

Synthetic proteins. What will consumers be eating in the future and are our food producers aware?



Memphis Meat's \$1,000 lab-grown meatball | COURTESY OF MEMPHIS MEAT



Jared Briggs

Kellogg Rural Leadership Programme

2017

Contents

Contents	2
Executive Summary	3
Acknowledgements	4
Introduction	5
History and predictions	7
Key companies	9
Aim and Objectives	13
Method	13
Survey results	14
Summary	22
Recommendations	22
References	22
Appendix	26

Executive summary

Synthetic meat, cultured meat, artificial protein. Many of us have heard the terms but what do they mean? More importantly do our food producers know what they mean and what impact they may have on them?

New Zealand's place in the world's meat supply has always been at the premium end. We are not high-volume suppliers. We offer something different; our food producers care about their animals, their health, the land and the fine people who are the caretakers of it.

This report surveys seventeen farmers to answer the question, is there enough information available for our food producers and to gauge what further information is required.

The questions cover a range of topics to gauge farmer awareness of the synthetic protein industry and how this may affect them.

Also included is an historical overview from the inception of this technology through to predictions for the future. Information on the key companies involved completes this study.

Key findings:

- 1) Our Food producers feel that they do not have enough information readily available. Information is available online. However, it requires effort to sort through the content!
- 2) Synthetic proteins are not currently seen as a high risk to our food producers. Other risks such as political and environmental influences feature highly.
- 3) Innovation in this sector is happening very quickly. New information is available daily and it's difficult to stay ahead. Without
- 4) Many producers see the introduction of synthetic protein as an opportunity and are looking to push the benefits of our sustainably produced, grass-fed premium products.

Acknowledgements:

Firstly, I would like to thank the support of my fantastically understanding wife Haylee. Without her support, whilst working full time and looking after our two children herself, I could not have attempted the programme.

Secondly, I would like to thank Shane McManaway for his encouragement and support throughout the programme and for his constant mentoring towards my own personal development. I also need to thank John Rutherford for his continued positive motivation and my fantastic team, Alan Wix and Christine Hart for holding the fort while I was away.

I would also like to thank Scott Champion, Anne, Lisa, Patrick and all my fellow Kelloggers on the course. I have enjoyed our time together and the lessons I take away will help me greatly throughout my career.

I would also like to thank all the food producers who took the time to complete my survey and provide their own opinions. I have had many interesting discussions on this important topic and thoroughly enjoyed each one.

Finally, I would like to thank all the sponsors of the Kellogg Rural Leadership Programme. The support you offer our Agricultural industry by helping train tomorrow's future leaders is fantastic and truly appreciated.

Introduction

New Zealand's place in the world's meat supply is at the premium end. We are not high-volume suppliers. We offer something different. Our food producers care about their animals, their health, the land and the fine people who are the caretakers of it.

Technology is advancing faster than ever before. (Smart Farm) technologies, expect the average farm to generate an average of 4.1 million data points per day in 2040, up from 190,000 in 2014. (Andrew Meola, Business Insider December 2016) We now have bit coin for currency, block chain will revolutionise banking and Silicone Valley are now eyeing up the primary sector. (Kim Brunhuber, CBC News, October 2016)

There is an eruption of disruption coming and to quote Kimbal Musk (the brother of Tessler's Eion Musk) "The next million-dollar ideas will come from disrupting the food industry." (Steven Overly, Washington Post 2016).

He goes on to add, "My advice for any entrepreneur or innovator is to get into the food industry in some form so you have a front-row seat to what's going on. Successful entrepreneurs in the food business are also more likely to hail from Minneapolis or Memphis than Silicon Valley or New York,". (Steven Overly, Washington Post 2016).

This is happening at a frightening pace. In the past month China signed a \$300 million-dollar deal with three Israeli companies: SuperMeat, Future Meat Technologies, and Meat the Future. This will see China import lab-grown meats for the first time. (Brad Jones, Futurism September 2017)

When discussing disruptive innovation people often talk about the "Kodak effect" and how failure to be aware of innovation can have terrible repercussions. (Nathan McAlone, Business Insider August 2015). In 1975, a Kodak employee Steven Sasson invented not only the first digital camera, but also a device to display it on. The technology was never fully embraced; the opportunity was missed and Kodak eventually filed for bankruptcy in 2012.

Are food producers in New Zealand facing their own potential "Kodak moment", with the introduction and increasing popularity of synthetic protein? Our red meat markets are both worth saving and savouring. With the price of lab-grown meat coming down from \$325,000 to just over \$11.00 per patty (Bec Crew, Science Alert, 2015) and the popularity of plant-based protein growing, is enough being done to educate our food producers?

"Fake animal proteins are set to disrupt world markets – and much faster than our agriculture industry is anticipating. The Synbio-led tsunami that is currently gathering momentum has the potential to crash hard into conventional agriculture's paddock – and probably sooner than we think." (food strategist Dr Rosie Bosworth, 2017)

The way consumers purchase their protein is changing, "Food today is no longer just about sustenance, it's intrinsically linked with social bonds and personal values. The food consumers eat says something about how they want the world to be, so in essence people are eating their values and these include the way animals are farmed - although food also needs to deliver on taste." (Mike Lee 2017)

Mike Lee also says plant based and cellular agriculture technologies have the potential to scale up within ten years and they'll be 80% there in terms of taste and costs within five years.

According to Waitrose in the UK, plant-based protein will be in the top 5 biggest food trends in 2018: "The demand for high-protein foods continues, and with more of us choosing a flexitarian diet it's no wonder there's such a buzz around new plant-based proteins. Whether with pulses, shoots, grains, seeds, soy or even algae, everyone from tiny start-up companies to big brands is looking for clever new ways to add a protein punch." (Allison Millington, Business Insider 2017)

As Nick Beeby: General Manager market development for Beef and Lamb New Zealand says, "Ultimately, the red meat sector is important to New Zealand's health and success. It's our second largest goods exporter and largest manufacturing industry, representing 3.2% of New Zealand's GDP and accounting for \$7.0 billion." (Nick Beeby, The Spinoff, 2017)

The American Government is concerned enough to fund the American National Academy of Sciences (NAS) report "Preparing for Future Products of Biotechnology". This will identify the impact of and products likely to be produced using biotechnology in the next 10 years.

In New Zealand, what are we doing?

The Parliamentary Commissioner for the Environment, Jan Wright, says New Zealand farmers should beware of synthetic meat and milk being developed by California's Silicon Valley. It is a "major challenge", she told the Agricultural Greenhouse Gas Mitigation conference in Palmerston North. "We know how fast they can develop things." (Jill Galloway, NZ Farmer 2017)

It is great to see Beef and Lamb NZ taking the proactive step of investigating further to help NZ farmers. I am looking forward to reading their upcoming report. General Manager of Beef and Lamb: Nick Beeby says that the report will answer the important question: "Can New Zealand's premium, natural pasture-raised meat co-exist in a world with alternative proteins?"

The aim of this project is to see if our food producers are aware of what possible disruption is coming.

History and predictions:

Sources:

http://www.tiki-toki.com/timeline/entry/147753/A-History-of-Cultured-Meat/#vars!date=2006-07-30_17:37:51! (retrieved October 2017)

<https://www.theatlantic.com/technology/archive/2013/08/chart-when-will-we-eat-hamburgers-grown-in-test-tubes/278405/> (Retrieved October 2017)

1910: Dr Alexis Carrel and Montrose T Burrows start experimenting by culturing adult mammalian tissue outside the body. Dr Carrel then established a series of chick embryonic heart cultures. One culture – number 725 became world famous.

1930: Winston Churchill writes his essay “Fifty years Hence”. Winston Churchill's essay "Fifty Years Hence" is published in Strand Magazine, where he predicts a future with cultured meat: "We shall escape the absurdity of growing a whole chicken to eat the breast or wing, by growing these parts separately under a suitable medium."

1946: Dr Alexis Carrel's culture number 725 dies after 34 years.

1980: 50 years pass since Winston Churchill's prediction

1994: NASA conducts early experiments with in vitro meat for long space voyages

1999: William van Elen secures the first cultured meat patent

2004: New Harvest presents at the “Transition towards sustainable protein supply chains" symposium, PROFETAS Conference, at Wageningen International Conference Center, the Netherlands.”

2005: Henk Haagsman at Utrecht University received a €2 million grant from the Dutch government to study in vitro meat development using stem cells. This research made a major contribution to the field and involved scientists from University of Amsterdam, Utrecht University, and Eindhoven University of Technology.

2005: Jason Matheny from New Harvest predicts "Within several years, lab meat could be used in Spam, sausage, and even chicken nuggets."

2006: Wired.com: "The technology to grow a juicy steak, however, is still a decade or so away. No one has yet figured out how to grow blood vessels within tissue."

2008: Telegraph: "It's predicted that commercial production could be underway within five years, with the hope that mass production of in vitro meat could feed the world's starving millions."

2009: Telegraph: "It's predicted that commercial production could be underway within five years, with the hope that mass production of in vitro meat could feed the world's starving millions."

2011: Neil Stephens: "The likelihood is that mass-produced artificial beef, pork, lamb or chicken is at least a decade away."

2015: The first cultured beef patty cost a whopping 250,000 euros, but within 10 years production could be scaled up to compete with traditional beef in cost, especially if beef prices continue rising, Professor Post said.

2015: Alternative Proteins to Claim a Third of the Market by 2054

2016: Memphis meats plan launching its products to consumers in 2021

2017: China signs \$300m partnership deal with Israeli

In-Vitro Meat Predictions 2005-2035

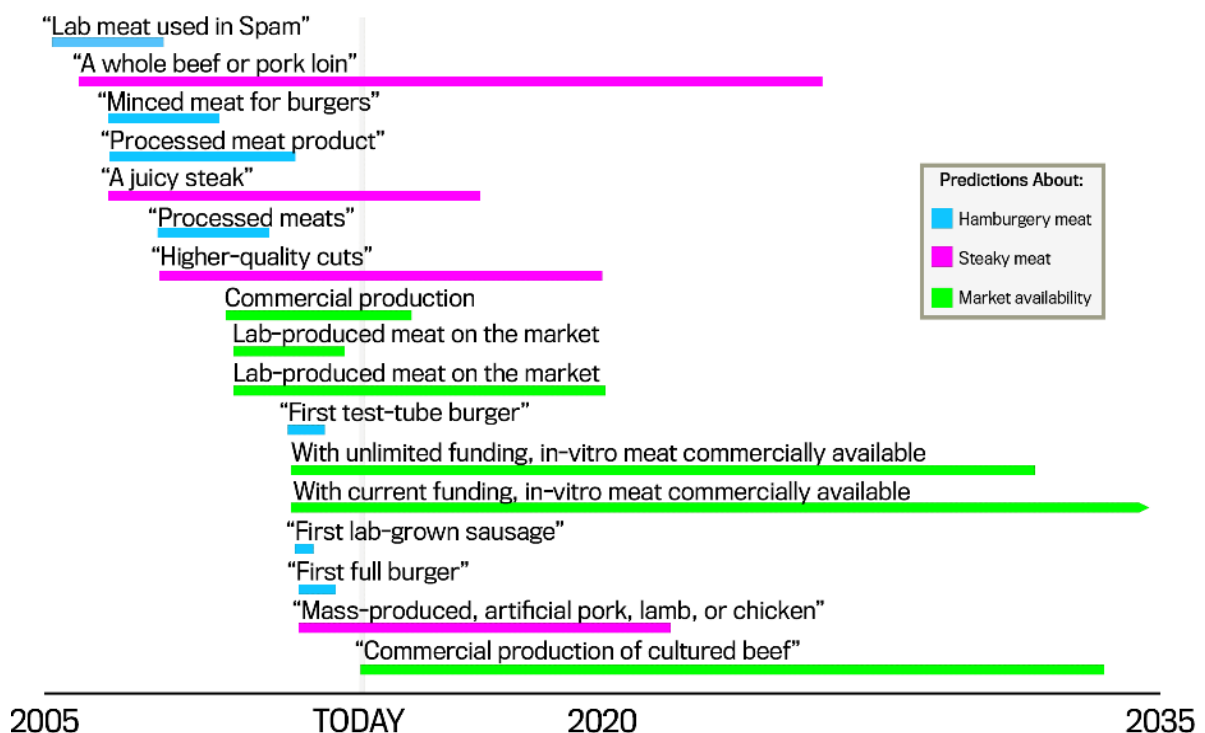


Figure 1

(ALEXIS C. MADRIGAL, AUG 6, 201

Key companies:



<http://www.new-harvest.org>

- Established in 2004, New Harvest is the non-profit research institute building and establishing the field of cellular agriculture.
- We strategically fund and conduct open, public, collaborative research that reinvents the way we make animal products - without animals.
- Our mission is to build and establish the field of cellular agriculture.
- Our vision is a strong foundation of accessible, public, fundamental cellular agriculture research, upon which we can build a post-animal bioeconomy, where we harvest animal products from cell cultures, not animals, to feed a growing global population sustainably and affordably.

Source:

(<http://www.new-harvest.org>, **October 2017**)



<http://www.memphismeats.com>

Probably the best-known name around at this point, this San Francisco-based startup is looking to produce products for beef, chicken, and pork. It was <http://www.memphismeats.com/about-us/> by CEO Uma Valeti, CSO Nicholas Genovese, and BBQ Pitmaster Will Clem. So far they have succeeded in putting together a couple of very edible looking products including their very well shared meatball. In February 2016, the company announced the close of their seed round, bringing in \$2.75 million from SOSV and New Crop Capital. (source Gabriele Avner, Geektime March 2017)

Memphis Meats has already dabbled in beef, unveiling a cultured meat-cell meatball in February 2016. The company isn't hanging a price tag on its products yet, but says its team "expects to continue reducing production costs dramatically, with a target launch of its products to consumers in 2021."

Memphis Meats is a food technology company headquartered in San Francisco aiming to grow sustainable cultured meat. The company was founded by three

scientists: Uma Valeti (CEO), Nicholas Genovese (CSO), and Will Clem. Valeti is a cardiologist and medical professor at the University of Minnesota.

The company plans to produce various meat products using biotechnology to induce stem cells to differentiate into muscle tissue and to manufacture the meat products in bioreactors. In February 2016 Memphis Meats published a video of a cultured meatball, and in March 2017 the company published a video of cultured chicken and duck dishes. The implications of this must be worrying for the poultry industry that they are also in the cross hairs.

The production cost of the cultured beef was \$18,000 per pound (\$40,000/kg), and the production cost of the cultured poultry was \$9,000 per pound (\$20,000/kg). The company said it anticipated cost

It's all a function of funding. We feel like we have the science worked out, so it's an engineering challenge at this point to meet the demand for our meat. Our goal is to be in the market in three years' time and in retail in five years, by 2021. (Uma Valeti, AgFunder 2016)

Source:

(<http://www.memphismeats.com> retrieved September 2017)

(https://en.wikipedia.org/wiki/Memphis_Meats retrieved September 2017)



Mosa Meat

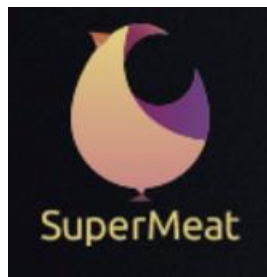
<http://mosameat.eu>

This company was founded by Professor Mark Post, a researcher out of Maastricht, Netherlands. Back in 2013, he made waves when he came on stage with his lab-grown burger, introducing the world to the concept of an actual burger that didn't come from a cow.

While the responses to his burger were mixed, what shocked the crowd at first was the high cost of their early stage product, hitting an astounding price tag of \$325,000. Thankfully, they now have it down to a much more reasonable \$11.36, but know that if they will have to bring it down way more if they want to make an impact.

Professor Post has noted that it is primarily an issue of scale, and once he is able to grow in large enough facilities, it should become a much more economically viable

product. Dr. Post's research has succeeded in attracting the attention of big name backers like Sergey Brin of Alphabet who put in €250,000 to help fund the project. (source Gabriele Avner, Geektime March 2017)



SuperMeat

<http://supermeat.com/meat.html>

SuperMeat is an Israeli Biotechnology startup that organically cultures chicken meat using regenerative technologies. The company was founded to address the technological and ecological challenges in feeding a growing global population. SuperMeat is an ideologically and scientifically driven effort to create a humane, animal-free solution, to nutritional security, which will drastically reduce carbon emissions and increase food safety worldwide.

Not to ones to miss an opportunity for innovation, this Israeli company has set their sights on replacing chicken through the work of Hebrew University Professor Yaakov Nahmias.

"I came to realize that, this is unsustainable," says Nahmias on the importance of his work. "If I want my children to eat the same fried chicken that my grandma used to make, I need to develop ground-breaking technology that will fundamentally change meat production in the coming century." (source Gabriele Avner, Geektime March 2017)

Source:

<http://supermeat.com/meat.html> (retrieved October 2017)

IMPOSSIBLE™

Impossible Foods

<https://www.impossiblefoods.com/>

This company has hit the ground running. They have already roused the interest of Google. The tech giant offered to acquire them for a gigantic sum in the range of \$200-\$300 million.

“We’re a mission-driven company and Google has a lot of interests,” Impossible Foods Founder and CEO Patrick Brown said at <http://www.recode.net/code-conference-2016> last summer. “We want to have control of our fate. It made no sense for us to be acquired by anyone at this stage.”



Sunfed Foods

<https://sunfedfoods.com/>

- Sunfed foods is a New Zealand company based in Auckland making plant based protein.
- They are gaining a following since featuring on TVNZ and Nigel Larter’s taste test on his show “What Next?”.
- The ingredients of chicken free chicken “Water, Pea Protein, Rice Bran Oil, Pea Fibre, Pumpkin, Natural Yeast Extract, Maize Starch.”

Source:

<https://sunfedfoods.com/> (retrieved October 2017)



Modern Meadows:

<http://www.modernmeadow.com>

Modern Meadows are using similar technology to create synthetic leather products.

- We're using living cells to grow nature's materials. We make bio fabricated leather materials from a process entirely free of animals.
- Our cell engineering optimizes collagen production while materials science and engineering organizes our fiber structure to deliver better performing materials.

Source:

<http://www.modernmeadow.com> (retrieved October 2017)

4.0 Aims and objective

My aim for the project is to answer the question, Is there enough information on synthetic protein available for our farmers? I also hope to gain a better understanding of the industry and technological advancements.

I look forward to sharing my learnings and trust they may be useful in the future.

5.0 Method:

An online literature review was completed. This research helped develop nine key interview questions. Questions were designed to gain a better understanding of how much farmer's awareness there is on the topic.

Seventeen sheep and beef farmers across New Zealand were selected. Farming operations were nationwide and had a mix of family enterprises as well as large commercial operations.

All seventeen surveys were reviewed and analysed upon receipt using descriptive analysis.

6.0 Survey results:

Q1. Is there enough information readily available for New Zealand farmers on synthetic protein/meat?

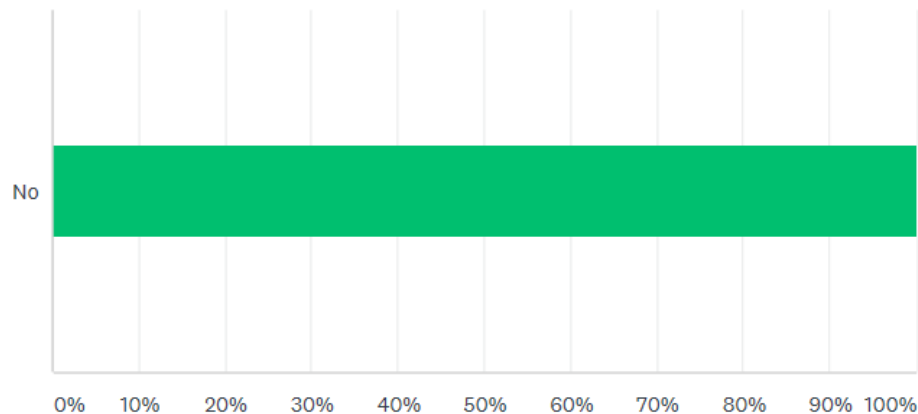


Figure 6.1

The answer was a unanimous No. There is clearly not enough information currently available for New Zealand farmers.

Q2. If so? What sources has this information come from? Please be as specific as possible.

Respondents listed the following sources:

- Media
- Internet and social media
- Beef and Lamb communications
- Farming Papers
- Television

Most of our farmers are receiving their information on Synthetic Protein from the media, the internet and social media. This is a concern as there is the chance for information to be overhyped.

Q3. Do you see synthetic protein/meat as a potential threat or opportunity?

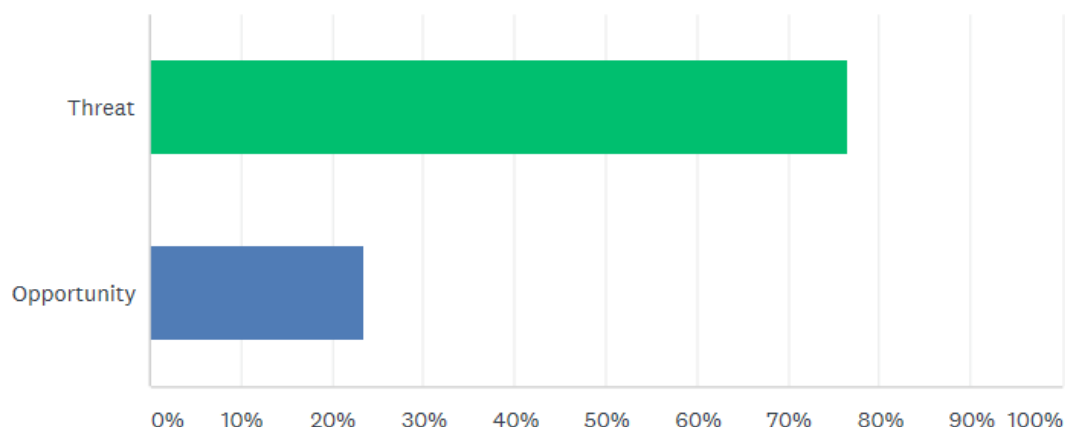


Figure 6.2

Having spoken to many farmers on the topic previously I thought more would find synthetic protein a threat.

However, nearly one in four respondents see synthetics as an opportunity. The following question gave respondents the chance their answer in more detail and makes very interesting reading.

Q4. Can you please explain why you see synthetic protein as a threat or opportunity in more detail?

Opportunities:

- “A chance to sell our story of how natural our products are and how the natural strength of our environment is used to produce a protein.”
- “There is a threat in terms of NZ being a Red Meat producer, but more of an opportunity for NZ to distinguish ourselves as premium producers of the very best meat in the world!!”

Threats:

- “Threat to the NZ grass fed produce model due to reduced impact on environment.”
- “Direct competitor to our farmed natural product.”

- “The cost of mass production of synthetic product will be a lot cheaper than natural protein & obviously the cost to the farmer could be significant.”
- “As a threat, this has the potential to crash the NZ beef industry.”
- “Seen and marketed as a cheaper, more sustainable and environmentally friendly source of protein. Has the potential to become very competitive with red meat sector.”
- “Threat: Out compete our dairy Beef/Lower value commodity end of market. Opportunity: Force industry to value add and pitch premium product to the world.”
- “Threat for NZ bull beef industry but not for our niche products.”
- “It is a commodity and we have the ability to produce a niche grass fed marbled product for the price indifferent consumers.”
- “Supply and demand. Less Environmental impact? Greenies not hurting animals (do gooders).”

Both:

- “It is a both a threat and an opportunity. A threat, as synthetic meat might replace our low value commodities, such as cull dairy cows, bull beef, etc. An opportunity to market high value meat, such as grass fed, storybook, well marbled meat.”
- “Loss of income for farmers but on the plus side we can market our meat is 100% natural and not man made. We would need to think outside the square more and market ourselves better as farmers.”
- “Synthetic meat is not aiming at vegetarians, it is aimed at meat eaters as an alternative protein. We need to consider other opportunities for sheep and beef farmers that is not reliant on 'one product'. What else can meat be used for? We also need to keep progressing with a competitive advantage of 'grass fed animals' but this is a short-term solution for a market trend that is continuously changing.”

Q5. Would you try a synthetic meat burger yourself?

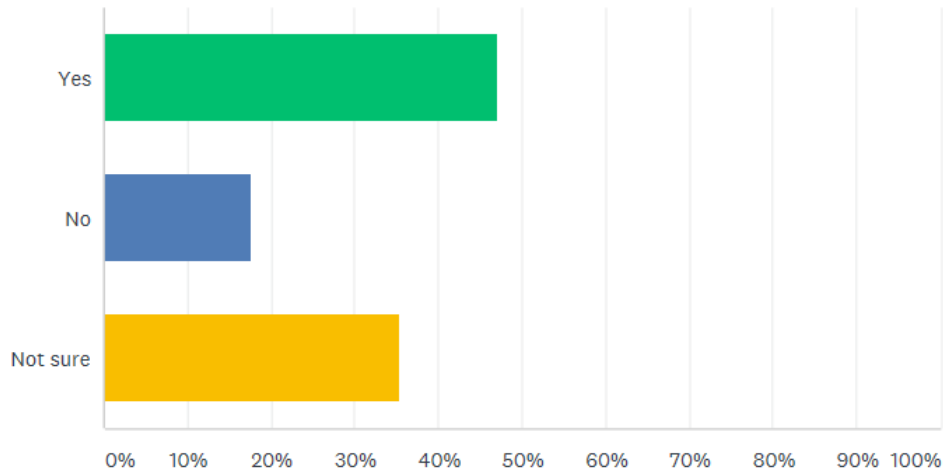


Figure 6.3

Only 47% of farmers would try a synthetic meat product themselves. There were only three who answered with a definite no and six producers were undecided. I would personally be interested in trying the product for taste and texture.

To compare, a recent survey conducted in the United States found that 65% of 673 participants would try a synthetic meat product.

Participants' willingness to engage with the product.

Question/response options	No. of Responses	Percentage of Sample
Would you be willing to try IVM?		
Definitely yes	213	31.1
Probably yes	234	34.2
Unsure	80	11.7
Probably no	86	12.6
Definitely no	58	8.5
Would you be willing to eat IVM regularly? *		
Definitely yes	44	6.4
Probably yes	179	26.2
Unsure	211	30.8
Probably no	129	18.9
Definitely no	51	7.5
Would you be willing to eat IVM as a replacement for farmed meat? *		
Definitely yes	49	7.2
Probably yes	166	24.3
Unsure	180	26.3
Probably no	144	21.1
Definitely no	62	9.1
Not applicable (I do not eat farmed meat)	13	1.9
How willing would you be to eat IVM compared to soy substitutes? *		
Much more	132	19.3
Somewhat more	194	28.4
Neither more nor less	151	22.1
Somewhat less	101	14.8
Much less	36	5.3
How much would you be willing to pay for IVM compared to farmed meat? *		
Much more	7	1.0
Somewhat more	101	14.8
Neither more nor less	230	33.6
Somewhat less	198	28.9
Much less	78	11.4

Participants who reported 'definitely not' willing to try IVM were excluded from the subsequent questions (*).

doi:10.1371/journal.pone.0171904.t002

Figure 6.4

Source Wilks M, Phillips CJC (2017) Attitudes to in vitro meat: A survey of potential consumers in the United States. PLOS ONE 12(2): e0171904.

<https://doi.org/10.1371/journal.pone.0171904>

<http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0171904>

Q6 If you wouldn't try a synthetic meat burger please explain why?

- "It's not the real thing grown in a lab (chemicals used?)."
- "It is so far away from how natural our meat is produced and processed. Should always eat food which is less processed and closest to the raw product."
- "Because I'm a beef farmer and I refuse to eat that ..."
- "I wouldn't as a matter of principle for supporting the red meat industry however I do eat falafels, chicken, pork therefore am I not already guilty of looking at other proteins and this is just another option?"
- "I have tried an Impossible burger, and enjoyed it.."
- "Because I'm a beef farmer and I refuse to eat that (****)..."
- "Not sure... prefer natural protein sources! But am curious!"
- "To see what the competition is."
- "Not natural."

Q7. How would you recommend New Zealand grass fed meat over synthetic meat to a consumer?

- "Natural raised and cared for by farmers vs mass produced in a factory in China."
- "100% natural, something man made that is not proven yet could have hidden setbacks"
- "Clean green grass fed beef raised in a paddock not a test tube"
- "Without trying synthetic meat it would be a biased opinion. But you can't beat the eating experience of a good piece of steak! Would definitely need to recommend from an emotive perspective - natural product, free range livestock, farmers livelihoods, tradition... emotions that meat grown in a lab can't affiliate with."
- "Grass fed meat is a natural product that is in its natural form, in multiple different cooking techniques. It has a unique story where in New Zealand we are proud to produce such a quality product that supports our rural communities."
- "Naturally produced from an animal that has been ethically bred specifically for superior eating quality."

Q8. Has this topic been discussed at any farmer discussion groups or meetings you have attended?

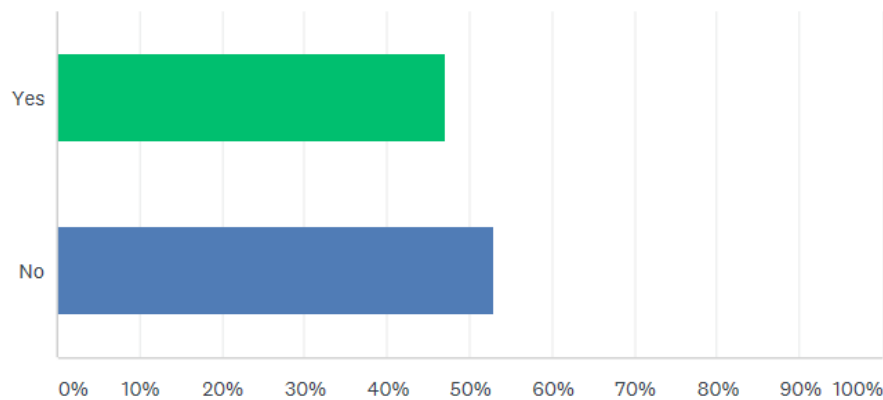


Figure 6.5

It's good to see that peer discussions are starting to take place.

Q9. If it has been discussed, what has been the general viewpoint or outcome from these discussions?

- “Concern and denial.”
- “Just one more worry on farmers’ plates.”
- “Farmer scared it is a risk to their future of our core assets; land, water, air. Risk it could devalue their products.”
- “Mainly denial that it will ever happen.”
- “Accept that it is here and look for the opportunities to define what we're producing. There are always going to be alternatives so we need to continue to develop our market. We need to continuously change and evolve and look for alternatives, rather than just food.”
- “It's a threat. And we don't want to be like Kodak. But disruption is an opportunity and we need to begin value adding and placing our product at the top”.
- “Basically, it is coming and we have to be on our game on the benefits of natural products.”
- “Most people view it as an opportunity.”

Q10. What do you see as the top risks to your farming operation over the next 5-10 years?

- Political
- Environmental restrictions
- Synthetic products
- Public perception and social license to operate
- Media interpretation
- Rural division and lack of understanding

The main risk identified by the farmers surveyed focused on political influence. However, the timing of the survey was just before the National Elections.

The environment, synthetic protein products and the social license to operate also feature strongly.

Q11. Where does synthetic or plant-based protein fit in your farm’s risk profile?

Only one respondent placed synthetic protein as a high-risk to them. The remaining farmers saw it as a medium to low risk.

Q12. If you would like to make a public comment or quote on the topic please feel free to leave your name and comment here.

“Farmers are keeping the world fed 3 times a day, working to enrich our natural products like we have done for centuries. We are getting smarter and more efficient, better environmentally to keep up with population growth, which lets them have choice to do what they want and know there is going to be food available for them. There is no more of a noble job than food production. Trust = willing to ingest our products for better health and environment. There is an opportunity to re-launch and re-establish ourselves in the modern world. We should be eating more nutrient dense foods which grass fed protein is stacked with”
(Matt Wyeth 2017)

“Synthetic or plant based protein may in time establish a place in a commodity market but will never compete with a sustainably produced grass fed well marbled Angus steak.”
(Ceri Lewis 2017)

Only two food producers were happy to make a public comment. Both producers are highly regarded within the industry.

Summary:

To summarise, our farmers feel that they do not have enough information readily available.

Feedback from farmer discussion groups revealed the topic raises some concern and worry. However, synthetic proteins are not currently seen as a high risk to the majority of respondents. Other risks such as political, environmental, social are of greater concern.

Many farmers see the development of synthetic proteins as an opportunity and are looking to reposition themselves as premium, grass-fed protein suppliers.

My hope is that as information becomes increasingly available to farmers, more time will be spent learning how to adjust to the changing conditions. This will result in farmers making positive influences on their own futures.

Recommendations:

- 1) To continue to keep up to date with the latest innovations.
- 2) Read the Beef and Lamb report on the potential threat of alternative food sources when it is available.
- 3) Encourage our food producers to discuss the subject more at focus groups and with peers.
- 4) Continue to produce the world's best grass-fed natural protein and promote it accordingly.
- 5) Support your fellow farmers through these changing and changing times.

References, websites and electronic documents:

- 1) Kim Brunhuber, CBC News, October 2016 - <http://www.cbc.ca/news/technology/how-these-silicon-valley-companies-are-disrupting-the-meat-industry-with-their-meatless-meat-1.4373873>
- 2) Steven Overly, Washington Post 2016 https://www.washingtonpost.com/news/innovations/wp/2016/08/02/farming-on-the-moon-and-meat-grown-in-a-lab-six-thoughts-on-the-future-of-food/?utm_term=.2f9b838f5435
- 3) NATHAN MCALONE, BUSINESS INSIDER, AUG 2015 <https://www.businessinsider.com.au/this-man-invented-the-digital-camera-in-1975-and-his-bosses-at-kodak-never-let-it-see-the-light-of-day-2015-8?r=US&IR=T>

- 4) Bec Crew, Science Alert, 2015
<https://www.sciencealert.com/lab-grown-burger-patty-cost-drops-from-325-000-to-12>
- 5) Dr Rosie Bosworth, 2017
<https://thespinoff.co.nz/business/24-10-2017/synthetic-meats-are-on-their-way-and-our-farmers-are-going-to-be-left-behind/>
- 6) Mike Lee, March 2017
<http://www.stuff.co.nz/business/farming/beef/90009303/american-foodie-thinks-nz-farmers-are-sitting-on-a-gold-mine>
- 7) Alison Millington, Business Insider, Nov 2017
<https://www.businessinsider.com.au/waitrose-food-and-drink-report-trend-predictions-for-2018-2017-10?r=US&IR=T>
- 8) Nick Beeby, The Spinoff, Nov 2017
<https://thespinoff.co.nz/business/01-11-2017/alternative-proteins-is-not-a-new-concept-beef-lamb-nz-on-the-threat-of-synthetic-meat/>
- 9) <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0171904>
- 10) Wilks M, Phillips CJC (2017) Attitudes to in vitro meat: A survey of potential consumers in the United States. PLOS ONE 12(2): e0171904.
<https://doi.org/10.1371/journal.pone.0171904>
<http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0171904>
- 11) Peak Milk Article, North and South 2016
- 12) <http://www.abacusbio.com/news/what-technologies-could-really-sink-us/>
- 13) <http://www.sciencemag.org/news/2016/08/lab-grown-meat-inches-closer-us-market-industry-wonders-who-will-regulate>
- 14) Artificial chicken grown from cells gets a taste test—but who will regulate it?
- 15) (Elizabeth Devitt Mar. 15, 2017 , 5:15 PM)
- 16) <http://science.sciencemag.org/content/349/6244/131>
- 17) <https://www.gizmodo.com.au/2015/08/the-future-will-be-full-of-lab-grown-meat/>
- 18) <http://nas-sites.org/biotech/2016/04/21/third-public-meeting/>
- 19) <http://www.memphismeats.com/about-us/>
- 20) <http://www.perfectdayfoods.com/>
- 21) <http://www.news.com.au/technology/innovation/inventions/artificial-meat-wars-impossible-foods-ceo-calls-meat-grown-from-cells-stupidest-idea-ever/news-story/75d5ab1f2ac695d0080a8f460f4ce280>
- 22) <http://www.perfectdayfoods.com/our-story/>
- 23) <https://www.recode.net/2016/10/12/13250362/impossible-foods-fake-meat-burgers-plant-blood-vegetable>
- 24) <https://www.impossiblefoods.com/>
- 25) http://www.new-harvest.org/mark_post_cultured_beef
- 26) <https://www.nytimes.com/2016/10/11/business/tyson-foods-a-meat-leader-invests-in-protein-alternatives.html?smid=tw-dealbook&smtyp=cur>
- 27) <https://www.businessinsider.com.au/this-man-invented-the-digital-camera-in-1975-and-his-bosses-at-kodak-never-let-it-see-the-light-of-day-2015-8?r=US&IR=T>
- 28) <https://www.nytimes.com/2016/03/07/business/trade-group-lobbying-for-plant-based-foods-takes-a-seat-in-washington.html>

- 29) <https://www.califiafarms.com/about-us>
- 30) Plant based foods association: <http://plantbasedfoods.org/>
- 31) <http://plantbasedfoods.org/why-plant-based/>
- 32) http://eventservices.penton.com/events/2015/ExpoWest/presentations/thursday/Special_Diets__Vegan_Market_Research_and_Brand_Positioning.pdf
- 33) <https://www.popsci.com/article/science/can-artificial-meat-save-world>
- 34) http://www.new-harvest.org/mark_post_cultured_beef
- 35) <http://www.hardmanagribusiness.com/21st-century-revolution-in-farming/>
- 36) <http://www.stuff.co.nz/business/opinion-analysis/87705060/Be-like-Uber-not-taxis-Businesses-told-to-innovate-as-disruption-rolls-on>
- 37) <http://www.new-harvest.org/>
- 38) <https://agfundernews.com/memphis-meats-closes-seed-round-oversubscribed-on-2-75m-expects-huge-demand5360.html>
- 39) Tomorrow's food, Cultured Meat - <https://www.youtube.com/watch?v=Se94UfeLwZA>
- 40) <http://www.stuff.co.nz/business/farming/90979628/warning-to-farmers-of-looming-synthetic-meat-and-milk>
- 41) http://www.new-harvest.org/clara_foods
- 42) <https://www.impossiblefoods.com/faq/>
- 43) <https://www.mcdonalds.com/us/en-us/about-our-food/nutrition-calculator.html>
- 44) http://www.new-harvest.org/clara_foods
- 45) <https://www.nytimes.com/2016/03/07/business/trade-group-lobbying-for-plant-based-foods-takes-a-seat-in-washington.html>
- 46) <http://www.stuff.co.nz/business/farming/90979628/warning-to-farmers-of-looming-synthetic-meat-and-milk>
- 47) <https://www.plantbasednews.org/post/sunfed-plant-based-chicken-keeps-selling-out-at-supermarkets-across-new-zealand>
- 48) <https://thespinoff.co.nz/business/24-10-2017/synthetic-meats-are-on-their-way-and-our-farmers-are-going-to-be-left-behind/>
- 49) <http://pureadvantage.org/news/2017/05/02/synthetic-biology-vs-paris-race-reduce-agricultures-emissions/>
- 50) <https://www.nap.edu/read/24605/chapter/1>
- 51) <https://thespinoff.co.nz/business/01-11-2017/alternative-proteins-is-not-a-new-concept-beef-lamb-nz-on-the-threat-of-synthetic-meat/>
- 52) <http://www.luxresearchinc.com/news-and-events/press-releases/read/alternative-proteins-claim-third-market-2054>
- 53) <http://www.beeflambnz.com/news-views/building-nz-brand>
- 54) <http://www.radionz.co.nz/news/country/342891/time-short-to-face-threat-of-synthetic-proteins>
- 55) <https://www.stuff.co.nz/business/farming/98077002/alliance-hopes-to-target-taste-preferences-in-customers>
- 56) <https://www.nytimes.com/2016/03/07/business/trade-group-lobbying-for-plant-based-foods-takes-a-seat-in-washington.html>
- 57) <https://www.theguardian.com/science/2013/aug/05/world-first-synthetic-hamburger-mouth-feel>

- 58) <https://www.sciencealert.com/lab-grown-burger-patty-cost-drops-from-325-000-to-12>
- 59) <https://www.technologyreview.com/s/536296/the-problem-with-fake-meat/>
- 60) <http://www.independent.co.uk/news/world/asia/china-israel-trade-deal-lab-grown-meat-veganism-vegetarianism-a7950901.html>
- 61) <http://www.theaustralian.com.au/news/health-science/3dprinted-meat-makes-the-cut/news-story/4b8a3f98b22103f8310d4a58c5ce4adf>
- 62) <http://gigabiting.com/will-3d-printers-really-be-making-our-dinner/>
- 63) <https://www.businessinsider.com.au/waitrose-food-and-drink-report-trend-predictions-for-2018-2017-10>
- 64) <https://www.reuters.com/article/us-israel-china-cleantech/israel-and-china-sign-300-million-clean-tech-trade-agreement-idUSKCN1BM13E>
- 65) Brad Jones, Sep 2017. <https://futurism.com/china-signed-a-300-million-lab-grown-meat-deal-with-israel/>
- 66) <https://www.geektime.com/2017/03/09/4-startups-working-on-lab-grown-meat-you-should-be-following/>

Appendix:

Survey Questions

Q1 Is there enough information readily available for NZ farmers on synthetic protein/meat?

Q2 If so what sources has this information come from? Please be as specific as possible.

Q3 Do you see synthetic protein/meat as a potential threat or opportunity?

Q4 Can you please explain why you see synthetic protein as a threat or opportunity in more detail?

Q5 Would you try a synthetic meat burger yourself?

Q6 If you wouldn't try a synthetic meat burger please explain why?

Q7 How would you recommend NZ grass fed meat over synthetic meat to a consumer?

Q9 If it has been discussed, what has been the general viewpoint or outcome from these discussions?

Q10 What do you see as the top risks to your farming operation over the next 5-10 years?

Q11 Where does synthetic or plant-based protein fit in your farm's risk profile?

Q12 If you would like to make a public comment or quote on the topic please feel free to leave your name and comment here