Institute of British Geographers*, Vol. 43, No. 4, pp. 586–600, 25 June 2018 [SUBSCRIPTION REQUIRED].

45. Statistics Canada, *Family Matters: Splitting household tasks: Who does what?*, 19 February 2020; and Halal Foundation Editorial Team, "Muslim Dietary Laws & Fasting Practices You Need to Know," American Halal Foundation blog, 22 November 2022.

46. Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021.

47. Government of Canada, "Greenhouse gas emissions from the agricultural sector," *Greenhouse gas emissions*, 2025.

48. Environment and Climate Change Canada, *2030 Emissions Reduction Plan: Canada's Next Steps for Clean Air and a Strong Economy*, p. 59.

49. Ibid.; OECD, *Resilience in agriculture and food systems*; and CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 47.

50. Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021.

51. Government of Canada, *Overview of Canada's agriculture and agri-food sector*.

52. Ibid.

53. Statistics Canada, "Table 14-10-0202-01: Employment by industry, annual," Database, accessed 14 March 2025.

54. Statistics Canada, "A look at those at work in agriculture," *StatsCan Plus*, 18 April 2024.

55. Silvia Malagoli, "Italy is set to ban lab-grown meat – here's why it should think again," *The Conversation*, 14 April 2023; and David Fischer, "'Lab-grown' meat maker hosts Miami tasting party as Florida ban goes into effect," *The Associated Press*, 30 June 2024.

56. Christopher J. Bryant, "Culture, meat, and cultured meat," *Journal of Animal Science*, Vol. 98, No. 8, 3 August 2020.

57. Protein Industries Canada, "Impact from Fund I," *Annual Report 2022–2023*.

58. OECD, *Making Better Policies for Food Systems*, 2021, p. 18.

59. Agriculture and Agri-Food Canada, *Agriculture and Agri-Food Canada's Strategic Plan for Science*, 2022, p. 13.

60. OECD, *Making Better Policies for Food Systems*, 2021, p. 18.

61. Protein Industries Canada, *What We Do*.

62. Protein Industries Canada, *Protein Industries Canada receives federal funding for another five years*, News release, 13 February 2023.

63. Nicolas Treich, "Cultured Meat: Promises and Challenges," *Environmental and Resource Economics*, Vol. 79, No. 1, 19 March 2021, p. 37.

64. Kevin Roose and Casey Newton, "Hard Fork: An A.I. Pin Drops + YouTube's Take on Deepfakes + a Lab-Grown Thanksgiving," *The New York Times*, 17 November 2023 [SUBSCRIPTION REQUIRED]; and CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. 52.

65. Government of Canada, *Support for technology innovation*; and Government of Canada, *Venture Capital Action Plan*.

66. CCA, *The Next Course: Expert Panel on Atypical Food Production Technologies for Canadian Food Security*, 2024, p. xii.