

PLANT-BASED MEAT: A HEALTHIER CHOICE?

A comprehensive health and nutrition analysis of plant-based meat products in the Australian and New Zealand markets

Developed in collaboration
with Teri Lichtenstein,
Accredited Practising Dietitian



EXECUTIVE SUMMARY

Purpose

Plant-based meat, as an increasingly popular category of meat alternatives across grocery and foodservice channels, has grown to reach critical mass in Australia and New Zealand. With countless new brands offering products across varied formats – from burgers and sausages to mince and poultry pieces – the category has become established enough to begin attracting comparisons to conventional meat.

As with any fast-emerging food category that is often associated with health, the wave of new plant-based meat products has consumers, media, health professionals, investors, food businesses and others asking questions about what these products are, their purpose and impact, and who is eating them.

Amongst this discussion are pointed questions regarding the nutrition and health impacts of plant-based meat, querying whether they are a 'healthy' swap for similar conventional meat products, and whether manufacturers are exploiting the 'health halo' associated with plant-based eating to convey their products as healthier, simply for being made of plants.

This publication, developed by Food Frontier in partnership with co-author Teri Lichtenstein, Accredited Practising Dietitian, sets out to answer these questions with an evidence-based exploration of the health and nutrition of plant-based meats, offering answers, insights and recommendations for consumers, food companies and health professionals.

Structure

Section I offers context on the historical evolution of meat alternatives, who is eating them and the role they can play in people's diets. This includes a categorical definition of plant-based meats, as well as other meat alternatives, as a reference for those new to the category.

Section II reviews the health effects of the conventional meats for which plant-based meats, given their design as a centre-of-plate protein option, offer an alternative. This includes the association between high consumption of red meat (particularly processed meat) and *non-communicable diseases*. This review also includes foodborne illness, generated by meat processing practices and contaminate supply chains, and the rise of both *zoonotic disease* in part enabled by the intensification of animal agriculture, and *antibiotic resistance* spurred by widespread use of antimicrobials like antibiotics to limit livestock infections and increase growth rates.

Section III presents the new research underpinning this report: an analysis of the nutrition averages of 141 meat alternatives available in the Australian and New Zealand markets, of which 95 are plant-based meat. The nutrition averages are presented across the most common categories of plant-based meat, from burgers to sausages to crumbed poultry and more, with comparison to similarly processed, conventional meat equivalents to which plant-based meats offer an alternative.

Section IV unpacks further research and data to examine these products within a more holistic understanding of 'health', exploring ingredients (including sodium and additives), as well as the impacts of processing. In regard to processing, the report explores its health effects with consideration given to a few of the commonly held concerns surrounding processed foods: foods

that are energy dense and nutrient-poor; hyper-palatability leading to overconsumption, and; contribution to disruption of healthy meal patterns.

Section V explores research and innovations to improve plant-based meats and address key ingredient and processing concerns, as well as provides general guidance for manufacturers to further improve the health and nutrition of their products. This section also offers guidance to consumers in determining the role of plant-based meats within their diet.

Authors



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Food Frontier is the independent think tank and expert advisor on alternative proteins in Australia and New Zealand. This report was developed by our team of food technology, nutrition and communications specialists, in partnership with co-author Teri and with review and input from external health professionals.

Findings

Many factors dictate the healthfulness of a food product. Rather than asking of foods that are positioned as a healthier alternative, “*are these healthy?*”— a more accurate question, as explored in **Section II**, is: “*considering all of the evidence, which is a better choice?*”

In answering that question, it is crucial to consider the health implications of the categories to which plant-based meats are an alternative. In the case of conventional red meats, including processed meats, these foods have been shown to promote non-communicable diseases (as detailed in **Section II**) and are the foods that health authorities warn against overconsuming. According to 2019 OECD data¹, last year Australians ate 102 percent more red meat than advised by the most recent dietary guidelines,² while New Zealanders consumed 36 percent more.³ The most recent nationally representative data on the dietary intakes of Australians indicates that one-third of adults’ average daily meat consumption is composed of non-lean or processed meats, the foods recommended to be limited by the dietary guidelines.⁴

Thus, these key findings on plant-based meats are presented in comparison to similarly processed, conventional meat categories to which plant-based meat offers an alternative. Comparison to these conventional meat equivalents demonstrates that:

01 Nutrition: Plant-based meats across most categories have, on average, lower or comparable kilojoules and sodium, higher or comparable protein, and lower fat and saturated fats per 100g, along with the presence of health-promoting fibre, in comparison to their conventional meat equivalents.

02 Health Star Rating: Plant-based meats have, on average, higher Health Star Ratings (HSRs) than their conventional meat equivalents in five out of six categories (Sausages, Burgers, Bacon, Poultry – crumbed, Poultry – un-crumbed) and the same HSR in one category – Mince. While the HSR system is a simplification of nutrient analysis, its favouring

of ‘positive nutrients’ and characteristics, such as protein, fibre and vitamins, or fruit or vegetable serves, and disfavour of ‘nutrients to limit’ such as fat, saturated fat and free sugars, provides a useful framework to inform consumer decision-making.

03 Sodium: Select plant-based meat products have been shown to be high in sodium, an ingredient that can be problematic for health if overconsumed – though on average, plant-based meats contain less or comparable sodium than conventional meat equivalents across most categories – averaging 23 percent of the suggested daily intake for adults per serving. An adult would need to consume five servings of the average plant-based meat per day to exceed their recommended daily sodium intake.⁵

04 Additives: Plant-based meats contain an average of five additives, while conventional meat equivalents contain four additives on average. Both products most commonly contain additives in the ‘emulsifiers, stabilisers, and thickeners’ category. All additives used in food products across Australia and New Zealand have been deemed safe to consume by Food Standards Australia New Zealand (FSANZ).

05 Public Health: Plant-based meats don’t present the same foodborne illness risks associated with conventional meat⁶, being free from livestock gut bacteria (which commonly contaminates conventional meat during slaughter), and therefore highly unlikely to contain common pathogens found in meat like *Campylobacter* and *Salmonella*. Additionally, the production of plant-based meats does not contribute to the rise of zoonotic disease, whereas the intensification of animal agricultural practices for conventional meat production is one of the interconnected risk factors for the rise of zoonosis.

06 Non-Communicable Diseases (NCDs): Plant-based meats generally do not present the same factors as conventional meats that are believed to contribute to the disease pathways for colorectal cancer, cardiovascular disease and type 2 diabetes mellitus – diseases that are among the leading causes of death in Australia and New Zealand. Of

note, plant-based meats are not designated ‘carcinogenic to humans’ or ‘probably carcinogenic to humans’ as processed red meats and red meats are designated, respectively, by the World Health Organization.⁷ On average, plant-based meats are also a “good” source of health-promoting fibre, which has been associated with lower risks of mortality and NCDs. This evidence is explored in **Section II** and evidenced further in the **Appendix**.

07 Processing: Plant-based meats are processed using extrusion technology that was first and is still widely used in conventional meat processing. This belies an important point: that the category to which we are comparing plant-based meats as an alternative is also inherently a processed food – conventional burgers, sausages, hot dogs and deli slices all fall within NOVA’s ‘ultra-processed’ classification.⁸ Research into ultra-processed food consumption and observed health impacts is emerging and ongoing, with research indicating a link between the two.⁹ Given the category of foods deemed ‘ultra-processed’ is so broad, this section explores the key concerns about processing and whether these concerns indiscriminately apply to plant-based meat. For example, plant-based meats do not, on average, present the problematic nutrition profiles typically associated with ‘ultra-processed foods’ (e.g. high sugar, sodium, saturated and trans fats, a lack of fibre or protein, or a high ratio of calories to nutrients). Regarding the question as to whether the palatability of plant-based meats drives overconsumption, further study is required. As centre-of-plate proteins served within a meal, plant-based meats may not be accurately grouped with ultra-processed packaged snacks and sweets, which are products of concern to health authorities for their role in disrupting healthy meal patterns.

Advice for plant-based meat manufacturers to address consumer demands, and for consumers in determining the role of plant-based meats within their diet, can be found in **Section V**.

Can plant-based meats play a role in consumer adherence to dietary guidelines?

As explored in **Section II** of this report, a robust body of evidence indicates that a diet rich in plant-based foods contributes to good health. This evidence informs recommendations from global authorities from the World Cancer Research Fund and the American Institute of Cancer Research to the World Health Organization and others. These recommendations say that Western consumers should increase their consumption of fruits, vegetables, whole grains and legumes, while decreasing consumption of red meat, particularly processed meat.

Eating an abundance of whole foods, such as legumes, whole grains and vegetables, is the gold standard for health – yet campaigns to increase consumers' consumption of these foods do not always account for the many factors informing their dietary decisions as highlighted in **Section II**. As more Australians and New Zealanders seek to reduce their meat consumption in line with government dietary guidelines, tastes and culinary preferences haven't changed (as noted earlier, one-third of Australians' average daily meat consumption is in the form of non-lean or processed meats). This is where plant-based meat offers an alternative for those seeking a centre-of-plate protein in familiar formats, like sausages and schnitzels. Although plant-based meats are not the whole foods represented in these gold standard dietary recommendations, most do provide some of the benefits associated with eating more whole plant foods, such as dietary fibre and considerably lower saturated fat on average than similarly processed, conventional meat products. They can also serve as a transition food towards a more plant-centric diet.

Considering benefits like these and the other nutrition and public health benefits as outlined in the key findings, plant-based meats can serve as a healthier alternative, in particular for consumers seeking to reduce their consumption of red meat, particularly processed meats. Governments and public health officials who are seeking to address their constituents' need to reduce meat consumption in line with dietary guidelines for good health should consider these findings as evidence of the important role plant-based meats can play in supporting healthier choices.



Rice paper rolls
made with
Fable Food Co's
Plant-Based
'Braised Beef'

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INTRODUCTION



INTRODUCTION

Aussies and Kiwis walking through their local supermarket or dining at their favourite quick service restaurant in the past 18 months will likely have noticed an expanding range of plant-based meat options. The news has reflected this boom, with story after story profiling the latest start-up or industry giant to launch a new plant-based meat product, or examining these products' health and environmental credentials. While conventional animal meat continues to play a major role in cultures around the world as a popular centre-of-plate protein, awareness of its contribution to disease and environmental degradation is growing. Millions more consumers, particularly in the West, are seeking alternatives that address these concerns, while still satisfying the cultural, social and economic drivers underpinning their desire to eat sausages, meatballs and dumplings.

In Australia and New Zealand, restaurant chains are sourcing the latest plant-based meats for their menus,^{1,2} grocery chains are stocking them in the meat aisle alongside conventional meat,³ and long-standing meat companies are launching and acquiring plant-based brands at a rapid pace.⁴

This section explores how plant-based meats came about, who is eating them, how they compare to their conventional equivalents and the role they can play in people's diets.

What are meat alternatives?

The boom of plant-based meats may be considered relatively modern, yet alternatives to meat as a protein source have existed for millennia. As early as 965CE, traditional products such as tofu and tempeh (made from soybeans) and seitan (made from wheat protein) have been used throughout Asia, where lack of access to animal meat amongst poorer populations, coupled with abstinence from meat for religious purposes, made these plant foods affordable, functional and nutritious protein sources.⁵

The 20th century saw the development of meat alternatives including Sanitarium's NutMeat, a wheat-protein-based meat alternative,⁶ and John Harvey Kellogg's Nuttose and Protose, created with the intention of promoting good health.⁷ The rise of these products was driven, in part, by concerns over sanitation in the early meat processing sector, with Kellogg also questioning the efficiency of animal agriculture in the context of a growing population⁸ – concerns still present today. Following World War II, significant advances in production technology contributed to the development of products based on plant protein isolates, concentrates and textured proteins, such as Tofurky, which were targeted at a niche vegetarian demographic.⁹

Over the past decade, entrepreneurs, food scientists and chefs have built upon these technologies in an effort to redefine meat. Advances in food science, ingredient characterisation, processing and production have resulted in a new era of plant-based meats designed to replicate the experience of preparing and eating conventional mince, burgers and fillets. Made to appeal to mainstream meat-eaters, these products are marketed toward the growing 'flexitarian' demographic – those who choose plant-based meals often but not exclusively, with consideration to factors such as their health or the environmental impact of their diet.

Meat alternatives serve to provide people's favourite foods in familiar formats, like sausages and schnitzels, using legumes, grains, vegetables, nuts, seeds, fruits and other plant-derived ingredients. They come in a variety of forms, as outlined on the following page.

Types of meat alternatives

Plant-based meats are made from combinations of plant proteins, oils, spices, seasonings and other plant derivatives, including starches and common food additives. Generally, these products use plant proteins (most often in the form of protein isolates, concentrates and flours) or mycoprotein (protein derived from fungi) to achieve a more meat-like appearance and texture, rather than incorporating whole grains, legumes, nuts or vegetables – though some products do. There are two types of plant-based meats:

Legacy products helped establish the category in the 1980s and are primarily marketed to people who follow a meat-free lifestyle, often appearing in a dedicated vegetarian/vegan section of the grocery store.

New generation products began to appear in Western markets from 2015 and aim to achieve a hyper-realistic sensory experience akin to conventional meat – from preparation to appearance, texture and flavour. As such, they are typically marketed to flexitarians and meat-reducers who are seeking familiarity and convenience.



Plant-based meat – Legacy: Tofurky® Plant-Based Deli Slices, Vegie Delights™ Veggie Sausages, Quorn™ Garlic & Herb Fillets



Plant-based meat – New generation: Beyond Burger®, Plantein™ Plant-Based Schnitzel, v2food™ v2mince

Traditional meat alternatives are products mostly composed of whole ingredients like whole grains, vegetables and legumes. As such, these products are not designed to closely replicate meat and are often marketed to vegetarians and vegans. This category includes **traditional alternatives**, foods long considered to be meat alternatives and made primarily of one ingredient, like tofu, tempeh and falafel, as well as **whole ingredient combinations** like a lentil burger. **Wholefood mimics** also fall into this category, and consist of fruits, vegetables or fungi prepared to mimic meat, like, ‘pulled pork’ jackfruit or ‘slow-braised beef brisket’ made of mushrooms. These foods can be used in meals as meat alternatives due to their meat-like appearance, texture and/or their ability to absorb flavours.



Traditional alternatives: Falafel, Pulled Jackfruit, Tofu

For people seeking to reduce their meat consumption and increase their vegetable intake – and still wishing to eat conventional meat – a further category of **blended meats** has arisen, such as Woolworths & veg Beef Mince with Carrots, Sautéed Onion, Celery & Tomato. These hybrid products use meat as a base and supplement in around 20-30 percent¹⁰ plant-based ingredients like vegetables, mushrooms and grains, boosting fibre and nutrient content.

Who is eating meat alternatives?

In Australia and New Zealand, home to some of the world's most avid meat-eaters, there has been a growing shift to eat less meat in recent years. Data from Roy Morgan,¹¹ Euromonitor International¹² and Mintel¹³ suggests millions of Australians are now choosing to eat less meat or follow a plant-based diet.

The most recent data is from leading market research agency Colmar Brunton, launched in Food Frontier's 2019 report *Hungry for Plant-Based*, which shows 42 percent of Aussies and 34 percent of Kiwis are eating less meat – or none at all.¹⁴ This figure represents more than ten million people in Australia and over a million in New Zealand who are either Flexitarians or Meat-Reducers¹⁵ – both actively limiting their consumption of meat – or Vegetarians and Vegans, who are entirely meat-free. Baby-Boomers are leading the Meat-Reducer¹⁶ trend, while Flexitarians¹⁷ are spread across all generations.¹⁸

As more Aussies and Kiwis seek to reduce their meat consumption, tastes and culinary preferences have largely remained the same, which correlates with the rise in popularity of plant-based meats in easy-to-prepare formats akin to conventional meat products. The study found six in ten Australians and New Zealanders have tried, or would like to try, new generation plant-based meats.¹⁹



COLMAR BRUNTON RESEARCH FOUND THAT IN 2019, 42 PERCENT OF AUSSIES AND 34 PERCENT OF KIWIS ARE EATING LESS MEAT – OR NONE AT ALL

Why are people seeking out plant-based foods and meat alternatives?

The rise of meat alternatives, from humble and ancient beginnings to today's modern technology-enabled, fast-growing sector, is reflective of several broader societal and consumer trends occurring globally.

As the world's population continues its march towards 10 billion people by 2050, demand for meat is growing exponentially. This demand is driving some of the greatest health, food security and sustainability challenges facing our world.^{20,21} In response to these challenges, global authorities have illustrated an urgent need to transform the West's food systems – especially our levels of meat consumption and industrial livestock production.^{22,23}

This is evidenced in studies like the well-publicised report by the EAT-Lancet Commission, in which more than 30 world-leading scientists spent three years analysing the best available data to form a global 'planetary health' diet, taking into consideration environmental sustainability, human health and food security.

The findings recommend a 50 percent global reduction in meat and more than doubling of protein consumption derived from pulses and grains.²⁴

The report underscored that Western countries such as Australia, where people eat nearly three-times the global average of meat, hold the greatest responsibility in reducing meat consumption to protect personal and planetary health.²⁵

Further research by Johns Hopkins University quantifies how dietary shifts can impact the environment, finding that choosing plant-based meals two-thirds of the time can cut a person's food-related emissions by nearly 60 percent.²⁶ A joint study by the University of Oxford and the LCA Research Group compiled data from 570 studies covering 38,700 farms in 119 countries (including Australia), finding that most plant-based foods produce 10-50 times fewer emissions than animal products.²⁷



CHOOSING PLANT-BASED MEALS TWO-THIRDS OF THE TIME CAN CUT A PERSON'S FOOD-RELATED EMISSIONS BY NEARLY 60 PERCENT (JOHNS HOPKINS UNIVERSITY)

One of the first countries to reflect the evidence that a plant-centric diet is optimal for both human health and the planet in its national health policy is Canada. Updates to the 2019 Canadian Dietary Guidelines encourage a strong emphasis on plant consumption and moderation of animal products.²⁸

Meat alternatives are one solution to help sustainably satisfy consumer demands, whilst addressing the rise of chronic diseases and other public health issues like antibiotic resistance and zoonosis. These remain a significant threat with continued, heavy reliance on systems of intensive animal agriculture.

Increasing consumer awareness about the health and sustainability implications of their diets, along with an increasing desire for convenience, are significant factors in the rising demand for meat alternatives in the West.^{29,30} In Asian cultures where the original meat alternatives like tofu and seitan were born, these foods continue to play a major role in traditional diets, though are often viewed as a less desirable choice of protein than conventional meat, which is associated with prosperity.³¹ Yet new generation plant-based meats are increasingly capturing the attention of Chinese consumers, as African Swine Flu decimates Chinese pig herds and trade tensions drive up meat prices.^{32,33}

The popularity of new generation plant-based meats can largely be attributed to their improved taste and sensory comparability to conventional meat, as well as increasingly widespread availability.³⁴ These new products now make up a significant portion of the more than 141 meat alternatives currently available in grocery stores and foodservice chains across Australia and New Zealand.

Australians spent \$150 million on plant-based meat products in 2018–19 and sales are expected to increase to \$3 billion by 2030.³⁵

Rising interest in plant-based eating and meat alternatives reflects an increasing desire amongst Australians and New Zealanders to reduce meat consumption for improved health. In consumer research by Colmar Brunton, health was named as the number one reason Aussies and Kiwis chose to eat less meat.³⁶ Amongst those who reported eating a primarily plant-centric diet, like Flexitarians and Vegetarians, or entirely plant-based diet (no animal products at all), like Vegans, consumers ranked “It’s good for my overall health” amongst the top reasons to do so.³⁷

It’s possible that the many well-publicised studies from leading world health organisations including the World Health Organization, EAT-Lancet Commission, World Cancer Research Fund, and Harvard T.H. Chan School of Public Health that issue strong warnings about the impacts of high meat consumption are resonating. Findings from these studies have been summarised in clear recommendations to the mainstream consumer:

Eat more plant foods, and less red meat, particularly processed meat, for better health and to combat chronic disease.

These findings and recommendations are explored further in **Section II**.

GLOSSARY OF TERMS

For purposes of this report

Diet Definitions:

- **Plant-centric:** A diet type or food emphasising plant foods, such as vegetables, fruits, grains and legumes, without excluding animal products entirely. This diet type includes both Vegetarians and Flexitarians.
- **Plant-based:** A diet type or food entirely comprising plants, free from any animal products. This diet type is also referred to as Vegan.
- **Meat-Eater:** A diet type describing a person who eats conventional meats at the same or greater level than during the last 12 months.
- **Meat-Reducer:** A diet type describing a person who eats less meat in the last 12 months.
- **Flexitarian:** A diet type describing a person who eats primarily plant foods, though occasionally eats conventional animal meats, a maximum of four times a week; includes pescatarians.

Food Definitions:

- **Meat alternatives:** Products that are typically entirely plant-based and provide an alternative to meat as a centre-of-plate protein option. This umbrella category includes traditional alternatives and plant-based meats.
- **Plant-based meats:** Products that are made from combinations of plant proteins and fats, spices and seasonings and other plant-derived ingredients, including common food additives, to achieve a sensory experience that is akin to similar conventional meats.

- **Conventional meat:** Flesh from an animal in both processed and unprocessed formats.
- **Conventional meat equivalents:** For purposes of this report’s nutritional comparisons, conventional meats that are equivalent in format to plant-based meats, e.g. a conventional meat sausage is equivalent to a plant-based meat sausage.
- **Conventional seafood:** Flesh of a fish, shellfish or other sea animal.

Why are meat terms used on plant-based products?

Plant-based meat products are often labelled with common terms like ‘sausages’ and ‘mince’ to convey the product’s utility, along with qualifiers like ‘plant-based’, to indicate its ingredients. For example: ‘plant-based burger’, or ‘meat-free mince’. Research shows that such labelling is well understood by consumers, who can still distinguish plant-based meats from their conventional meat equivalents while grocery shopping:

- 91 percent of Australians and 94 percent of New Zealanders have never mistakenly purchased a plant-based product thinking it was its animal-based equivalent, and vice versa.³⁸
- Of the small percentage who did mistakenly buy a product thinking it was its equivalent, it was more likely Vegetarians/Vegans who mistakenly purchased a product that contained meat, thinking it was plant-based.³⁹

EVIDENCE FOR MEAT REDUCTION



EVIDENCE FOR MEAT REDUCTION

Decades of global data has galvanised health authorities^{12,3} to reiterate a consistent and urgent message: nations consuming a high level of meat (predominantly those in the West) must eat less, in order to reduce the prevalence of non-communicable disease and threats to public health.

Despite this evidence, meat consumption continues to grow globally, following its long-term trend increase of 62 percent since 1963. This increase is driven primarily by population growth and rising disposable incomes in developing countries.⁴ In nations where meat is consumed far beyond what is recommended by dietary guidelines, this overconsumption has contributed to detrimental impacts on human health. These impacts are underscored by a major body of evidence spanning decades.

Food Frontier has reviewed and compiled a range of the most recent and rigorous studies that offer insight into the impacts of high levels of meat consumption, and what these findings mean for human health.

Non-Communicable Diseases

The risk factors that lead to many non-communicable diseases (NCDs) worldwide can be mitigated with lifestyle changes, particularly related to diet.⁸ NCDs are chronic diseases that cannot spread from person-to-person and include cancer, diabetes and cardiovascular disease, with incidence of all increasing globally. The burden of lifestyle-related NCDs is expected to rise, placing additional strain on the Australian⁹ and New Zealand¹⁰ healthcare systems over the coming decades. Non-communicable diseases cause more deaths than all other causes combined, accounting for almost two-thirds of all global deaths in 2008 (36 million), and projected to make up a further 44 percent of deaths annually by 2030 (52 million).^{11,12} Just under half of Australians (47 percent) have one or more NCDs,¹³ while NCDs are the highest cause of mortality in New Zealand.¹⁴

Meat is a rich source of dietary protein, iron, vitamin B-12, niacin, phosphorus and zinc, and it contains all essential amino acids.¹⁵ The health benefits of lean meats in particular are recognised in

Australian, New Zealand and international dietary guidelines as a source of readily absorbable zinc and haem iron for those with increased iron requirements including infants, girls of menstruating age and pregnant women.^{16, 17, 18, 19, 20} However, the association between meat consumption and NCDs has also been extensively studied.

Table 8 in the **Appendix** summarises some of the strongest epidemiological research on the three NCDs most commonly linked to the high consumption of meat: cancer, cardiovascular disease and type 2 diabetes mellitus. For reference in reviewing this evidence: conventional red meat includes beef, pork, lamb and goat, which are red in colour due to the presence of haem iron, and; processed red meats, which are transformed through salting, curing, fermentation, smoking, extrusion or other processing to enhance flavour and preservation, including commercial burgers, deli meats, bacon and sausages.

In summary, strong evidence from large prospective cohort studies (those that study groups of people over time) and multiple meta-analyses²¹ has consistently demonstrated a positive dose-response relationship with high consumption of red meat, particularly processed meat, to the increased incidence of and mortality^{22,23} from colorectal cancer,^{24,25,26,27} cardiovascular disease^{28,29,30} and type 2 diabetes mellitus,^{31,32,33} diseases that are among the leading causes of death in Australia^{34,35} and New Zealand.³⁶ Commonalities between the research identified a higher risk from consumption of processed red meat compared to red meat. Those with the highest consumption of both red processed and unprocessed meats had significantly higher incidence of and mortality from NCDs compared to those consuming little to no animal protein.³⁷

Annual meat consumption in Australia and New Zealand, per person (OECD, 2019)⁵

AUSSIES EAT MEAT AT ALMOST 3X THE GLOBAL AVERAGE & KIWIS AT 2X GLOBAL AVERAGE



AUSSIES EAT MORE THAN DOUBLE THE RECOMMENDED AMOUNT OF RED MEAT AND KIWIS EAT 36% MORE THAN RECOMMENDED

2X



AU Dietary Guidelines Recommended Consumption,⁶ NZ Dietary Guidelines Recommended Consumption⁷

Researchers have hypothesised about the potential disease pathways resulting from meat consumption, suggesting that meat consumption (and consumption of components found within red and processed red meats, such as nitrates, nitrites and haem-iron) can promote oxidative stress causing chronic inflammation.^{38,39,40,41} It has also been speculated that certain cancers may be linked to mutagens (compounds that cause a mutation in DNA cells, and thus can become carcinogenic) that can arise when cooking conventional meat, particularly at high temperatures (e.g. grilling or barbequing).^{42,43} Saturated fat intake from conventional meat, both processed and unprocessed, is another risk factor linked to NCD development. This is supported by evidence from intervention studies that monitored the impact of reducing saturated fat consumption from animal sources, and replacing it with polyunsaturated fats from plant sources, using control groups and measuring participants' biomarkers to ensure dietary compliance and to track results.^{44,45} These studies found a lower incidence of cardiovascular disease in the groups that reduced saturated fat intake from animal sources.

This evidence has informed global public health authorities' development of dietary guidelines regarding meat, given that the effects of dietary and lifestyle factors on disease and mortality risk manifest over a span of years to decades.^{46,47,48}

Dietary Recommendations for Disease Prevention

Given the links between high consumption of red meat, particularly processed meat, and many NCDs, various government and non-governmental health and nutrition organisations recommend restricting intake of these meats.⁴⁹ The World Cancer Research Fund and the American Institute of Cancer Research recommend consuming no more than 300g of red meat a week on average, and suggest that very little of it be processed. The World Health Organization (WHO) recommends moderate consumption of processed meat (e.g. sausages, salami, bacon and ham) for cancer prevention.⁵⁰ One-third of Australian adults' average daily meat consumption⁵¹ is composed of non-lean or processed meats, the foods recommended to be limited by the Australian Dietary Guidelines (ADGs).⁵²

Based on data from the same consumption survey, the dietary guidelines provide specific recommendations to adult men to consume about 20 percent less red meat than existing consumption levels (at the time of their publication in 2013).^{53,54}

Such recommendations have been made on the basis of what these organisations consider 'strong evidence'.⁵⁵

In 2019, the Australian Heart Foundation revised their dietary guidelines to recommend that Australians get most of their protein from plant-based sources, as well as fish and seafood, rather than poultry and red meat. For the first time, the Heart Foundation recommended a specific limit on red meat consumption: no more than three lean serves (totalling 350 grams) of unprocessed beef, pork, lamb or veal a week.⁵⁶

When announcing these recommendations, the Foundation cautioned that "many Australians need to rethink how much red meat they're eating, as evidence indicates it increases risks for heart disease and stroke and may lead to weight gain".⁵⁷ In general, the Foundation recommends Australians consume more plant-based foods, including a variety of vegetables, fruits and whole grains.^{58,59}



There is robust evidence to suggest that choosing a diet rich in plant-based foods contributes to overall good health, aiding in the prevention of cardiometabolic diseases and premature mortality. Several large studies, many derived from the well-known 'Adventist Health Study', which comprises 40 years of research on the diets of more than 96,000 participants, have found that vegetarian dietary patterns are associated with reductions in risk for hypertension,^{60,61} metabolic syndrome,⁶² diabetes,^{63,64} ischaemic heart disease^{65,66} and cancer.⁶⁷

One characteristic of plant foods that has been shown to contribute to positive health outcomes is fibre. Fibre is a central component of a healthy diet as evidenced by wide and far-ranging research. An increased fibre intake is associated with a decreased risk of cardiovascular events, colorectal cancer, incidence of diabetes, and all-cause mortality (that refers to an association with death, regardless of the underlying cause).^{68,69,70,71,72,73,74,75,76,77} Yet most Australians and New Zealanders do not consume enough fibre, falling short of national dietary guidelines.^{78,79} One meta-analysis of 25 studies has shown a negative dose-response relationship between fibre and colorectal cancer,⁸⁰ which indicates benefits for those who consume even more fibre than the minimum recommended daily intake. Fibre is found in cereals, fruits and vegetables and in almost all plant-based meat alternatives in the Australian and New Zealand markets, however it is absent in meat. In choosing to replace conventional meats with plant-based meat, consumers may increase their intake of dietary fibre, which has been associated with lower risks of mortality and NCDs.⁸¹

Phytochemicals are another characteristic of plant foods that contribute to positive health outcomes. Phytochemicals are biologically active compounds found in plants and vary depending on their role and origin; some phytochemicals help a plant outgrow its competitors, whilst others assist with chemical defence from predators or pathogens.⁸² When consumed, phytochemicals have been shown to promote general health and fight disease due to their anti-inflammatory, anti-proliferative and antioxidative effects.⁸³

Other Relevant Public Health Issues

Governments and health organisations that caution against high meat consumption are generally concerned with mitigating or preventing disease, with health systems under considerable stress from the rising incidence of NCDs. At the same time, public health systems worldwide face other challenges due to the current scale of meat production and consumption – from foodborne illness generated by meat processing practices and contaminated supply chains, to the rise of zoonotic disease in part enabled by the intensification of animal agriculture and antibiotic resistance spurred by widespread use of antimicrobials like antibiotics to limit livestock infections and increase growth rates.

Antimicrobial Resistance

Antibiotics have been widely used in livestock and poultry since the 1950s.⁸⁴ With the advent of intensive animal farming including aquaculture, which brought greater farm sizes and stocking densities, the need for disease management increased, as did the desire for faster growing and larger animals to meet increasing consumer appetite for affordable protein.^{85,86} The introduction of antimicrobial agents (including antibiotics) in animal feed has achieved these purposes, as well as a reduction in foodborne pathogens, bringing major benefits to the industry.⁸⁷ Yet these practices come at a hefty cost: a rise in prevalence of antibiotic-resistant bacteria, or ‘superbugs’, concurrently in both humans and animals.⁸⁸

Antimicrobial resistance (AMR) contributes to millions of illnesses each year worldwide, from foodborne gastroenteritis, to multidrug-resistant tuberculosis or even death from infected wounds or clinical procedures. The term AMR encompasses resistance to drugs used to treat infections caused by microbes beyond bacteria.⁸⁹ This resistance threatens the viability of lifesaving antibiotic therapy for infections and thus impacts public health.⁹⁰ AMR is cited to be among the most important health concerns of this century according to the WHO,⁹¹ the UK Department of Health Review on Antimicrobial Resistance,⁹² the Food and Drug Administration (FDA) and the Centres for

Disease Control and Prevention (CDC) in the U.S.⁹³

Due to high demand for affordable meat, and excluding therapeutic reasons, antimicrobials are also used as growth promoters. The use of some antimicrobials as growth promoters is subject to a partial ban in Australia and New Zealand.⁹⁴ On a global scale, antibiotic consumption in animals raised for food is projected to rise by 67 percent from 2015 to 2030.⁹⁵ This widespread use is causing a global emergence of certain resistant strains of bacteria.⁹⁶ Antibiotic resistance occurs when bacteria adapt in response to the use of antibiotics; these bacteria may then infect humans and animals and become harder to treat than non-resistant bacteria.

After previously high use of antibiotics in animal agriculture at the turn of the 20th century,⁹⁷ both the Australian and New Zealand governments implemented strict controls and monitoring systems to decrease and manage the amount of antimicrobials used in food animals.⁹⁸ The New Zealand Ministry of Primary Industries notes that the country has one of the most stringent regulatory control programs for antibiotic use in the world under the Agricultural Compounds and Veterinary Medicines act.⁹⁹ Australia was ranked fifth lowest worldwide for rates of antibiotic use in animal agriculture,¹⁰⁰ with the Australian Government describing its use of antimicrobials (including antibiotics) in farmed animals as “one of the most conservative approaches in the world”.¹⁰¹ However, a systematic review identified a scarcity of data in Australia relative to European countries necessary to monitor AMR,¹⁰² with notably limited data on the extent of antibiotic use in animals and how it compares with use in humans.¹⁰³ Some Australian infectious diseases experts have criticised the lack of transparency from the Australian agricultural industry for failing to provide up-to-date data on the true extent of antibiotic use or resistance.¹⁰⁴ Unlike comparable developed nations, not all segments of the Australian animal production sector have industry standards for antimicrobial stewardship, nor is there a nationally co-ordinated surveillance system, both of which must be established to enable the management of AMR risk from food animals.¹⁰⁵

Most developed countries track human consumption of antibiotics, yet struggle to track current antibiotic use in livestock,¹⁰⁶ including Australia.¹⁰⁷ Whilst some efforts have been made to reduce the risks of AMR, risks are far from being eliminated entirely. A 2011 New Zealand surveillance survey found that *E. Coli* isolates found in animals were more likely to be resistant than *E. Coli* found in fresh produce, with isolates in only 48% of poultry samples and 35% of pig samples susceptible to all antimicrobials tested, compared to 90% of fresh produce.¹⁰⁸ A 2017 report issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA) has detailed the prevalence of multidrug-resistant bacteria, particularly from pigs and poultry.¹⁰⁹ It is recognised that resistance to antimicrobials is dramatically amplified by their overuse, underuse or poor management, both in humans and animals.¹¹⁰ A 2019 government report found that rates of AMR are increasing in Australia for organisms such as *E. coli* and *Salmonella*.¹¹¹ The report also found that despite overall vancomycin resistance rates falling, Australia still has higher rates of vancomycin-resistant *Enterococcus faecium* (a bacteria commonly found in clinical settings), compared to European nations.¹¹²

Residues of antibiotics in food meant for human consumption can also have health impacts, like contributing to allergic reactions and interference with gut and intestinal microbiota.^{113,114} In Australia¹¹⁵ and New Zealand,¹¹⁶ antibiotic residues remain insignificant and are not a threat to human health at this time.



Broiler (meat) hen in commercial farm

Foodborne Illness

Foodborne illness can occur when gut bacteria originating from livestock reaches humans through food cross-contamination.¹¹⁷ When transmitted to a human, these strains of bacteria may cause prolonged illness, hospitalisation or may even result in death.¹¹⁸ These bacteria are sometimes found to be antibiotic resistant, compounding the issue. Other causes of foodborne illness include viruses and parasites.

The main bacterial pathogens associated with foodborne illness in Australia are *Salmonella*, *Campylobacter*, *E. Coli* and *Listeria*. These pathogens typically enter the meat supply chain during slaughter, when faecal residue on the animal's feet and skin/feathers, or the unintended puncture and spillage of the animal's intestinal tract during processing, leads to faeces contaminating the meat intended for human consumption. Undercooked meat and eggs are frequently associated with infections caused by these pathogens.¹¹⁹

The most recently available Food Standards Australia New Zealand surveillance study (2010) testing found that 67 percent of chicken flocks examined were contaminated with *Campylobacter* and 47 percent had *Salmonella*.¹²⁰ Despite chicken carcasses being commonly treated with chlorine in Australia to kill such pathogens,¹²¹ the study included data finding that 90 percent of raw poultry samples from retailers were contaminated with *Campylobacter* and 37 percent with *Salmonella*.¹²²

Table 1 – Main Bacterial Pathogens and Associated Symptoms and Vectors

Pathogen	Typical Symptoms	Typical Food Vehicles
<i>Salmonella</i>	Headache, fever, abdominal cramps, diarrhoea, vomiting, nausea	Poultry, raw egg desserts and mayonnaise, sprouts, tahini
<i>Campylobacter</i>	Fever, nausea, abdominal cramps and diarrhoea (sometimes bloody)	Poultry, unpasteurised milk and water
<i>E. Coli</i>	Diarrhoea (often bloody), abdominal cramps	Beef, unpasteurised milk and juice, sprouts and water
<i>Listeria monocytogenes</i>	Meningitis, sepsis, fever	Soft cheeses, unpasteurised milk, ready-to-eat deli meats

Table adapted from NSW Government Food Authority – Foodborne illness pathogens

Each year an estimated 4.1 million cases of gastroenteritis occur in Australia due to consumption of contaminated food.¹²³ This equates to each Australian experiencing an episode of foodborne gastroenteritis approximately every five years. While foodborne gastroenteritis is often not serious, it results in considerable societal costs in the form of healthcare resources and days of work lost. It is estimated that foodborne illness in Australia costs \$1.25 billion annually.¹²⁴

Improved food quality control of meat and eggs is an important step in curtailing the major burden of foodborne illness as well as consumer education on safe handling and thorough cooking of raw meat, poultry and eggs. Given that substituting conventional meats for plant-based meats bypasses the issue of bacterial pathogens from livestock, greater uptake of protein alternatives would logically reduce the incidence of foodborne illness.

Zoonotic Disease

Zoonotic diseases, or 'zoonoses', are pathogenic animal diseases that infect humans. Zoonoses make up the majority of recurring and emerging infectious disease threats, and are considered to be one of the most significant threats to contemporary public health by the WHO, FAO and The World Organisation for Animal Health.¹²⁵ Of the 30 new pathogens detected in humans over the last three decades, 75 percent are zoonoses.¹²⁶

The spread of zoonotic disease is complex and varied, due to the unique localised connections and feedback loops that exist between ecosystems, animals and humans; and their continuous evolution. It is therefore difficult to generalise or comprehensively summarise all zoonotic transmission methods, however several key pathways have been identified for zoonotic disease to cross from an animal host to a human,^{127,128,129} including industrial agriculture food systems, as explored in the following.

A recent systematic review from the University of London found strong evidence that modern zoonosis emergence is linked to modern farming and the intensification of animal agricultural practices.¹³⁰ Although the authors noted this intensification cannot conclusively be determined as the only reason for zoonosis emergence and spread, they concluded that the rate of future zoonotic spread is closely linked to the evolution of the agriculture-environment nexus (interactions between the two). A new report from the United Nations Environment Programme (UNEP)¹³¹ also highlighted unsustainable agricultural intensification and the increasing demand for animal protein as two of seven trends driving zoonotic disease transmission. Common systems of animal agriculture crowd animals into intensive environments conducive to the spread of disease. Diseases can jump the species barrier between infected livestock and humans within agricultural operations and spread further via human-to-human transmission, with pandemic potential.¹³²

Human-induced environmental change, unsustainable utilisation of natural resources and land use, including farming operations, are also amplifiers.^{123,134} As human populations grow and become more urbanised, agricultural operations have been pushed further into wilderness areas, encroaching on previously isolated ecosystems.^{135,136} Land clearing and deforestation to accommodate expanding agricultural operations shrinks habitats and brings wildlife into closer proximity with domesticated livestock, facilitating the spread of disease between wild and domesticated species.¹³⁷

The trade in, and exploitation of, wildlife represents another infection point for zoonoses.¹³⁸ In some developing nations such as in West Africa and Central America, some populations rely on wildlife or 'bushmeat' for sustenance.¹³⁹ In China and southeast Asia there is also significant trade in wildlife, including for meat, which represents an additional path for zoonoses.¹⁴⁰ In the most recent case of pandemic zoonosis, SARS-CoV-2, scientists suggest the COVID-19 virus was likely transmitted from a bat to another animal host such as a pangolin, which was then sold for human consumption at a 'wet market' in China.¹⁴¹

Studies have shown that densely populated industrial pig farms had higher incidences of influenza A viruses, and were a facilitator for the evolution of the 2009 H1N1 'swine flu' pandemic influenza A virus,^{142,143} while intensive poultry operations have been directly linked to the evolution and spread of avian influenza A outbreaks, colloquially known as 'bird flu'.^{144,145} Scientists studying the genetic material of the 'Spanish Influenza' pandemic of 1918 believe the disease had zoonotic avian or swine origins.¹⁴⁶

Animals within industrial agricultural operations are selectively bred for conformity and have little genetic variability, and therefore potentially have a lower range of resistance to disease.^{147,148} Consequently, pathogenic diseases can quickly spread through entire farms while increasing in virulence.¹⁴⁹ Evidence also indicates that animals raised in intensive environments often experience stress on-farm and during transport, causing their immune systems to become more susceptible to pathogens.¹⁵⁰ Significant surveillance and swift containment efforts are necessary to prevent these diseases from spreading to humans.¹⁵¹ Experts from the University of Florida, University of London, UNEP and International Livestock Research Institute have predicted that as modern meat producers continue to increase the size and intensity of their commercial farms to meet consumer demand, the potential for the generation, spread and sustainment of novel zoonotic diseases will increase.^{152,153,154}

In summary, plant-based meats offer the following public health benefits:



NO ANTIBIOTIC OR ANTIVIRAL DRUGS REQUIRED



EXPONENTIALLY LOWER RISK OF FOODBORNE ILLNESS



DO NOT CONTRIBUTE TO ZOOONOTIC DISEASE



BENEFITS OF HEALTH-PROMOTING FIBRE



NOT CLASSIFIED AS 'CARCINOGENIC'

Can plant-based meats address public health issues by helping consumers meet dietary recommendations?

There is widely-held agreement about the positive contribution animal products can make to a healthy diet when consumed in moderation, particularly in developing countries where food resources may be more limited.^{155,156,157} There is also wide agreement amongst global health authorities about the need for many countries to reduce consumption of meat¹⁵⁸ and increase consumption of fruits, vegetables, legumes and whole grains to reduce chronic diseases and public health risks, and to promote good overall health.¹⁵⁹ The evidence behind these recommendations has been used to inform mainstream dietary guidelines. A considerable number of doctors, nutritionists, cardiologists and public health experts^{160,161,162} take the evidence further to recommend a plant-centric, whole foods diet as the gold standard for individual health in a Western context.^{163,164}

Health campaigns to influence consumer behaviour

In an attempt to encourage increased consumption of plant foods, specifically fruits and vegetables, both governments and non-government organisations have launched public health promotion campaigns including Nutrition Australia's 'Try for 5', first launched in 2015,¹⁶⁵ and New Zealand's '5+ A Day', which has run since 2007.¹⁶⁶ These campaigns serve to reinforce the Australian and New Zealand dietary guidelines that recommend to consume an average of two serves of fruit and five serves of vegetables each day.^{167,168,169} Yet in the 2017-2018 National Health Survey by the Australian Bureau of Statistics, only 5.4 percent of Australians (age 18 and above) met guidelines for the recommended daily serves of fruit and vegetables.¹⁷⁰

New Zealanders fare better in comparison, with 27 percent of Kiwis consuming the recommended daily serves¹⁷¹ – albeit less than a third of the population. Recognising the “need for a consolidated national approach” to create more impactful campaigns, in 2020, the ‘Fruit and Vegetable Consortium,’ made up of 11 members including Nutrition Australia, the Cancer Council of Victoria and various government bodies, was established in Australia. The Consortium will advocate for funding for a behaviour change strategy and campaign to “deliver a substantial and sustained increase in vegetable consumption”.¹⁷²

The gap between recommendations and behaviour

It is clear that promoting increased consumption of fruits and vegetables in Australia and New Zealand hasn’t achieved its intended outcome of significantly improving people’s diets.

Consumption of these foods has remained consistently low amongst Aussies,¹⁷³ while Kiwis’ consumption has stayed similar, and in some cases even declined.¹⁷⁴ This data indicates that it is not realistic to expect that consumers, particularly men and obese adults, will alter long-term behaviour based solely upon an increased promotion of recommended dietary changes.

In considering the socioeconomic and cultural contexts in which dietary choices are made, these dietary recommendations may suggest an unrealistic leap from gold standard advice to eat a whole foods diet abundant in fruits and vegetables, to how consumers actually make choices – based foremost on taste and price, with health trailing those factors.^{175,176}

Alternatives as a vehicle for behaviour change

A pragmatic approach to population-wide dietary behaviour change considers that incremental improvements can best be achieved by offering consumers viable, appealing alternatives to their current dietary choices,^{177,178,179} with new options that suit their existing eating patterns and fulfil nutritional needs.

While the intake of fruits and vegetables has been widely promoted in an effort to influence consumer behaviours, recommendations to limit meat consumption in-line with dietary guidelines do not receive the same promotional campaigns, despite overconsumption amongst Australians and New Zealanders (see graphic pg. 12). This begs the question; can promoting plant-based meats as an alternative to conventional meats, particularly red and processed meats, help enable the dietary changes that prior education campaigns have largely failed to achieve? How far could these products actually take consumers towards improving health and addressing the aforementioned diseases and food safety risks?

Plant-based meats as a ‘better’ alternative

Many consumers who are time poor, driven primarily by taste and price, and searching for convenient options are increasingly choosing discretionary foods, including those that require minimal preparation such as processed conventional meats, desserts and snack foods.¹⁸⁰ Approximately one-third of Australian diets¹⁸¹ and a quarter of New Zealand diets¹⁸² are composed of discretionary foods. While some healthier convenience foods exist, many do not contain healthy amounts of the grains, vegetables, legumes and fruit recommended by the Australian Dietary Guidelines (ADGs) and would be considered discretionary. Discretionary choices are defined in the ADGs as “not an essential or necessary part of healthy dietary patterns” and are “high in kilojoules, saturated fat, added sugars and/or salt or alcohol”.¹⁸³

The ADGs’ examples of discretionary choices include ‘commercial’ burgers and processed meats and sausages, which are the formats of conventional meat that public health experts recommend limiting. Plant-based burgers and sausages are not currently mentioned amongst these examples. These categories of plant-based meats are, on average, lower in kilojoules, saturated fat and sodium (as detailed in **Section III**) than conventional meat equivalents; however, some individual products are still high in sodium. Given this, it is unclear whether or not they would be categorised as ‘discretionary’ in a future review of the guidelines. If plant-based meats did meet the definition of discretionary foods, as processed meats do, neither would inherently be defined by a dietitian or health expert as ‘healthy’.

Therefore, it appears that plant-based meats are being held to a higher standard than their conventional, similarly processed equivalents when media, health experts and others ask, “are these healthy?” Perhaps, a more compelling question to ask of any food that presents itself as an alternative is “are these a better choice?”



veef™ Smoky
BBQ
Plant-Based
Burger Patty

Plant-based meats as a transitional food

Some public health experts have noted that plant-based meats can serve the role of a transitional food, standing in as a centre-of-plate protein for consumers seeking to reduce their meat consumption or move towards a more plant-centric way of eating, in line with global health authorities' recommendations.

The Chair of the Department of Nutrition at Harvard T.H. Chan School of Public Health, Professor Frank Hu, considers plant-based meats as “transitional food for people who want to eat a healthier diet”.¹⁸⁴ Hana Kahleova, PhD., M.D., author of the European Prospective Investigation into Cancer and Nutrition (EPIC)-Oxford study, explains the concept of transitional support as: “Processed plant-based foods like veggie sausage, bacon, or vegan cheese can be useful for some to use as transition foods, because they provide the taste of the animal products people are accustomed to consuming, with fewer health risks. Often, as people experiment more with plant foods their taste buds change, and they rely less on these processed foods and more on whole plant foods. There are also many great plant-based replacements made from healthful, whole foods, for example veggie burgers made with beans, rice, and vegetables”.^{185,186} Cynthia Sass, a U.S.-based registered dietitian, says of plant-based meat, “plant options that displace red meat are a step in the right direction”.¹⁸⁷

Are critical dialogues on the role and healthfulness of plant-based meats balanced?

Critical commentary about the healthfulness of plant-based meat amongst some journalists and nutritionists has mostly overlooked or failed to acknowledge the role these foods play as both an additional centre-of-plate protein option that helps meet growing global consumer demands, and a transitional food for those seeking to reduce their meat consumption.

An analysis of 52 articles from 2019-2020 across mainstream Australian and New Zealand media outlets found that 65 percent of coverage discussing the healthfulness of plant-based meat cast doubt about whether they were a healthy option.¹⁸⁸

Only 21 percent of articles acknowledged the health benefits of plant-based meat, like fibre content and lower saturated fat than their conventional meat equivalents. Instead, these discussions at times question whether plant-based meats deserve the ‘health halo’ (10 percent) associated with plant-based eating,^{189,190,191} as well as critiquing plant-based meat’s processed nature (57 percent), ingredients and additives (51 percent), sodium levels (39 percent) and saturated fat content (13 percent). These articles rarely include mention of the health impacts of the conventional meats to which plant-based meats are an alternative (10 percent of articles), but instead ask whether these products can be deemed ‘healthy’.

Some plant-based meat producers have refuted this framework as a basis of judging the role of these foods in peoples’ diets. Pat Brown, CEO of Impossible Foods emphasised that such critics are missing the point, saying: “Our product is substantially better for the consumer than what it replaces... a burger made from a cow, not a kale salad.”¹⁹²

The conclusion? Read on for data-driven analysis and expert guidance

Beyond this exploration of whether plant-based meats play a role in helping address public health concerns, this report aims to provide expert guidance as to whether plant-based meats can in fact be a ‘healthier’ choice than the conventional, similarly processed meats to which they are an alternative. **Section III** offers the first comprehensive nutritional analysis of plant-based meat products in the Australia and New Zealand markets, as evidence to determine whether their nutrition profiles merit the critical commentary to-date. This is followed by a review of the additional health impacts of plant-based meats in **Section IV** to provide a holistic assessment of evidence beyond nutritional content. **Section V** will explore how, as with any new and emerging product category, manufacturers of plant-based meats are continuing to test and reformulate their products to meet consumer expectations relating to taste, health and more.



Stir fry using
NEXT! Chick'n
Chunks

NUTRITION OF MEAT ALTERNATIVES



NUTRITION OF MEAT ALTERNATIVES

At its most basic biochemical level, all food comprises molecular structures – primarily amino acids (proteins), sugars (carbohydrates) and triglycerides (fats) – which combine to form the larger molecular structures of what we recognise as proteins, carbohydrates and fats. When we consume and digest foods, they are metabolised by the body and utilised or stored. A nutritional analysis therefore considers the impacts of these molecules, or ‘nutrients’, and their metabolised effects.

All conventional meat is made up of water, protein, fat and micronutrients such as iron or zinc. Depending on the recipe for processed meats including sausages, burgers and deli meat slices, sugars or other carbohydrates may also be present. To create plant-based meat, chefs and food technologists use the same primary building blocks – fats and proteins from plants, plus water – to achieve the familiar, meaty taste, texture and cooking experience their customers are seeking.

A wide range of meat alternative products exist in the Australian and New Zealand markets. To inform this nutrition analysis, Food Frontier reviewed products available in these markets as of July 2020,¹ across two broad categories:

- **Traditional meat alternatives** are products composed of mostly whole ingredients, like whole grains, vegetables and legumes, such as a lentil burger, as well as wholefood mimics made of fruits, vegetables or fungi that can be prepared to mimic meat, like jackfruit ‘pulled pork’ products.
- **Plant-based meats** are made with plant proteins (most often flours, concentrates or isolates), blended with plant oils, spices, seasonings and other plant derivatives, including starches and common food additives, to more closely mimic similar conventional meats. ‘Legacy’ plant-based meats, represented by brands like Tofurky, are typically made using decades-old processes and generally marketed to a vegetarian/vegan audience. ‘New generation’ plant-based meats, typically created using customised processing technology and/or novel ingredients or ingredient combinations, are designed to achieve a sensory experience akin to conventional meat products. As such, these products are marketed toward flexitarian and meat-reducing consumers and are most often stocked in grocery meat aisles. Examples of these products include the Beyond Burger®, v2food™ v2mince and Sunfed Meats Chicken Free Chicken®.

This analysis of nutritional averages focuses on the latter category of **plant-based meats**, which constitute two-thirds (67 percent) of products in the meat alternative category in Australia and New Zealand.

As an analogous comparison of **traditional meat alternatives**² to conventional meat is not possible, these products were not included in the overall analysis. Traditional meat alternatives do however constitute one third (33 percent) of the category, and as such, included below in Table 2 are these products’ nutrient averages for reference.

To note, this analysis does not include other vegetarian alternatives like tofu, tempeh and falafel, as well as plant-based ready-made meals, plant-based seafood (as explained below) and categories that had too few products.

Food Frontier’s analysis of **plant-based meats**³ includes nutrients that are mandatory to be listed on nutrition information panels, based on the standard panel serving size of 100 grams. Given the nutrition profiles of pre-packaged food products vary considerably, this analysis categorises plant-based meat products by format (e.g. burgers, sausages, poultry pieces) and uses categorical nutrient averages as a basis for analysing individual nutrients.

As plant-based meats offer consumers an alternative to conventional meat products in equivalent formats, comparative nutritional averages of these equivalents have also been included (hereafter referred to as ‘conventional meat equivalents’). Conventional meat burgers, sausages, bacon and crumbed poultry are sold pre-seasoned and are ready-to-cook, the same as plant-based meats. For conventional meats that are not traditionally sold pre-seasoned but can be – specifically, poultry pieces – this analysis includes nutrition information representing a variety of poultry pieces: unseasoned, raw chicken breast, along with ready-to-cook, pre-seasoned chicken pieces, including shredded, pulled and whole piece formats. As some plant-based poultry pieces come pre-seasoned, this ensures a more accurate comparison.

Nutrition Averages

Table 2: Traditional meat alternatives (per 100g)

(excludes tofu/tempeh/falafel)

Nutrient	Traditional Meat Alternatives (n=46)
Energy (kilojoules)	669
Protein (g)	6.9
Fat, total (g)	5.4
Saturated Fat (g)	1
Carbohydrate (g)	18.8
Sugars (g)	3.8
Dietary Fibre (g)	6.2*
Sodium (mg)	365.3
Health Star Rating	

* Dietary Fibre: Calculated based on products that list fibre nutrient value (Traditional Meat Alternatives, n=25)

Method: Nutrition composition data for conventional meat equivalents (Mince, Sausages and Bacon) was obtained through FSANZ’s Australian Food Composition Database and is referenced in the end notes. Information for the varied styles of conventional meat Burgers, Poultry – pieces and Poultry – crumbed necessary to make a direct comparison to plant-based meat in the same styles did not exist within this database; methods for calculating these product averages are referenced in the end notes.

A Note on Health Star Ratings (HSRs): For the purpose of displaying HSRs on product packaging, the HSR system awards stars in whole-to-half-star increments. This analysis averaged HSR data across all products in each category, hence the HSRs shown here do not follow the on-pack increments format. Average HSRs were calculated per the HSRs available on-pack for Traditional Meat Alternatives; plant-based Sausages, Burgers, Mince, Bacon, Poultry – crumbed, Poultry – un-crumbed; and conventional meat Burgers, Poultry–crumbed. For the remaining categories of conventional meat Sausages, Mince, Bacon, Poultry – un-crumbed, average HSRs were determined using the online HSR calculator.¹⁰

Table 3: Red meat-style plant-based meats and conventional red meat equivalents (per 100g)

Nutrient	Sausages (n=23)	Sausages ⁴	Burgers (n=23)	Burgers ⁵	Mince (n=9)	Mince ⁶	Bacon (n=4)	Bacon ⁷
Energy (kilojoules)	785.1 ●	987	863.3 ●	950.4	757.7 ●	767	971 ●	1310
Protein (g)	16.3 ●	14.5	14.7 ●	16	17.2 ●	22.5	22.4 ●	15.4
Fat, total (g)	9.0 ●	18.7	10.9 ●	16.4	9.2 ●	10.4	12.2 ●	28.2
Saturated Fat (g)	2.7 ●	8.7	3.7 ●	7.5	4 ●	4.7	2 ●	10.9
Carbohydrate (g)	8.6	2.9	11.8	4.3	6.4	0	8.8	0.3
Sugars (g)	1.8	0	1.8	1.3	1.9	0	1.6	0.3
Dietary Fibre (g)	4.5* ●	0	3.9* ●	0.1	5.8* ●	0	2.7* ●	0
Sodium (mg)	501.1 ●	740	416.7 ●	471.3	346.4 ●	51	639.0 ●	1274
Health Star Rating								

* Dietary Fibre: Calculated based on products that list fibre nutrient value (Sausages, n=19; Burgers n=15; Mince, n=4; Bacon, n=1)

Table 4: White meat style plant-based meats and conventional white meat equivalents (per 100g)

Nutrient	Poultry – crumbed (n=25)	Poultry – crumbed ⁸	Poultry – un-crumbed (n=11)	Poultry – un-crumbed ⁹	
Energy (kilojoules)	847.1 ●	970.1	684.6 ●	644.6	■ = Plant-based Meat
Protein (g)	12.6 ●	13.8	18.6 ●	18.1	● = Plant-based average is superior
Fat, total (g)	10.3 ●	12.5	5.8 ●	7.9	● = Average is comparable within 10%
Saturated Fat (g)	2.1 ●	2.7	1 ●	2.4	● = Plant-based average is inferior
Carbohydrate (g)	14.3	15.8	6	2.4	
Sugars (g)	2.3	2.6	1.6	1.3	
Dietary Fibre (g)	4.9* ●	0.6*	5.6* ●	0.1	
Sodium (mg)	541 ●	596	506.4 ●	504.2	
Health Star Rating					

*Dietary Fibre: Calculated based on products that list fibre nutrient value (Poultry – crumbed, n=23; Poultry – un-crumbed, n=10)

**Includes raw and pre-seasoned poultry pieces

What about seafood alternatives?

Plant-based alternatives to seafood are relatively new entrants to the market and represent a small proportion (seven percent) of the overall plant-based meat category. Conventional seafood, unlike red and processed meats, does not incur warnings from public health authorities regarding overconsumption and adverse health impacts (aside from recommendations to limit certain fish due to mercury content¹¹), and some consumption is recommended as a contributor to good health. Yet Australian seafood consumption levels declined eight percent over ten years (from 2006-7 to 2016-17),¹² while the latest report recording New Zealand seafood consumption called it “relatively stable.”¹³

Without significant or increasing demand for seafood, or health-driven demand for an alternative, the development of plant-based seafood products has proved to be less of a commercial priority. This correlates with where seafood alternatives are positioned in-store: in the meat-free frozen section instead of near conventional seafood, unlike many white and red meat-style alternatives that are stocked in a section parallel to their conventional equivalents. This suggests these products cater not to those seeking to reduce their seafood consumption but instead to vegetarians and vegans wanting to recreate specific seafood recipes. Taking into consideration these extenuating factors, this analysis does not include plant-based seafood alternatives.

LEADING THE PACK: SUPERIOR NUTRITION AND ‘CLEAN LABELS’

Amongst the quickly evolving plant-based meat category, some brands stand out for developing products that offer superior nutrition and ‘clean labels’, which are increasingly sought after for containing fewer and more familiar ingredients.¹⁴

Sunfed Meats has taken a streamlined approach to ingredients, with their Chicken Free Chicken® Wild Meaty Chunks product made of a yellow pea protein base and minimal ingredients derived from common, recognisable and local sources, such as natural yeast extract and colouring from New Zealand pumpkin. Their ingredient choices have also enabled the brand to make notable superior nutrition claims in comparison to its conventional alternative, noting its Chicken Free Chicken® has “62% more protein than fresh lean skinless chicken breast,”¹⁵ and is high in iron (9.1mg per 100g, compared to conventional chicken’s 0.4mg per 100g¹⁶).

Fable Food Co’s Plant-Based Braised Beef, an alternative to pulled beef, is made of shitake mushrooms that comprise two-thirds of the product. It contains no additives and boasts 14 grams of dietary fibre per 100g, as well as lower than average sodium (138mg per 100g) compared to most plant-based meats. It also contains 35mcg of Vitamin D per 100g, which is more than double the Recommended Dietary Intake (RDI).¹⁷

Products across the Quorn™ range, such as Quorn™ Mince and Quorn™ Pieces, are primarily made up of mycoprotein (94 percent), a protein derived from fungi, along with egg white and some flavourings. Several products boast low sodium levels (58mg per 100g for Quorn™ Mince) and low saturated fat (1g per 100g for both Quorn™ Pieces and Quorn™ Mince).¹⁸

NEXT! Foods has used a soy protein base and seven other ingredients (including water) to create their Original Chick’n Chunks. The result is a product that qualifies as a “good source” of protein and “low fat” food and provides 5.8 grams of fibre per serve – almost a quarter of an adult woman’s RDI and almost a fifth of an adult man’s RDI.¹⁹



Sunfed Meats, Fable Food Co, Quorn™, NEXT! Foods

KEY FINDINGS

In a comparison to their conventional meat equivalents, plant-based meats across most categories have, on average, lower or comparable kilojoules and sodium; higher or comparable protein, and lower fat and saturated fat per 100g, along with the presence of health-promoting fibre.

The following analysis was undertaken in collaboration with co-author Teri Lichtenstein, Accredited Practising Dietitian, exploring key findings for each nutrient in depth, based on plant-based meat nutritional averages by category. Although some health experts consider reviewing individual nutrients as reductive,²⁰ others believe it can be a useful tool to compare products side-by-side and assist consumers with choosing healthier options.²¹ The World Health Organization and the Food and Agriculture Organization's joint international food standards setting body, the Codex Alimentarius Commission, dictates that food products should be labelled with nutrition information that provides consumers a profile of the food's nutrients that are considered to be of nutritional importance.²²

This analysis reviews the individual nutrient averages for each plant-based meat category in a comparison to conventional meat categories by using the terms “higher,” “lower” or “comparable”. Comparable is defined by a nutrient data point falling within 10 percent of its comparison figure. In addition to reviewing comparisons of individual nutrients, this report addresses further health considerations in **Section IV** to offer a more holistic assessment of the healthfulness of plant-based meats.

Dietary energy

Definition: Dietary energy (measured in kilojoules or kj) is released in the body from food, once consumed. Humans require energy for metabolic processes, physical activity, heat and the growth and synthesis of new tissues.²³ A generalised Recommended Dietary Intake (RDI) for energy (kj) cannot be set, as an individual's energy requirement depends on many factors including their activity level and developmental needs.²⁴

Health Impact: Overconsuming energy (kj) has been demonstrated as a contributing factor to health issues including obesity, type-2 diabetes, metabolic syndrome and some cancers.²⁵ Australian and New Zealand dietary advice recommends that people consider the total number of kilojoules they consume in relation to their energy requirement, to ensure they maintain a balance for a healthy weight.²⁶

Analysis Findings: As plant-based ingredients tend to have lower energy densities than conventional meats, four out of six categories of plant-based meat products (Sausages, Burgers, Bacon and Poultry – crumbed) have a lower energy average per 100 grams than their conventional meat equivalents. The remaining two categories, plant-based Mince, and Poultry – un-crumbed, were comparable in kilojoules to their conventional equivalents.



**PLANT-BASED MEATS
HAVE LOWER KILOJOULES
IN 4 OF 6 CATEGORIES**



Gardein™ The Ultimate Beefless Ground mince has 54 percent fewer kilojoules than the category average energy of 757kj per 100g

Protein

Definition: Proteins are nitrogenous organic compounds that have both structural and functional properties, such as assisting with cell growth and repair. The Australian and New Zealand RDI for protein is 46g per day for women (age 19-70) and 64g per day for men (age 19-70).²⁷

Health Impact: Protein is required in a high enough quantity to avoid malnutrition.²⁸ There are 20 amino acids that make up proteins, with ‘complete’ proteins containing all nine essential amino acids required to synthesise the remaining 11 non-essential amino acids within the body.²⁹ Whilst all animal proteins are considered complete, individual plant foods generally lack sufficient levels of one or more of the essential amino acids (such as lower levels of leucine, methionine, lysine and tryptophan)³⁰, with some notable exceptions such as soy³¹, quinoa³² and amaranth.³³ However, as research from The Medical Journal of Australia clarifies, “There is no need to consciously combine different plant proteins, as long as a variety of foods are eaten from day to day, because the human body maintains a pool of amino acids which can be used to complement dietary protein”.³⁴

Analysis Findings: Protein is one of the foundational nutrients in plant-based meat alternatives, as these products are designed to offer an alternative ‘centre-of-plate’ protein. When compared to their conventional meat equivalents, two out of six categories of plant-based meat (Sausages, Bacon) have higher average protein per 100 grams, and three categories (Burgers, Poultry – crumbed and Poultry – un-crumbed) had comparable protein content to conventional equivalents. One category, plant-based Mince, contains lower protein content. Eighty-two percent of plant-based meats meet the FSANZ requirements to be a “good source” of protein (at least 10g per serve).³⁵



PLANT-BASED MEATS HAVE HIGHER OR COMPARABLE PROTEIN IN 5 OF 6 CATEGORIES

MYTH-BUSTER: IF I EAT A MEAL WITH ONLY PLANT-BASED PROTEINS, I WON'T GET ENOUGH...

...quality, complete proteins

The amino acid composition (essential vs. nonessential, complete vs. incomplete) and digestibility of protein determines its biological value. Plant foods contain varying amounts of essential amino acids (EAAs) (with exception to soy³⁶, quinoa³⁷ and amaranth³⁸, which contain large amounts of all EAAs). Yet the idea that to ensure a sufficient intake of EAAs: 1) individual protein sources must contain all nine essential amino acids, or: 2) foods must be combined to include all essential amino acids in one meal, has been disproven.³⁹ When looking at single sources of protein, there are significant differences between plant and animal products, particularly with cereal proteins (e.g. wheat, rice), which are low in amino acids such as lysine. Hence, if intake of plant-based protein is restricted to a single plant source, people may miss out on essential amino acids and need to eat a greater amount of the single protein source to ensure sufficient intake.⁴⁰ However, this can be mitigated by eating a variety of plant-based protein sources, which is more likely than restricting oneself to a single plant source. The need for extraordinarily high levels of protein intake in a plant-based diet to ensure sufficient EAA intake is a common myth: simply ensuring adequate energy intake and eating a variety of plant-based proteins and plant foods throughout the day fills in amino acid gaps.⁴¹

... protein to meet my daily requirements

Australians on average consume well above the RDI for protein: for women (ages 19-70) the RDI is 46g per day, while the average intake is 79g per day; and for men (ages 19-70) the RDI is 64g per day, whereas the average intake is 107g per day. Australians eating vegetarian and vegan diets were shown to consume less protein than omnivores (men ages 19-70: ~80g per day; and women ages 18-45: ~54g per day), yet still consume well above the RDI.⁴²

...micronutrients

Iron and zinc, micronutrients that are widely available in conventional meat and other animal products, can also be found in plant sources. Following a meat-free diet that is balanced and varied can provide adequate amounts of these nutrients.^{43,44} Whilst some micronutrients are not as naturally bioavailable in plant-based sources as conventional meat, bioavailability can be enhanced through food processing^{45,46} as well as including a source of vitamin C in the diet, which increases absorption of iron from plant foods.⁴⁷ Vitamin B12, a nutrient produced by microbes in the soil, is found almost exclusively in animal-based foods (including red meat, dairy, eggs),⁴⁸ thus those who limit intake of all animal-based foods may require a vitamin B12 supplement. For further guidance on micronutrients, see the consumer recommendations in **Section V**.

Carbohydrates

Definition: The primary role of dietary carbohydrates is to provide energy to cells, particularly the brain, which requires glucose for its metabolism.⁴⁹ A generalised RDI for carbohydrate in grams has not been set for adults, as limited data exists to inform an estimate of requirements.

Health Impact: Carbohydrates provide glucose, the brain's preferred energy source,⁵⁰ and dietary fibre, which is necessary for good digestive health as discussed in **Section II** of this report. Dietary guidelines in a number of countries focus on encouraging whole grain carbohydrate intake,⁵¹ as people who eat more whole grain foods have a lower risk of disease and mortality than people who eat the lowest amounts.^{52,53,54,55,56} The Australian and New Zealand dietary guidelines recommend consuming carbohydrates in the form of vegetables, legumes, fruits and whole grains where possible.

Analysis Findings: Plant-based meats are made up of legumes (whole or as protein isolates, flours and concentrates) and vegetables and grains (whole grains or flours), which all contribute to carbohydrate content. As such they have a higher average carbohydrate content across five out of six categories when compared to conventional meat equivalents, which have little (primarily in the form of added sugars and starches in processed meats) to none, with the exception of the Poultry – crumbed category. Plant-based meat on average contains 10.2g of carbohydrates per serve.



PLANT-BASED MEATS ON AVERAGE HAVE 10.2G OF CARBOHYDRATES PER SERVE

Fat

Definition: Fat is the most concentrated form of energy for the body and is categorised depending on its chemical structure, which is either saturated, mono-unsaturated or poly-unsaturated.⁵⁷ To reduce the risk of chronic disease, the Australian and New Zealand Nutrient Reference Values recommend dietary fat consumption within the Acceptable Macronutrient Distribution Range of between 20-35 percent of total energy intake.⁵⁸

Health Impact: As the most energy dense macronutrient, foods high in fat tend to be higher in kilojoules.⁵⁹ Dietary fat is essential to support bodily functions and aid in the absorption of fat-soluble vitamins⁶⁰ and compounds. However, overconsumption of fats has been linked to being overweight and obese, and to the development of chronic disease.⁶¹

Analysis Findings: Plant-based meats are, on average, lower in total fat content compared to conventional meat equivalents across all six categories. Ten percent of plant-based meats meet the FSANZ requirements to be a “low-fat” product (below 3g per 100g).⁶²



PLANT-BASED MEATS HAVE LOWER FAT IN ALL 6 OF 6 CATEGORIES

Saturated fat

Definition: Saturated fat is primarily found in animal products such as red meat, poultry and full-fat dairy products, but is also found in oils sourced from palm and coconut. Australian Dietary Guidelines recommend that saturated fat intake be limited to 10 percent of total daily energy,⁶³ while the Australian Heart Foundation recommends saturated fat reduction focusses specifically on limiting intake of animal fats from meat.

Health Impact: Saturated fats raise total cholesterol levels, particularly low-density lipoprotein (LDL or ‘bad’) cholesterol levels, which have been linked to an increased risk of cardiovascular disease.⁶⁴

Analysis Findings: Compared to their conventional meat equivalents, plant-based meats contain lower levels of saturated fat, on average, across all six categories in our analysis. The largest differences were seen in the red meat categories, with plant-based Bacon being 81 percent lower in saturated fat than conventional pork bacon; plant-based Sausages 68 percent lower than conventional sausages, and plant-based Burgers 50 percent lower than conventional burgers. Per serve, plant-based products contain 2.6g of saturated fat, with 52 percent of products meeting the FSANZ requirements to be “low in saturated fat” (under 1.5g per 100g).⁶⁵



PLANT-BASED MEATS HAVE LOWER SATURATED FAT IN ALL 6 OF 6 CATEGORIES

Trans fats

Definition: Trans fats are found naturally in some foods such as butter, dairy and some meat products, as well as processed foods such as pastries and deep-fried foods.⁶⁶ Anyone consuming meat and dairy cannot completely eliminate trans fats from their diets, so one percent of total energy intake is the recommended limit by the World Health Organization.⁶⁷ On average, the Australian population has a low intake of trans fats in their diets, with consumption rates at 0.5 percent and 0.6 percent, on average, for Australia and New Zealand respectively.⁶⁸

Health Impact: Trans fats, although mono-unsaturated, behave in a similar manner to saturated fat in the body when consumed.⁶⁹ Given strong evidence linking the consumption of trans fats with cardiovascular disease, nutrition authorities have stated that all trans fats are harmful and recommend that their consumption be reduced to trace amounts.⁷⁰

Analysis Findings: As trans fats are not mandated to be included on nutrition information panels in Australia and New Zealand, there is not enough data available to provide averages for this report. In considering ingredient composition of plant-based meat alternatives, a conclusion can be drawn that although formulation varies between manufacturers, trans fats are likely either entirely absent (as seen on nutrition labels of the Beyond Burger and Impossible Burger – both 0g trans fats – in the U.S., where food manufacturers were banned from adding artificial trans fats to foods in 2018⁷¹), or present in very low levels, in comparison to conventional meats.⁷²



**0G TRANS FATS FOR U.S. PRODUCTS.
DATA FOR OTHER PRODUCTS NOT AVAILABLE.**

Dietary fibre

Definition: Dietary fibre is the indigestible parts or compounds of plants. Rather than an RDI, an Adequate Intake (AI) level for Australia and New Zealand has been set at 25g per day for women (age 19-70+) and 30g per day for men (age 19-70+).⁷³

Health Impact: Dietary fibre is essential for proper gut function. As outlined in **Section II** of this report, consumption of fibre has been shown to reduce the risk of a number of chronic diseases,⁷⁴ such as colorectal cancer and type-2 diabetes; yet both Australians⁷⁵ and New Zealanders⁷⁶ are currently not consuming the recommended quantities of dietary fibre.

Analysis Findings: All plant-based meats contained dietary fibre at levels higher than their conventional meat equivalents, which contain little to none. On average, plant-based meat products that list dietary fibre on their nutrient panels contain 4.6g of fibre per serve, which is 18 percent of the AI for women and 15 percent of the AI for men. Soybeans and legumes such as peas are common ingredients in plant-based meats, and are high in fibre.⁷⁷ Although a percentage of the fibre is removed from legumes during the process of isolating and concentrating the protein, the end plant-based meat product still contains far more dietary fibre than conventional meats, which contain little to none. Of the plant-based meats that listed dietary fibre content, 65.7 percent meet the FSANZ requirements to be a “good source of fibre” (at least 4g per serve).⁷⁸ As such, choosing plant-based meat products over conventional meat is one opportunity for consumers to increase their daily dietary fibre intake.



**PLANT-BASED MEATS HAVE
HIGHER FIBRE IN ALL 6 OF 6 CATEGORIES**



Quorn™ Pieces offer 7.86g of fibre per 100g, which classifies the product as an “excellent source” of fibre

Sodium

Definition: Sodium is a mineral found in most of the foods we eat, the largest source of which is sodium chloride, more commonly known as table salt. Sodium plays an essential role in human physiology and energy production⁷⁹ and can cause adverse impacts when overconsumed. The Australian and New Zealand Nutrient Reference Values recommend a Suggested Dietary Target for sodium consumption of 2000mg per day.⁸⁰

Health Impact: Sodium is an electrolyte that amongst other functions, helps the body regulate blood volume and pressure.⁸¹ Excess consumption of sodium is linked to high blood pressure and hypertensive disorders.⁸²

Analysis Findings: When compared to their conventional meat equivalents, which are generally pre-seasoned with sodium during processing, four categories of plant-based meat: Sausages, Burgers, Bacon and Poultry - crumbed contain lower average sodium, and one category – plant-based Poultry – un-crumbed contained comparable levels of sodium per 100g. When compared to conventional mince (which does not typically come in any pre-seasoned varieties), plant-based Mince (as a pre-seasoned, ready-to-cook product) has a higher sodium content.

The average sodium content of plant-based meats per serving is 464mg, or 23 percent of an adult's daily suggested dietary target. With 481mg of sodium per 100g, over a third (37 percent) are categorised as 'good' or 'moderately salted foods' (food products with less than 400mg of sodium per 100g) according to the Eat for Health guidelines,⁸³ and Australian Heart Foundation guidelines,⁸⁴ respectively. Products with less than 120mg per 100g are recommended as the 'low salt foods',⁸⁵ or 'best'⁸⁶ choices, and four plant-based meat products currently fit this categorisation. Amongst the products that fall in categories targeted for the Australian Department of Health's Healthy Food Partnership reformulation guidelines for sodium⁸⁷ set to be implemented beginning July 2020, half (50 percent) are already equal to, or below the target sodium level per 100g.⁸⁸

Some individual products within all categories analysed contain high levels of sodium. As this is an important health consideration and sodium can be both naturally occurring and included as an additive, sodium is examined in further detail in **Section IV**.



PLANT-BASED MEATS HAVE LOWER OR COMPARABLE SODIUM IN 5 OF 6 CATEGORIES



vEEF™ Smoky BBQ Plant-Based Burger Patties contain 296mg of sodium per 100g, which is 37 percent lower than the average sodium of conventional beef burgers

Summary of Key Findings

A comprehensive review of the nutrient averages (Tables 3 and 4) shows that plant-based meats across most categories have, on average, **lower or comparable kilojoules and sodium, higher or comparable protein, and lower fat and saturated fat per 100g**, along with the **presence of health-promoting fibre**, in comparison to their conventional meat equivalents.

This is clearly illustrated in a comparison of Health Star Ratings (HSRs): plant-based meats outperform conventional meat equivalents with **better HSRs in five of six categories** (Sausages, Burgers, Bacon, Poultry – crumbed, Poultry – un-crumbed) and **the same HSR in one category** – Mince.

There are three main reasons for this:

1. Conventional meat products across some categories are higher in saturated fat and higher or comparable in sodium compared to plant-based meats.

Amongst most of the red meat-style categories surveyed, conventional meats had anywhere from double to five times the amount of saturated fats than plant-based meats. For those categories of conventional meats that had greater sodium, the comparison gap is significant: conventional meat sausages have 47 percent more sodium on average than plant-based meat sausages. Conventional bacon has 99 percent more sodium than plant-based bacon, on average.

2. Plant-based meats contain higher levels of dietary fibre compared to conventional meat products, which contain no fibre.

Those products listing dietary fibre on their nutrient panels contain 4.6g of health-promoting fibre on average per serving, which is 18 percent of the AI for women and 15 percent of the AI for men.

3. Some plant-based meats contain minimally processed fruits, vegetables, nuts and legumes, for which the rating system awards points based on the total percentage of these ingredients.

Given the wide variety of products available on the market, individual plant-based meat products may have an HSR higher or lower than the average rating for its equivalent conventional meat, and thus the Health Star Rating system can be used as a screening tool for consumers searching for products with the most favourable nutrition profiles.

Health Star Rating: Useful tool or marketing mechanism?

The Health Star Rating is a voluntary but widely implemented labelling system that rates the nutritional profile of packaged food and assigns it a score from .5 a star to 5 stars, implying that the more stars a product is allocated, the healthier the product is deemed to be.⁸⁹

The HSR system was developed by Australia's state and territory governments and the New Zealand government in collaboration with industry, public health experts and consumer groups. These stakeholders developed an algorithm to determine the HSR of any particular food based on widely used nutritional metrics. The algorithm awards stars for 'positive nutrients' and characteristics, such as protein, fibre and vitamins, or fruit or vegetable serves, and reduces stars for the higher content of 'nutrients to limit' such as fat, saturated fat and free sugars (sugars added to the product by the manufacturer, or naturally present in honey, syrups and fruit juice). However, the algorithm doesn't take into account a nuanced review of the impacts of specific nutritional components.

For example, the HSR does not distinguish natural from added sugars (a review is currently underway to more accurately differentiate between natural/added sugars) – the latter of which is considered a far greater detriment to health.⁹⁰ The HSR does not measure trans fats, despite a widely accepted consensus that trans fats are harmful and increase the risk of cardiovascular disease.^{91,92,93,94}

The HSR system was specifically designed for consumers to make better informed purchasing decisions towards choosing 'healthier' foods, when comparing the health score of two similar products from the same category – such as a supermarket brand

pre-seasoned burger patty versus the Beyond Meat plant-based burger patty. The ratings system is less effective across categories, which may have different uses or serving sizes, such as a comparison between ready-made meals and burger patties.

As the HSR is an opt-in system in which food manufacturers can choose to calculate and display ratings on their products, there is little incentive for manufacturers to utilise the system if their product will not rate favourably. Despite this, the HSR system is widely employed throughout Australia and displayed on thousands of products. As a result, there is a high level of awareness of HSRs among Australian consumers, although an Australian study has shown consumers have little understanding of how the scores are calculated.⁹⁵

A five year review of the HSR System has proposed a series of changes to be introduced in late 2020 that would improve the operation of the HSR Calculator that drives the attribution of stars. These changes include: increasing the HSRs for a category of products that include certain fruits, vegetables and dairy products; more strongly penalising total sugars; improving sodium sensitivity, and; re-categorising certain discretionary foods.⁹⁶ Notably, calculation parameters for sodium will make it difficult for products with high sodium levels – processed meats, and to a lesser extent, plant-based meats – to maintain their current health star rating. This will encourage companies creating products with high sodium content (>900mg per 100g) to reformulate to lower sodium iterations and will highlight products with low sodium per 100g as healthier options to consumers.

Health stars
are simple
to use:
the more
the stars the
healthier.



Health Star Rating
campaign image,
as found on
healthstarring.
gov.au

EXAMINING MARKETING CLAIMS: ARE PLANT-BASED MEATS TAKING ADVANTAGE OF A ‘HEALTH HALO’?

Marketing of plant-based meat in the U.S. often positions these products as healthier than conventional meats, using comparisons of specific nutrient values,⁹⁷ which in turn elicits criticism from some quarters for claiming a ‘health halo’.^{98,99,100}

Comparative marketing can serve as a useful tool for consumers seeking to determine whether meat alternatives are a healthier choice than their conventional equivalents. However, this approach is rarely used in Australia, with one of the only examples being v2food, which includes a nutrition panel comparison between its v2mince and beef mince on its website. A blog post describes v2food’s products as mimicking the “qualities of meat - namely its great taste and high protein, iron and B vitamin content - while slashing cholesterol and adding in the goodness of dietary fibre”.¹⁰¹

Companies producing plant-based meat instead appeal to consumer interest in health by highlighting key nutrients, a common practice for on-pack marketing. Food Frontier’s 2019 research with Colmar Brunton found that a variety of on-pack claims motivate Aussies and Kiwis to choose plant-based meat alternatives, from high Health Star Ratings, as well as “high in protein”, to simply being noted as a “plant-based” product.¹⁰² Product claims like these communicate to consumers that plant-based meats can offer the nutritional benefits they’re seeking in an alternative to conventional meats – in the same familiar and convenient formats.

On retail packages

In Food Frontier’s review of on-pack claims across the Australian and New Zealand markets, no products were found to be making health claims as defined and regulated by FSANZ. Health claims include both “general level”, which refer to a nutrient or substance in the food and its effect on health, and “high level”, which refer to a nutrient of substance in food and its relationship to a serious disease. The specific claim that a product is ‘healthy’ is further restricted in Australia by the Food Standards Code, Australian Association of National Advertisers (AANA) Code of Ethics and Australian Consumer Law.

The most common on-pack nutrient content claims revolve around plant-based meat products being “high in fibre” and a “good/high source” of iron or vitamin B12 to refer to positive nutrient levels. Sixty-five percent of products made claims about nutrients contained within the product,¹⁰³ which are voluntary but must be supported by evidence (also as defined and regulated by FSANZ).¹⁰⁴ While these are not ‘general level’ or ‘high level’ health claims as defined by FSANZ, claims about nutrients can be inferred to have a ‘health halo’ effect. Yet, as countless food products use these types of nutrient claims and may also benefit from a ‘health halo’, plant-based meats are by no means unique.

A large majority of products (89 percent) made claims including “vegan”, “vegan friendly”, “made from plants”, “100% plant based” and “non-GM(O)”, which indicate the products’ ingredients, and all fall under the FSANZ umbrella of labelling for ‘Religious, environmental, animal welfare and other consumer value issues’ and are not regulated in the same way that nutrient content and health claims are by FSANZ.¹⁰⁵ Although not a health or nutrition content claim, 30 percent of products carried claims of “gluten free”, which is a form of allergen labelling regulated by FSANZ.



On-pack claims of v2mince, by v2food™

Some consumers may interpret a food product marked “gluten free” as being healthier than a product that does contain gluten.¹⁰⁶

In food service

Plant-based meat products have become increasingly available since 2019 at food service restaurants across Australia and New Zealand, including Dominos, Grill’d, Hungry Jack’s, Lord of the Fries, Mad Mex and Pie Face. Food Frontier’s review of promotional materials across the companies’ online channels found that in general, marketing did not contain health-related phrasing or imagery to promote the plant-based options as healthier. One exception is Grill’d’s use of the phrase “A meat-free Monday keeps the doctor away”¹⁰⁷ in content for its Beyond Burger® offerings. This implies, although not explicitly, that there are health benefits associated with choosing their plant-based offerings, which include the Beyond Burger®. Grill’d, Hungry Jack’s and Pie Face use the colour green and plant iconography in their product promotion, which may be interpreted by some consumers as an association with health.¹⁰⁸

Table 5: Plant-based meat and traditional meat alternatives products making a nutrient content claim, allergen claim or “other” claim¹⁰⁹:

Protein (high/good source)	64%
Low fat/cholesterol	16%
Low fructose	3%
Low carbohydrate	0.5%
Fibre (excellent source, good source, source)	39%
Vitamin B12 (high or source of)	17%
Iron (high, good source, source of)	20%
Gluten-free	27%
Other claims (vegan/ vegan friendly, vegetarian, dairy free)	87%
Plant-based, plant powered, 100% plant-based	23%
No GMO	27%

OTHER HEALTH CONSIDERATIONS

IV



OTHER HEALTH CONSIDERATIONS

Determining whether plant-based meat is a healthier option than similar conventional meat products requires analysis of factors other than nutrition. More consumers are looking beyond nutrition profiles and questioning the processes and ingredients used to create food products and how these factors influence a food’s overall contribution to health.

Plant-based meats have generated some criticism for their ingredients, specifically sodium and other additives, as well as the processed nature of many options on supermarket shelves. The following section presents the latest and most robust data available to assess the merit of this criticism.

Ingredients

Plant-based meat products consist wholly of plant-based ingredients, with both ‘legacy’ and ‘new generation’ plant-based meats commonly featuring blends of protein isolates and concentrates, plant oils, spices, seasonings and other plant derivatives, along with common food additives. Some products also contain grains, legumes, vegetables and nuts.

The new generation of plant-based meat aims to replicate the experience of cooking and eating conventional meat – from preparation to appearance, texture and flavour. To achieve this, chefs and food scientists combine plant protein isolates, concentrates or flours with plant oils and water to mimic the same building blocks that make up conventional meat: proteins, fats and water. Smaller quantities of other ingredients such as starches, gums, binders, vitamins, minerals and other plant derivatives are added to achieve a meaty sensory experience, improve nutrition, or extend shelf life. For example, v2food’s

v2mince is made up of 10 ingredients, though 96 percent of the product is rehydrated soy protein (78 percent) and vegetable oils such as canola and coconut oil.

Additives are explored separately later in this section.

Table 6 – Common ingredients in plant-based meat and conventional meat equivalents* contributing to key nutrient categories¹

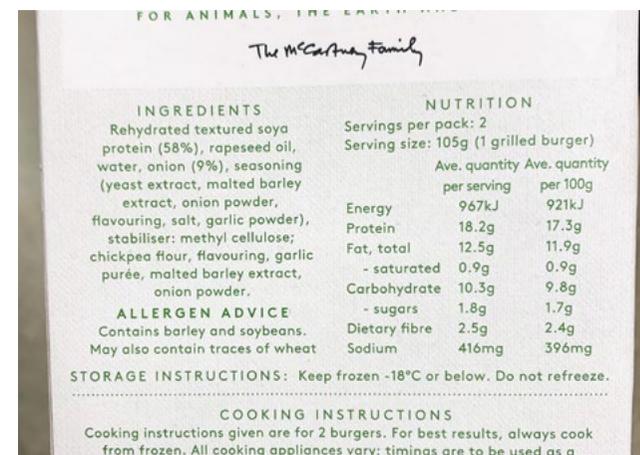
Listed in order of most frequently occurring across all products; appear in 10% or greater of products

Nutrient	Ingredient Listed
Protein	Plant proteins (soy , wheat/wheat gluten, pea, rice, and other unspecified vegetable proteins as whole foods, flours, concentrates and isolates), mycoprotein
Fat	Canola oil , sunflower oil, coconut oil, vegetable oil (unspecified)
Carbohydrates	Plant starches (corn, potato, rice, wheat, other), plant flours (wheat, rice), sugar, onion , oats
Dietary Fibre	Cellulose/methylcellulose, vegetable fibres (konjac, pea, potato), gums (xanthan, guar, other)
Vitamins and Minerals	Iron in 21/95 products; (via supplemental iron or fortified flour), vitamin B12 in 18/95 products; calcium in 16/95; zinc in 13/95 products

***Bolded** = Commonly occurs in conventional meat equivalents (in 20% or greater of products surveyed)²

Researchers and companies seeking to evolve plant-based meat formulations are exploring a wide variety of novel plant ingredients yet to be tapped for their suitability in plant-based meat, including less obvious raw materials like lupins,³ fungi⁴ and algae.⁵ In the immediate future, plant-based meat companies have demonstrated continued commitment to improving product

formulations to reduce or replace existing ingredients linked to health concerns, such as sodium and additives. Examples of these developments, as well as recommendations to plant-based meat companies regarding ingredients, can be found in **Section V**.



Ingredient and nutrition panel, Linda McCartney’s Vegetarian Burger Patties

MYTH-BUSTER: EATING SOY PRODUCTS WILL NEGATIVELY AFFECT MY HORMONES

Extensive research has been conducted over the past 30 years into the health impacts of soy consumption, primarily focused on phytoestrogens – specifically isoflavones, a type of phytoestrogen found in soybeans. Soy isoflavones have been shown to have positive health benefits in some individuals,⁶ including: alleviating hot flashes and improving arterial health in menopausal women;⁷ links to reduced risk of breast cancer⁸ and prostate cancer;⁹ as well as potential protective factors for cardiovascular disease.¹⁰ For these reasons, medical professionals may prescribe soy isoflavone supplementation to certain patients.¹¹

Despite this, soy consumption has been at the centre of sensationalist reports claiming it may reduce testosterone levels, increase estrogen levels or even cause male ‘feminisation’, due to a misconception that plant phytoestrogens such as soy isoflavones have a significant impact on human reproductive hormones when consumed at average (or even double the average) levels.

Phytoestrogens are a large group of compounds that occur naturally in plant foods, and are named such due to their similar chemical structure to the human hormone oestrogen, or as commonly known, estrogen.¹² The structural similarity of phytoestrogens to estrogen enables them to interact with

estrogen receptors in the human body under certain experimental conditions and to increase or decrease the effects of estrogen.¹³ However, the effects of phytoestrogens are shown to be significantly weaker than human-produced estrogen.¹⁴

As with most nutrients, the impacts of isoflavones on the human body appear to be dependent on the dose. Traditional soy products such as tofu or soymilk contain approximately 25mg of isoflavones per 100 grams – which is a typical serving size.¹⁵ In societies that regularly consume traditional soy foods such as Japan, estimates of average isoflavone intakes range between 11 to 54mg per day – equivalent to one or two serves of soy foods on a daily basis.¹⁶ Isoflavone intake in Western diets is much lower: between 3.3mg per day for omnivores and 30mg per day for vegetarians.¹⁷ The quantity of isoflavones decreases in foods as a result of processing, with the amount of isoflavones present in plant-based meat estimated to be minimal.^{18,19} This calculation considers that soy protein isolate - commonly used in plant-based meats - loses around 80-90 percent of its isoflavone content during processing.

Amongst the extensive body of research on the impact of soy consumption published annually,²⁰ there is a variance in findings, primarily due to differences in study design or subject – animal, in vitro or human.^{21,22} As suggested by the National Health and Medical Research Centre,²³ it is useful to take into account the comprehensive findings from this body of research, rather than individual studies, when considering the health impacts of soy, or indeed any food.

The current body of evidence in human studies indicates that average or even double the average soy isoflavone consumption does not significantly impact sex hormones in men.²⁴

A meta-analysis of 32 studies investigating the impact of soy protein or isoflavone intake of biological males (in which the average daily intake was almost double the average amount consumed by Japanese males – some of the highest consumers of soy foods in the world²⁵) found no significant effects on testosterone or other reproductive hormones.²⁶ Multiple studies of men consuming 150mg per day of isoflavones have reported no increase in estrogen in males.²⁷ The few studies that observed an impact to hormone levels were conducted on animals or cells (in vitro) – which do not hold the same weight as studies observing the impacts on humans^{28,29} – or impacts were only observed at levels of soy isoflavone consumption six-times that of average Japanese male consumption.³⁰



Sodium

A common criticism of plant-based meat is that products can be high in sodium, with critics voicing that subsequently, these foods “pose health risks”³¹ or “may not be the best option for the health of our bodies”.³² Sodium content is important to examine, considering high sodium intake is associated with the development of high blood pressure and cardiovascular disease.³³ While most plant-based meat categories have, on average, less sodium than their conventional equivalents (See Tables 3 and 4 in **Section III**), there are certain individual products that contain a relatively high sodium content.

Food Frontier’s extensive analysis of coverage on plant-based meats and sodium indicates that public commentary frequently omits important details or fails to use comparative data.

One comparison often highlighted in media is between a ready-to-cook plant-based meat burger and an unseasoned conventional beef burger. An example is the Beyond Burger®, which has considerably more sodium (380mg) than a conventional homemade beef burger from mince (80mg), with some media noting its up to 4.9 times the sodium level.^{34,35,36,37} Another story referenced the Beyond Burger® as a problematic product that contains *too much* sodium, while simultaneously providing the data to show it has *less* sodium than its conventional equivalent in a comparison between finished, ready-to-serve burgers.³⁸

In spite of plant-based meat burgers containing more sodium relative to unseasoned beef, it is critical that any comparative evaluation of sodium content account for preparation and serving methods, for example, consumers adding seasonings like table salt (sodium chloride) to unseasoned meat. When asked how often they add salt to food in the cooking and preparation stage, 32 percent of Australians responded they add salt “very often” and 19 percent add it “occasionally”. A further 49 percent add salt to food at the table.³⁹

As salt is used to season meat at home, as well as in restaurant settings, making a direct comparison of the sodium content of unseasoned, uncooked red meat with that of a ready-to-cook plant-based product does not accurately capture the sodium content of the food upon consumption. A more equivocal comparison would be a pre-seasoned conventional beef burger and a pre-seasoned plant-based burger, both of which are ready to cook and serve.

As demonstrated in the nutrition analysis in **Section III**:

Most plant-based meat categories have, on average, less sodium than their conventional meat equivalents in Australian and New Zealand supermarkets.

The analysis also included plant-based meat menu items in major national foodservice chains, where preparation methods and other ingredients add to a meal’s total sodium content. Where a conventional meat equivalent is offered, our analysis (see Table 9 in **Appendix**) found that the plant-based meat options contain lower sodium at two outlets, Grill’d and Pie Face, and higher sodium at Mad Mex and Hungry Jack’s. Mad Mex does not offer the same flavour sauce for both of their plant-based and conventional chicken burritos, making a direct comparison of nutrients and sodium levels unattainable.

Further criticism documented in Australian media stemmed from a 2019 study by the George Institute for Global Health reviewing meat-free alternatives through the lens of sodium content. The study formed part of the Institute’s *Victorian Health Promotion Foundation Salt Reduction Partnership* with VicHealth and the Heart Foundation, an initiative aimed at reducing the average salt intake of Victorians by one gram by June 2020. It analysed a range of meat-free alternatives, including plant-based meats as well as traditional meat alternatives like falafel and tempeh, and found that the average sodium content per serving was 333mg.⁴⁰

Guidance from the Australian Heart Foundation suggests choosing “low salt foods” – products with less than 120mg of sodium per 100g – while “moderately salted foods”, those with less than 400mg of sodium per 100g, are “ok” choices.⁴¹

The report found that the average meat alternative product contains less than a quarter of an adult’s daily intake of sodium. A dietitian from the Heart Foundation was quoted in media noting, “Our research showed that there are large ranges in the amount of salt between meat alternative products” and “It is possible to choose a healthier item by picking the lower salt option. It also clearly shows that manufacturers can produce products that are much lower in salt”.⁴² While some coverage reflected this balanced assessment, most stories relied on outlier data points to support sensationalist headlines. For example, meat-free bacon, as the highest sodium product in the study at 2g of salt per serving, was included in many media stories; yet the majority highlighting this point^{43,44,45} did not provide their readers with the context that its conventional equivalent, conventional pork bacon, contains considerably more sodium at 3g of salt per serving. Without this context, consumers may not understand that plant-based bacon provides a lower sodium alternative for those who wish to enjoy the experience of bacon but wish to reduce their sodium intake.

Consumer and public health experts’ concerns about sodium are driving plant-based meat manufacturers like Impossible Foods⁴⁶ and v2food to work towards changing their product formulations to reduce sodium content, as explored further in **Section V**.

Additives

Additives used in many plant-based meats such as flavours, colours, preservatives and thickeners are also commonly used in other packaged food products.⁴⁷ Many substances used as additives are naturally occurring, such as organic acids like citric acid, which is commonly found in citrus fruits, and natural colour extracts like beet and paprika from various fruits and vegetables.

Research shows the human body cannot distinguish between a chemical that is naturally present in a food and that same chemical present as an additive.^{48,49}

In Australia and New Zealand, the use of food additives is governed by the Food Standards Code and regulated by Food Standards Australia New Zealand (FSANZ), which reviews safety evidence before it approves an additive for use. FSANZ also conducts an exposure assessment to estimate the likely consumption amount if the additive were permitted for use. FSANZ recommends a maximum permitted amount for the food additive, based on both the technological need and assuring safe limits.⁵⁰

Food Frontier's analysis of 95 plant-based meats in the Australian and New Zealand markets found that these products contain, on average, five additives, with 'emulsifiers, stabilisers and thickeners' being the category of additives most often used, followed closely by flavours. In a survey of 75 conventional meat equivalents in the Australian and New Zealand markets, products contained, on average, four additives, and also used 'emulsifiers, stabilisers and thickeners' most frequently, followed closely by preservatives.⁵¹

Table 7: Additives in plant-based meat products available in Australia and New Zealand⁵²

Function	Percentage of products containing additives in this category (Some products contain one or more additives per category)	Most frequently used additives (Appear in 10% of products or greater)
Colours	42%	Caramel (19%), Beet (15%), Paprika (13%)
Preservatives	42%	Citric acid (17%), Calcium acetate (10%)
Antioxidants	6%	Used sparingly; none commonly used
Emulsifiers, Stabilisers & Thickeners	78%	Methylcellulose (55%), Carrageenan (21%), Guar gum (21%), Xanthan gum (10%), Sodium alginate (10%)
Mineral Salts	34%	Calcium chloride (15%), Potassium chloride (13%)
Flavours	77%	Natural flavours (unspecified) (36%), Flavours (unspecified) (29%), Smoke flavour (13%), Amino acid flavour (10%)
Vitamins & Minerals	31%	Iron (19%), Vitamin B12 (19%), Zinc (14%)
Starches	6%	Used sparingly; none commonly used. (Note: plant-based meat commonly uses a variety of food starches, but not those in the additive format.)

Methylcellulose, one commonly used ingredient in many plant-based meats (55 percent of products), is synthetically made from natural cellulose, which is the basic structural component of plant cell walls. Methylcellulose is shown by research to be safe⁵³ and is a commonly used food thickener. However, for companies seeking product formulations that produce 'clean labels' labels with more widely recognised ingredients, methylcellulose is one

ingredient targeted to be replaced with alternatives from chickpea flour to pulse protein,⁵⁴ and citrus fibre,⁵⁵ which are of natural origin.

The additive 'smoke flavour' in some formulations has been shown in animal studies to be potentially carcinogenic.⁵⁶ The potential for smoke flavour to be carcinogenic depends on the polycyclic aromatic hydrocarbon (PAH) content in either the woodsmoke or the synthetic smoke flavour ingredients, and the technique used to produce the flavours.⁵⁷ Studies have shown that foods smoked over wood, such as conventional meat and fish, have a much higher PAH content than foods treated with smoke flavouring, which contained little to no PAH.^{58,59} Smoke flavour, found in 13 percent of plant-based meats and 16 percent of conventional meats surveyed, is an approved additive, as noted in Codex Alimentarius,⁶⁰ used as guidance by FSANZ.

Another additive that remains controversial amongst consumers^{61,62} – despite no medical evidence of health impacts after decades of consumption studies – is flavour enhancer monosodium glutamate, or MSG. This enhancer is present in one plant-based meat product. MSG occurs naturally in some foods such as meat, mushrooms and tomatoes, and imparts an umami savoury flavour in food. Food manufacturers use MSG in product formulations to reduce the amount of sodium necessary to season a food. Given the long ongoing controversy, some manufacturers have removed MSG from their products. MSG was the subject of This American Life's episode "The Long Fuse," which explored the genesis of this controversy: a practical joke by one doctor in a 1968 op-ed⁶⁴ published by the New England Journal of Medicine. A review of the current evidence determined that no credible negative impacts have been observed due to MSG consumption.⁶⁵ Despite this, some food companies opt to replace the flavour enhancer with ingredients containing glutamates like vegetable protein extracts, which are ultimately chemically indistinguishable from MSG. While only one product in our analysis contained MSG, some plant-based meat products use ingredients with glutamates like yeast extract or textured vegetable protein. However, a systemic review found no significant health impact response to MSG in blind studies⁶⁶ (where the

subjects were unaware of which sample they consumed), suggesting any reaction may be due to a placebo effect.

While some media coverage on plant-based meats references additives⁶⁷ (generally in tandem with a discussion of processing, as explored below), the stories rarely specify any additives of concern. Consumers can find reassurance in knowing that the additives in plant-based meat are commonly used across a wide range of food products and have been reviewed for safety and regulated accordingly by FSANZ. Additionally, plant-based meats are free from certain food additives sometimes used in conventional processed meats – potassium and sodium nitrite, and potassium and sodium nitrate – which have been classified by the World Health Organization’s International Agency for Research on Cancer as “probably carcinogenic to humans (group 2A)”.⁶⁸

In that light, concerns surrounding the consumption of specific additives may be balanced with the information that plant-based meats offer, on average, superior or comparable nutritional statistics when compared to their conventional meat equivalents, as highlighted in **Section III** of this report.

Processing

The majority of media commentary describing plant-based meats as ‘unhealthy’ does so with reference to the fact that they are processed foods.^{69,70,71} It is firstly important to acknowledge that most plant-based meats currently on the market are alternatives to conventional meat products that are inherently processed, including burgers, sausages, hot dogs, bacon and deli slices, which all fall under NOVA’s ‘ultra-processed’ designation, as explained further below.⁷² The most recent nationally representative data on the dietary intakes of Australians indicates that one-third of adults’ average daily meat consumption is composed of non-lean or processed meats.⁷³ In terms of total kilojoules consumed from conventional meat, further analysis of this data by researchers examining ultra-processed foods found that 30 percent of Australians’ average overall meat intake is processed meat (10 percent) or ultra-processed meat (20 percent).⁷⁴

Food processing is a spectrum, with various terms used to define the level of processing used. Commonly accepted terms include *minimally processed* (for example, an apple that has been washed, sliced and treated with a one-ingredient preservative like ascorbic acid (Vitamin C) to prevent browning), to *processed* (applesauce that requires cooking of the apples, and the addition of sugars and preservatives prior to bottling) to *highly or ultra-processed* (apple juice with added sugar, colouring and other fruit concentrates for flavouring).

Almost all foods have been processed to some degree – frozen, chopped, cleaned, blended, dehydrated, heated and more. Plant-based meat undergoes advanced levels of processing, as combinations of heat, chemical and mechanical stresses via processes like protein isolation and extrusion are applied to convert globular plant proteins into a fibrous, textured strand resembling those found in animal muscle. From a nutritional standpoint, processed and even ultra-processed foods can provide key nutrients, with nutrients such as protein naturally retained throughout processing.⁷⁵ However, nutritionists and health experts consistently align on recommendations that whole foods should comprise the majority of people’s diets, and consumption of processed and highly processed foods should be limited.⁷⁶

The NOVA food classification, a system that identifies and defines levels of processing in foods, is the system most applied in scientific literature around food processing and discussions of the public health impacts of processed foods.⁷⁷ The NOVA system categorises levels of processed foods as: *unprocessed or minimally processed foods*, *processed culinary ingredients*, *processed foods* and *ultra-processed foods*.⁷⁸ Within the NOVA system, both conventional meat products like burgers, sausages, hot dogs and other reconstituted meat products, as well as plant-based meats, would be considered ‘ultra-processed’ foods. This is due to the inclusion of either protein isolates or mechanically separated meat, as well as additives, according to one facet of NOVA’s classification, which denotes “containing formulations of ingredients, mostly of exclusive industrial use, typically created by series of industrial techniques and processes”, as ‘ultra-processed’.⁷⁹

To create plant protein isolates and concentrates, which are a primary input for plant-based meat products, a process called fractionation is used to extract protein from crops such as legumes (e.g. soybeans or peas). To subsequently create a plant-based meat product with similar function, taste and texture to the conventional meat consumers are accustomed to, these protein isolates undergo a process called extrusion. Extrusion combines isolates with plant fats and binders, and the mixture is moistened and shaped via heat, mechanical energy and pressure to create a fibrous, textured and meat-like structure. Following extrusion, further moisture, heating, cooling and pressure is applied to create the finished product. Extruders have been used in food processing since the late 1800s, when the first model created for a food application was designed to produce meat sausages. Extrusion technology is now widely used to produce common foods like pastas, breads and breakfast cereals.

A recent narrative review of largely observational studies identified a link between intake of ultra-processed foods and at least one adverse health outcome (such as being overweight and obese, cardio metabolic risks and all-cause mortality) in the majority of studies analysed.⁸⁰ The association with adverse health outcomes was more commonly seen in those with higher rates ultra-processed food consumption compared to those with lower consumption rates.⁸¹ Given that research into consumption of ultra-processed foods is in its infancy, researchers have only hypothesised about the potential mechanisms behind these observations.⁸²

Researchers have noted some of the potential effects of ultra-processed food consumption as: 1) resulting in diets with unfavourable nutritional profiles, 2) their ‘hyper-palatability’ driving overconsumption of ultra-processed foods (and in turn, all other foods), and 3) increased snacking leading to disrupted meal patterns.⁸³ Another concern of health professionals in an emerging field of research is how the total impact of processed foods – with an eating experience that requires less chewing, and their contents including a mix of ingredients not found independently in nature (including nutrients added back in, like vitamins and minerals) – affects the human gut microbiome.

A review of these potential impacts of processed foods' should take a nuanced approach to assess whether these concerns apply to all foods that are considered ultra-processed by the NOVA classification system. Critics of NOVA suggest the 'ultra-processed' term is too broad and therefore captures a vast array of foods within its parameters that may not be responsible for the health outcomes observed by other researchers.⁸⁴ As follows, we explore three concerns arising from consumption of ultra-processed foods, and their applicability to plant-based meat.

1. Processing and energy dense, nutrient-poor foods

Some forms of industrial food processing beyond what a home cook might employ – bottling, canning, freezing – affect foods' nutrition profiles by reducing or eliminating desirable nutrients and adding less-desirable nutrients. Importantly, industrial processing methods can also help preserve nutrients. Researchers have noted that ultra-processed products tend to be energy-dense and high in saturated and trans fats, added sugar and sodium. Though this tendency does not apply to every ultra-processed food,⁸⁵ it can mean diets high in these foods are significantly associated with consumption of foods that are lower in fibre, micronutrients and protein, and higher in consumption of sodium, added sugars or 'simple carbohydrates', saturated and trans fats.⁸⁶ Researchers have proposed that those adverse health outcomes observed in people who consume ultra-processed foods may not be simply explained by individual nutrient and ingredient compositions, suggesting instead that the processing these components undergo to create the final product could also be a contributing factor.⁸⁷

Advice from the Harvard T.H. Chan's School of Public Health suggests people should choose a processed food by reviewing its nutrition content and evaluating its long-term health impacts, noting that "an ultra-processed food that contains an unevenly high ratio of calories to nutrients may be considered unhealthy".⁸⁸

With this advice in mind, consumers seeking to reduce or replace a particular food in their diet with concern to health, such as processed conventional meats, should consider how the alternative compares nutritionally, as well as the overall role of processed and ultra-processed foods in their diets. As outlined in **Section II**, dietary guidelines recommend that consumers should seek to increase their consumption of whole foods. However for consumers seeking alternative centre-of-plate proteins to conventional meat, this report's review of nutrition profiles of plant-based meats across the Australian and New Zealand markets illustrates that in comparison to similarly processed conventional meat equivalents, on average, plant-based meats have lower or comparable kilojoules and sodium; higher or comparable protein, and lower fat and saturated fat per 100g, along with the presence of fibre.

For the most part, the nutritional averages of plant-based meat show these products are favourable across key nutrients (with exception to some outliers containing high sodium) and do not contain high amounts of the problematic nutrients typical of other foods in the ultra-processed category.

2. Processing and hyper-palatability leading to overconsumption

A range of studies have reviewed the impacts of processed foods that are deemed hyper-palatable (i.e. as having an exponentially more enjoyable/agreeable taste) and whether it is the hyper-palatability itself that may lead to overconsumption, or other factors in the foods' nutritional makeup.

In a study examining the impacts of a primarily whole foods diet versus one of entirely processed foods – despite participants being provided meals and snacks with the same total amount of calories, fats, protein, sugar, salt, carbohydrates and fibre – those eating the processed foods diet ate more of the food (equivalent to 508 calories per day) and gained more weight than those on the whole foods diet, who gained none.⁸⁹ Though the study was not designed to discover the mechanisms of processed food that

lead to overconsumption, researchers hypothesised that the hyper-palatability of, and ease of chewing these foods may lead to faster eating rates and thus greater total overconsumption of energy, along with a potential urge to consume until protein needs have been met (protein leverage hypothesis).⁹⁰ Other studies have hypothesised that consumption of processed food products – many of which have high energy densities – may promote excess energy intake as a person's innate optimal regulation of food intake and satiety signals are likely regulated and impacted by the volume of food consumed, rather than number of kilojoules (energy).^{91,92} Additional studies have suggested that the refined carbohydrates contained in many ultra-processed foods can alter the body's insulin response, which may promote the shuttling of excess nutrients away from oxidation, and instead direct them towards storage in adipose (fat) tissue.^{93,94} Some researchers suggest that the high refined carbohydrate or fat content of some ultra-processed foods may produce changes in reward neurocircuitry, leading to addictive-like eating behaviours and subsequent overconsumption.^{95,96}

To make plant-based meats an appealing alternative with similar flavour to conventional meat, sodium and other additives are used to increase palatability. As explored in our nutrient analysis in **Section III**, the sodium content of plant-based meats places these foods within an adult's suggested daily target of sodium by the Australia and New Zealand National Health and Medical Research Council, at 23 percent on average. However, these products do not, on average, have high energy densities, or contain high levels of refined carbohydrate or fat content, which are the factors associated with hyper-palatability driving overconsumption. The question remains as to whether the other hypotheses apply to these products. Following is an examination of the dietary patterns within which plant-based meats are consumed, and explores whether those concerns have merit when considering an adult's total dietary intake.

3. Processing and meal patterns

In his commentary on the issues of processing, creator of the NOVA system Carlos A. Monteiro of the School of Public Health at the University of Sao Paulo, criticised that ultra-processed foods “induce eating patterns such as ‘grazing’ and skipping main meals, eating when doing other things...and eating alone”.^{97,98} Whilst Monteiro rightly points out that the rise of ultra-processed convenience snack foods has impacted traditional meal patterns and led to increased incidence of snacking,^{99,100} his research does not explore the nuance around processed foods that are designed to be consumed as an ingredient within a main meal.

Most plant-based meats are designed to be cooked and served as part of a main meal – for example, mince to be cooked for burritos, a burger to be served in a bun alongside a salad and chips, or sausages to be served with potato and greens. As these are not snack foods that would lead to disrupted meal patterns, they are potentially not representative of Monteiro’s criticism regarding the eating patterns and formats related to other processed foods.



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SUMMARY: DO CONCERNS ABOUT THE HEALTH IMPACTS OF PROCESSED FOOD APPLY TO PLANT-BASED MEATS?

As explored in **Section II** and in the preceding pages, dialogue in the media about plant-based meat often points to its processed nature as a reason why these foods are ‘unhealthy’. In reviewing some of the concerns of public health authorities on the potential impacts of consuming ultra-processed foods, it is clear that evidence to explain these potential impacts is still emerging, and whether these impacts apply indiscriminately to all foods in this category is yet to be determined.

In considering the hypotheses on these impacts in relation to plant-based meat, we note that plant-based meats do not, on average, have the problematic nutrition profiles typically associated with ‘ultra-processed foods’ – that is high sugar, sodium, saturated and trans fats, a lack of fibre or protein, or a high ratio of calories to nutrients. As some individual products do contain a relatively high sodium content, it’s important to review product nutrition panels when making an assessment of health impacts (as explored further in **Section V**).

Determining whether plant-based meats’ palatability profiles might drive overconsumption requires further study, as there is currently no conclusive evidence to confirm the hypotheses on the factors driving overconsumption, and not all hypotheses may be applicable to plant-based meats. Finally, as centre-of-plate proteins designed to be served within a meal, plant-based meats may not be accurately grouped with ultra-processed packaged snacks and sweets, which are the products of concern to health authorities for their role in disrupting healthy meal patterns.

As an area of research in its infancy that’s largely supported by observational studies, there remains limited understanding about the impacts of consuming ultra-processed foods. Further research over time to investigate existing hypotheses about ultra-processed foods’ mechanistic pathways can help address unanswered questions and offer guidance to both consumers and manufacturers alike.

RECOMMENDATIONS



RECOMMENDATIONS BY TERI LICHTENSTEIN, APD AND FOOD FRONTIER



This report finds that on average, across most categories, plant-based meats are nutritionally comparable or superior to their conventional meat equivalents. Yet there are opportunities for

plant-based meat companies to improve product nutrition and reduce undesirable ingredients, leveraging solutions such as those explored below in Commercial Innovations. For consumers, there are a number of factors to consider in making a 'better-for-you' plant-based meat choice that will meet their individual dietary and other personal requirements.

Commercial Innovations

As plant-based meats are made from a combination of ingredients, product formulations can be changed or enhanced to meet varying dietary needs and elevate the products' overall nutritional offering. Food companies, ingredient suppliers and academic researchers are unlocking solutions to some of the key ingredient and processing concerns as reviewed in this report. Examples include:



Givaudan Swiss ingredients supplier Givaudan announced new technology for fat encapsulation that has the potential to reduce up to 75 percent of the fat content and 30 percent of the calories in plant-based meats currently on the market, while stabilising flavours to deliver a more authentic 'meaty' experience.¹



Australian maker of the plant-based patty in Hungry Jack's 'Rebel Whopper', v2food, improved the product's nutrition profile to ensure it falls within the Australian government's Eat for Health guidelines' "good" choices category for sodium content (less than 400mg) prior to launching in grocery stores.



When introducing its 'Impossible™ Burger 2.0', Impossible Foods improved the plant-based burger's nutrition profile: lowering sodium by 36 percent, decreasing saturated fat by 43 percent, increasing fibre content, and boosting quantities of several essential micronutrients, including folate, calcium, potassium and zinc.²



Smart Protein, a US\$10.5 million project to develop protein-rich foods from plants, fungi, and by-products is exploring new methods for optimising plant proteins and using novel protein sources to bio-mimic meat, eggs and dairy. The project, funded by the European Commission and undertaken by the Good Food Institute, ProVeg, and 31 partner organisations across 21 countries, will seek to identify the most optimal crops and ingredients for functionality, efficiency, and sustainability.³ The use of selective breeding could optimise protein-rich crops like peas and fava beans to have more desirable flavour, textural or nutritional qualities,⁴ reducing the need for additives.



Motif FoodWorks, an ingredients company, has partnered with the University of Queensland to use lab testing techniques assessing the mouthfeel of plant-based meats to create the ideal texture and juiciness to mimic conventional meat. Motif FoodWorks is also using a process called 'precision fermentation' to develop "high-impact ingredients" made using microbes to produce key proteins. These proteins can be added to existing plant-based formulations, not to replace the core protein source but to improve the overall sensory experience. Dr. Leonard, CTO at Motif FoodWorks, says these ingredients both improve functionality and have the potential to "clean-up labels", noting methylcellulose as one ingredient certain plant-based meat companies are seeking to remove from their products as it is "frequently cited as evidence of the highly-processed nature of some plant-based meat products."⁵



Nutriati, an ingredients company focused on pulses and grains, has created a unique plant protein that eliminates the need for plant starches, and binders like methylcellulose, to create a plant-based meat that with a "juicy" and "firm but chewable" texture.⁶ The proprietary protein is called Artesa Textured Pulse Protein and is made from a blend of yellow pea protein and chickpea flour.

Recommendations for Plant-Based Meat Companies and Consumers

As consumers continue to choose products that suit their dietary needs, taste preferences and budgets, the fight for retail shelf space will require plant-based meat companies to innovate in response to market demands. As an actionable takeaway from this research report, Food Frontier and co-author Teri Lichtenstein, APD, present the following recommendations to guide the sector in addressing consumer demands, and to guide consumers in determining the role of plant-based meats within their diet.

Companies

To provide an alternative to conventional meat that meets a range of consumer nutritional requirements and health concerns, individual manufacturers of plant-based meat should ensure product formulations and processing have minimal negative impact on their food's nutritional value. Manufacturers should aim to achieve nutrition profiles that are on par with (or better than) their meat equivalents. Consequently, manufacturers might consider:

Increasing desirable nutrient values

- Biofortification:** To satisfy consumers seeking greater protein or higher levels of micronutrients (but who are still concerned about food additives), manufacturers can consider novel ways of delivering key micronutrients, not through fortification with vitamin and mineral additives, but through biofortification. These could include micronutrients such as tryptophan (which can be converted in the body to niacin⁷ and is also found in some plant foods), iron and zinc, of which conventional meat is a primary source. Biofortification of the base ingredients, like grain and legumes crops, can help increase the nutrient concentration and bioavailability in plant crops. Abundant research is underway by academia and industry on biofortifying crops with a certain nutrient, for example; optimising crops to contain higher levels of protein or a certain amino acid profile. Clemson University (U.S.) is conducting one such research project, looking at breeding organic pulse and

cereal crops like field pea and sorghum with higher protein levels, to deliver complete plant proteins for use in plant-based meats.⁸ Some biofortified crops are already commercially available, with biofortification originally developed to address widespread deficiencies of vitamin A, iron, and zinc that remain prevalent in low-income countries, where people may not have access to commercially processed fortified foods.⁹ For example, Harvest Plus, a program run by the International Food Policy Research Institute (IFPRI) has developed a pearl millet fortified with up to 80 percent of the average daily needs of iron, and a wheat fortified with up to 50 percent of daily needs of zinc.¹⁰ Food manufacturers can work with accredited nutritionists and food scientists to identify potential biofortified ingredients to increase positive nutrients in their product formulations.

- Protein:** Consumer interest in products with substantial levels of protein is at an all-time high, as illustrated by current demand figures and predictions that Australia's 'fortified and functional' market will grow to \$5 billion by 2030.¹¹ This report noted consumer research showing that "high in protein" is a motivator for Aussies and Kiwis to purchase a plant-based meat product. For the 21 percent of plant-based meat products do not have enough protein to be deemed "a good source" per FSANZ regulations, manufacturers should consider whether the product requires reformulation, such as by including biofortified protein as mentioned above. At the same time, with almost all Australians already meeting their requirements for daily protein¹², companies should be careful not to over-emphasise protein in any product formulation. Instead, ensure the product meets consumer expectations by delivering protein levels similar to equivalent conventional meats, whilst also delivering on other important purchase motivators.
- Dietary Fibre:** The presence of dietary fibre in plant-based meat is a clear differentiator from conventional meat, which contains none. Like protein, fibre is a nutrient that many consumers are seeking to increase in their diet.¹³ For the 55 percent of plant-based meat products not yet a "good" (4g

fibre per 100g) or "excellent" (7g fibre per 100g) source of fibre as regulated by FSANZ¹⁴ (or lesser than the average for plant-based meats listing fibre – 4.6g per 100g), manufacturers might consider further boosting fibre content. They can do this with the addition of vegetable fibres such as konjac, pea, oat or potato, or by conducting further research to understand how whole grains can be incorporated in plant-based meat formulations.

Reducing less desirable nutrients and ingredients

- Additives:** With continued ingredient list scrutiny, and increasing consumer interest in 'clean labels', manufacturers should consider opportunities to choose ingredients closer to their original source, considered to be more natural. The advent of 'clean label' approaches is already underway in the plant-based meat sector, offering manufacturers new solutions in ingredient substitution. For example, Motif FoodWorks' 'precision fermentation' project as mentioned previously is exploring innovation in fermentation to find a suitable alternative ingredient to methylcellulose.
- Sodium:** Sodium is one nutrient that can negatively impact health when consumed above suggested daily intake levels. With this in mind, plant-based meat manufacturers should continue to develop products that meet health guidelines for sodium, whilst delivering on taste, which remains a major determinant of food choice, overriding other factors that influence food selection.¹⁵ Given the wide variety of products available on the market with varying levels of sodium, it is clear that manufacturers using formulations with higher levels of sodium (more than 450mg per 100g) can produce products lower in salt and still appeal to consumer tastes. This is supported by the Food Frontier findings that 50 percent of plant-based meat products already meet the Australian Department of Health's Healthy Food Partnership reformulation guidelines for sodium in conventional meat (450mg or less per 100g).

Consumers

For the millions of consumers seeking familiar alternatives to conventional meat, the factors influencing their choice of a plant-based meat product vary considerably. In addition to social, economic and cultural factors, health is often a predominant motive, as conventional meats (to which plant-based meats are an alternative) have been the subject of warnings from public health authorities for their contribution to non-communicable disease. Plant-based meat products can support consumers to reduce their meat intake in line with dietary guidelines and contribute to their overall health goals. The recommendations below can help consumers choose the healthiest plant-based meat product that will also suit individual taste requirements.

Considering dietary guidelines

- When seeking to make any kind of dietary decisions with respect to individual health, it is important to consult an expert such as an Accredited Practising Dietitian or a qualified health professional. Relying on media coverage of health studies, which has been shown in this report to sensationalise study findings or omit important contextual information, may not provide guidance useful to individual dietary needs.
- If individual consumption of red meat, particularly processed meat, is higher than recommended by the Australian and New Zealand dietary guidelines, consideration should be given to reducing meat intake in line with government health authorities' recommendations, to prevent chronic disease. At the same time, consideration should be given to increasing intake of protein from plant-based sources in line with dietary recommendations from organisations like the Australian Heart Foundation.

Choosing plant-based options

- There are many options to eat plant-based meals with whole foods, including vegetables, mushrooms, legumes and grains. However, if consumers wish to reduce meat consumption but are still seeking the most convenient and familiar options – such as a burger to barbeque or bacon for a BLT – plant-based meats can provide alternatives to similar conventional meat products that are, on average across most categories, nutritionally comparable or superior.
- A wide variety of plant-based meat products are available in the Australian and New Zealand markets, with varying formulations and thus varied nutrition profiles and ingredients. It's important to read food labels and nutrition information panels when choosing the healthiest product to suit individual needs. Products with a Health Star Rating of 3.5 or greater should be favoured, along with products containing the least amount of sodium (that still suits taste) and the greatest amount of dietary fibre, two key nutrients of focus in the Australian and New Zealand dietary guidelines. As a guide, choose low or moderately salted products (120 – 400mg sodium per 100g) and plant-based meats that are a good source of fibre (4g of fibre or more per 100g).
- On average, plant-based meats contain about 23 percent of the adult recommended daily intake of sodium per serving. However, as outlined in **Section IV** of this report, select products are considerably high in sodium. The Australian and New Zealand Nutrient Reference Values Suggested Dietary Target for sodium should be referred to for consideration as to how these products fit within an individual diet.
- For consumers concerned with adequate intake of micronutrients that are commonly found in conventional meat (e.g. iron, zinc, vitamin B12), it's important to eat a varied diet to maximise nutrient intake and bioavailability, including selecting meat alternatives that contain these key micronutrients. Consumers should seek individualised advice from an appropriate health professional to ensure individual micronutrient requirements are being met.

- As with any food added to a diet, the nutrition panel and ingredients of plant-based meats should be reviewed to ensure the product selected meets requirements in line with individual recommendations from a health care provider or a qualified Accredited Practising Dietitian.



Tacos using Fable Food Co's Plant-Based 'Braised Beef'

ABOUT FOOD FRONTIER

Food Frontier is the independent think tank and expert advisor on alternative proteins in Australia and New Zealand. Funded entirely by donations, our work is creating a safer, more sustainable and diversified protein supply.

Global economic, environmental and public health authorities continue to urge for a reduction in both meat consumption and our reliance on industrial systems of livestock farming and fishing. These authorities have stressed that diversifying protein production is essential to feed global populations safely and sustainably into the future. Alternative proteins, like plant-based meat and meat cultivated from cells, are a critical part of this solution.

Through reports, conversations and events, Food Frontier provides data and insights on alternative proteins and their economic, environmental and public health benefits. We advise and connect businesses, innovators and policymakers – from start-ups to grocery giants, farming bodies to regulators – helping leaders navigate and pursue opportunities in the emerging plant-based meat and cultivated meat industries.



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APPENDIX

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Section I

Table 8 – Summary of Epidemiological Research on NCDs related to meat consumption

Condition	Description	Evidence
Type 2 Diabetes Mellitus (T2DM)	<p>Type 2 Diabetes Mellitus (T2DM) is a progressive condition in which the body becomes resistant to the hormone insulin and/or gradually loses the capacity to produce enough insulin in the pancreas.¹ T2DM can cause blindness, amputations, cardiovascular disease and premature death.²</p> <p>Incidence of T2DM has been increasing globally and has tripled in Australia in the past 25 years³ to one million cases.⁴ In New Zealand, T2DM is the fastest growing health condition with 210,000 New Zealanders (7 percent) diagnosed.⁵</p>	<p>A number of cohort studies,⁶ meta-analyses^{7,8} and critical reviews⁹ have investigated the association between both red and processed meat and risk of T2DM.¹⁰ Additionally, some observational studies indicate that overconsuming red meat, due to its energy density and saturated fat content, is linked to obesity and increased waist circumference, which are both established risk factors for T2DM.¹¹</p> <p>One meta-analysis concluded that the risk of T2DM increases by 19 percent for every 100g of red unprocessed meat, and 51 percent for every 50g of red processed meat consumed per day, respectively.¹² Another study found that when comparing high versus low intake of red and processed meat, the relative risks of developing T2DM were 21 percent and 41 percent respectively.¹³</p> <p>Previously mentioned studies have found significant relationships between the amount of red and processed meats consumed and death due to T2DM.^{14,15,16,17}</p>

Table 8 Cont.

Condition	Description	Evidence
Cancers	Cancer is a generalised term for a disease in which specific cells grow and reproduce abnormally. ¹⁸ One-in-two Australians will be diagnosed with cancer by the age of 85; ¹⁹ in New Zealand, it is one-in-three. ²⁰	<p>In 2015, experts from the International Agency for Research on Cancer (IARC), the specialised cancer agency of the World Health Organization (WHO), reviewed and assessed more than 800 epidemiological studies that investigated the links between cancer and consumption of red and processed meat²¹ across different settings and populations. Their conclusions, published in renowned medical journal <i>The Lancet</i>, led to the classification of processed red meat as “carcinogenic to humans” (Group 1 Carcinogen) and of red meats as “probably carcinogenic to humans” (Group 2A Carcinogen).²²</p> <p>The largest body of data links meat consumption with colorectal cancer, the third most commonly diagnosed cancer in Australia and estimated to be the second most common cause of cancer death.²³ One large meta-analysis²⁴ found for every 50g of processed meat consumed per day, the risk of colorectal cancer increased by 18 percent.²⁵ The association with red meat was also significant - for every 100g of red meat consumed per day, the risk of colorectal cancer increased by 17 percent. Other large cohort studies from Australia and Sweden have found associations between increasing consumption of red meat and increased incidence of colorectal cancer.^{26,27,28} Prospective studies have also demonstrated an increased risk of cancer recurrence and death in colorectal cancer survivors who ate the most red and processed meats.²⁹</p> <p>A more recent meta-analysis found a significant association linking consumption of processed red meat to breast cancer.³⁰ Australians should take these findings seriously, as breast cancer is estimated to be the most commonly diagnosed cancer in Australia.³¹</p> <p>Consumption of red meat and processed red meat has also been significantly associated with breast cancer,³² oesophageal cancer³³ and gastric cancer^{34,35} by multiple meta-analyses.³⁶ Consumption of both red meat and processed red meat is associated with cancer development, though processed red meat more consistently represents the higher risk factor.</p>
Cardiovascular disease (CVD)	Cardiovascular disease (CVD) is a collective term for diseases of the heart and blood vessels, such as coronary heart disease (CHD) and stroke. ³⁷ In Australia, approximately one-in-twenty Australians suffers from CVD, and it is the leading causing of death at just under one-in-three deaths each year. ³⁸ In New Zealand, approximately one-in-twenty suffer from cardiovascular disease ³⁹ and it is the leading cause of death at 33 percent annually. ⁴⁰	<p>A systematic review found that the risk of coronary heart disease increased by 42 percent with every 50g of processed meat consumed per day,⁴¹ and a large cohort study of over 80,000 women found an increased risk of CHD with the consumption of both processed and unprocessed meats.⁴²</p> <p>Several studies on patients with CVD have established significant associations between meat consumption and mortality.⁴³ One meta-analysis showed an increased risk of CVD mortality related to daily consumption of red meat: a 24 percent increase for every 50g of processed red meat, and a 15 percent increase for every 100g of unprocessed red meat.⁴⁴ The Etemadi et al study (as referenced in ‘all-cause mortality’ below) found relationships between death caused by stroke and by heart disease, for both processed and unprocessed red meat consumption.⁴⁵</p>
All-cause mortality	All-cause mortality is an epidemiological term for death from any cause. Studies that investigate an association between excess meat consumption and a range of NCDs often also assess ‘all-cause mortality’ as an outcome, which can be helpful to reflect a potential relationship between an input (i.e. meat) and multiple concurrent diseases (e.g. cardiovascular disease, cancer and T2DM).	A large 2017 cohort study published by Etemadi et al in the <i>British Medical Journal</i> (BMJ) found the risk of all-cause mortality increased in association with increased intake of both processed and unprocessed meat, as well as associations with nine other chronic diseases. ⁴⁶ Those consuming the most red meat were found to have a 26 percent increased risk of death compared to the lowest consumers. Two other large cohort studies have also found a significant association between all-cause mortality and meat overconsumption. ^{47,48}

Table 8 Cont.

Condition	Description	Evidence
What are the potential disease pathways?	<p>Researchers have developed multiple hypotheses to explain the harms observed in these studies.</p> <p>One of the leading possible explanations is related to oxidative stress,⁴⁹ an imbalance between the production of harmful oxygen-containing molecules (known as free radicals) and antioxidant defences (molecules that can counter the effect of free radicals). Continued oxidative stress can lead to chronic inflammation, which in turn can facilitate the development of chronic diseases including cancer, T2DM and CVD.^{50,51} This indicates there may be a common underlying mechanism to these NCDs, which shows how foods such as red and processed meats can be linked to multiple chronic illnesses.</p> <p>Haem-iron, found naturally in red meats, as well as nitrates and nitrites – components that occur naturally but are added to some processed conventional meats like bacon and sausages – have been shown to promote oxidative stress and inflammation in different organs when consumed in high quantities.⁵² Furthermore, high intake of haem-iron has been associated with many adverse health outcomes such as T2DM, CVD and cancer.^{53,54,55,56,57} Despite these potential associations, haem iron remains the most efficiently absorbed form of iron.^{58,59}</p> <p>Beyond the inflammatory pathway, it has been speculated that certain cancers may be linked to mutagens/carcinogens (compounds that cause a mutation in DNA cells) that can arise when cooking conventional meat, particularly at high temperatures (e.g. grilling, barbecuing).^{60,61}</p> <p>Saturated fats found in conventional meat, both processed and unprocessed, are another factor potentially linked to CVD and T2DM. While the potential harms associated with all saturated fatty acids are a source of ongoing debate, specific types found in meats have been shown to increase markers known to have adverse effects on cardiovascular and metabolic health.^{62,63} Peak health authorities including Australia's National Health and Medical Research Council and the World Health Organization recommend limiting the consumption of saturated fats.⁶⁴ Other components abundant in red meat - L-carnitine, choline and their gut metabolite trimethylamine-N-Oxide (TMAO) – are strongly associated with the build-up of fats, cholesterol and other inflammatory substances in the arterial wall (atherosclerosis), which is believed to partially explain the links between red meat consumption and CVD risk.^{65,66}</p> <p>This represents a small snapshot of burgeoning research on the potential mechanisms behind the harms of red and processed meats. Future research is expected to shed further light on the pathophysiological processes induced by red and processed meats that lead to disease.</p>	
Interpreting the evidence	<p>This emerging body of evidence should concern people who eat meat frequently, though it is worth noting these studies have some limitations. Although many have established a significant association between meat consumption and certain outcomes, association doesn't necessarily always equal causation. There may be variables in diet and lifestyle that cannot be entirely controlled for in such studies. To overcome these limitations, the findings shared in this report have been intentionally drawn from studies that have controlled for these possible variables by using multi-variate analyses.⁶⁷</p> <p>Second, some of the studies that assessed a dose-response relationship compared low-level consumers of meat (i.e. 10-20g/day) to high-level consumers (i.e. >160g/day), while few studies assessed risks associated with occasional low-level consumption compared with zero consumption.</p> <p>As many of the studies surrounding the harms of conventional meats stem from the U.S., it may be a question as to whether their conclusions are transferable to populations with different dietary patterns. However, Australians and New Zealanders by-and-large eat a similar 'Western Diet' as the U.S., and therefore the findings should be assumed to be highly relevant to the health of local populations.</p> <p>Finally, the risks reported above largely apply to consumption of red and/or processed meats, versus poultry or seafood. One major study, while finding an increased risk from red meats, found a 25 percent reduced risk of all-cause mortality for consumers who replaced red meat with white meat, and a 34 percent reduction of mortality from heart disease for those following plant-based (lacto-vegetarian) diets.⁶⁸ On the other hand, there is positive evidence that replacing animal protein (of all types) with plant protein reduces the risk of death and CVD especially for those who have pre-existing cardiovascular risk factors such as smoking, heavy alcohol intake, are overweight or obese or have reduced physical activity.^{69,70} Given that two-in-three Australian adults are overweight or obese, one-in-eight smoke daily and one-in-five consume more than two standard drinks per day – a large majority of our population have these risk factors, meaning plant-based protein can provide health benefits when consumed as an alternative to animal protein.⁷¹</p>	

Section III

Glossary – for Myth-buster: If I eat a meal with only plant-based proteins, I won't get enough

- **Essential** – amino acids that are not produced by the human body and need to be obtained from food/exogenous sources
- **Non-essential** – amino acids that the human body produces and do not need to obtain from food/exogenous sources
- **Complete protein** – a protein that contains all essential amino acids required for protein metabolism
- **Incomplete protein** – a protein that lacks one or more essential amino acids and cannot be used as a sole source of dietary protein

Table 9: Comparison of plant-based meat and conventional meat equivalent menu items at Australian fast food chains

Ave. qty (per serve)	Grill'd Simply Grill'd	Grill'd Beyond Simply Grill'd	Hungry Jack's Whopper	Hungry Jack's Rebel Whopper	Pie Face Mexi Mince Pie	Pie Face Vegan Mexi Mince Pie	Mad Mex Chicken Chipotle Burrito	Mad Mex Baja BBQ Vegan Chicken Burrito
Energy (kJ)	2680	3160	2700	2820	2220	2170	3229.6	3233.6
Protein (g)	32.6	38.8	25.9	28.3	16.8	12.9	34.7	35.4
Fat, Total (g)	31.3	41.1	39	36.3	31.7	27.2	26.1	24.3
Saturated (g)	9	10.1	11.6	11.5	15	13.3	13.2	11.9
Carbohydrate (g)	52.8	52.6	48.1	58.0	44.2	53.4	92.6	93.1
Sugars (g)	11	9.6	8	8.4	2.2	3.4	8.8	8.8
Sodium (mg)	1140	1100	844	1150	629	601	1588.8	1905.6

END NOTES

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I. INTRODUCTION

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II. EVIDENCE FOR MEAT REDUCTION

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III. NUTRITION OF MEAT ALTERNATIVES

- Data provided by Grains & Legumes Nutrition Council via an audit of plant-based meat substitutes in the four major supermarket brands (Aldi, Coles, IGA, and Woolworths) of metropolitan Sydney in June 2019, replicating a process that was conducted on the same category in 2015. Data set was expanded by Food Frontier through July 2020 to account for new products. These supermarket chains represent more than 80% of total Australian market share and were chosen to reflect choices available to the majority of Australian shoppers.
- Brands included in analysis: Australian Eatwell, Bean Supreme, Bite Me Fine Foods, Coles, Grounded Plant Based Nutrition, Larder Fresh, Nature's Kitchen, Simple Vegetarian, Syndian Natural Food Products, The Fry Family Food Co, Veggie Delights
- Brands included in analysis: Amy's Kitchen, Bean Supreme, Beyond Meat, Eaty, Funky Fields, Gardein, Harvest Gourmet, Herb & Sons, Linda McCartney, Made With Plants, Moving Mountains Foods, Nature's Kitchen, NEXT!, NextGen2, Plant Asia, Plantein, Quorn, Simply Vegetarian, Sunfed Meats,

- The Alternative Meat Co., The Fry Family Food Co, The Vegan Factor, Tofurky, Unreal Co, v2food, Veef, Veggie Delights
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 5. Information for Burgers did not exist within the FSANZ Australian Food Composition Database; nutrition data was averaged from 15 conventional beef burger products across a range of price points, including both fresh and frozen products, available for purchase in Coles, Woolworths and IGA stores in June, 2020. Brands included: Woolworths Market Value, Woolworths Brand, Coles Brand, Coles Finest, Beak & Sons, Fitzco, Peppercorn, Cleavers Organic, Created with Jamie, Community Co, I&J, The Gourmet Sausage Company
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 8. Plant-based products in the Poultry – crumbed category are designed as an alternative to chicken nuggets, chicken burgers, chicken schnitzels (all crumbed) or other crumbed formats, therefore comparative nutrition data is most accurate if all styles are included. Nutrition data for these crumbed styles of Poultry - crumbed did not exist in the AFC database, thus nutrition data was averaged from AFC entry for F002755: Chicken, nugget, purchased frozen, baked, no added fat; and data averaged from 14 crumbed chicken products available at Coles, Woolworths and IGA stores in June 2020. Brands included: Coles, Woolworths, Steggles, Ingham, Bayview, Bite Me Fine Foods, Lilydale. Formats included: Schnitzels, crumbed chicken burgers, crumbed chicken kiefs, crumbed chicken bites and crumbed chicken nuggets; fresh and frozen.
 9. Plant-based products in the Poultry – un-crumbed category are designed as an alternative to ready-to-cook chicken pieces, which can be raw or pre-seasoned. Nutrition data for this category was averaged across a combination of both pre-seasoned chicken pieces (14 products available at Coles, Woolworths and IGA stores in June 2020. Brands included: Woolworths Deli, Woolworths Market Value, Woolworths Macro, Coles, Steggles, Ingham's, Primo, Moira Macs, Luv-a-duck and Poachers Pantry. Formats included: smoked chicken breast, flavoured pieces, slices, shredded, pulled, roasted and butterflied chicken, turkey and duck; fresh and frozen), as well as FSANZ data for raw chicken pieces including: Chicken, breast, lean flesh, skin & fat, raw: F002597
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IV. OTHER HEALTH CONSIDERATIONS

1. Analysis of 95 plant-based meat products on the AU/NZ market by Food Frontier external support (PhD in Food Science); cataloguing top six ingredients (by volume) by macronutrient, with exception to ingredients that may appear later in ingredient list but have significant contribution to a macronutrient, such as oils/fat.
2. Analysis of 75 conventional meat products available at Woolworths and Coles in the AU/NZ market by Food Frontier external support (PhD in Food Science); cataloguing additives by functional category and calculating occurrence of each additive category across all products, as well as most frequently occurring additives. Products selected at random to secure approximately 10 examples across each format category as analysed for plant-based meat (sausages, burgers, bacon, mince, poultry crumbed, poultry chunks, poultry slices).
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VII. APPENDIX

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