Report

Roland Berger

THE NETHERLANDS

The Protein Revolution

THE FUTURE OF FOOD

Roland Berger

MANAGEMENT SUMMARY

Proteins play a crucial role in human health. And with rising income levels and a multiplying global population, the demand for protein is increasing. What does this mean for supply? Traditional protein sources will not be the answer, with their drastic environmental implications, animal welfare concerns, and detrimental effects on our health. Alternative sources of protein, like plant-based burgers and cricket snacks, may be the key out of this paradox.

The alternative proteins market is still relatively young but booming, and is dominated by plant-based protein sources – though novel sources like animal cell culture, fermented proteins and insect proteins are on the rise. This is a market that is set to grow substantially, driven by strong consumer pull, especially among the younger generations who are looking for more sustainable, animal-friendly and healthy food.

Companies are responding by diversifying their protein sources away from animal proteins. Significant investments are being made in all parts of the value chain, from protein extraction to the marketing of consumer products. Their success will depend heavily on the degree to which they can deliver on product quality, cost efficiency, consumer adoption and maturity in the value chain.

Today, companies active in the plant-based protein space come closest to the operational efficiency and production capacity needed to compete with traditional protein sources. Especially technologically-driven ingredient players are well positioned to help these companies create the products that meet consumer demand: natural, tasty products that benefit people, animals and the environment. There is also considerable potential in other next-generation protein sources, but these will require more time, capital and a holistic approach from governments and stakeholders if they are to reach commercial scale.

The moves that companies make today will not only shape tomorrow's protein industry, but more importantly the landscape of food supply around the world. Food security plays a key role in the UN's Sustainable Development Goals, and the decisions made in our protein supply chain will have far-reaching implications in the work to reach a healthier and more sustainable planet.

FAST FACTS & CONTENTS

There will be nearly **10 billion** people globally by 2050

↘

Overall food demand is expected to increase by **>50%**

↙

To meet this demand

sustainably, sources of protein need to become more efficient and diversified

1 / The protein paradox

Central to our food system, but *harmful to our world*

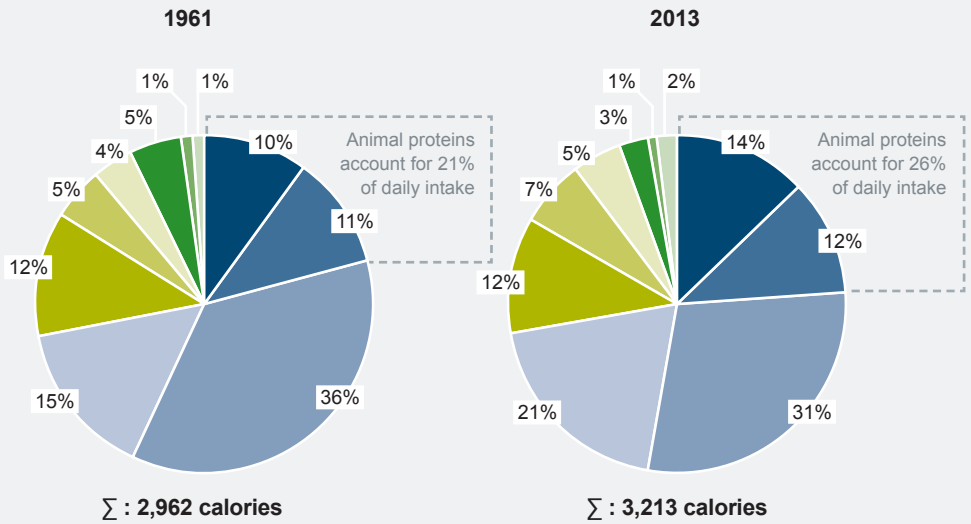
Food is fundamental to our existence. And we have become better and better at producing large amounts of foods to meet the ever growing demand for more nutrients, including proteins. Unfortunately, though, this is not without consequences. As climate change threatens the planet, we must find other ways to meet our food – and protein – demand.

Proteins are complex molecules that play critical roles in our bodies and are vital for the proper functioning of cells. Proteins are composed of large chains of amino acids which can be arranged in near infinite ways. There are nine essential amino acids that the human body cannot synthesize and that we have to obtain from food. Traditionally, we get these amino acids mainly from animal protein such as meat, eggs and dairy products. → A

The production of animal proteins for human consumption, however, has drastic implications for the environment: deforestation, biodiversity loss, greenhouse gas emissions and the depletion of natural resources. In addition, rising ethical concerns around animal welfare and increasing public health consciousness have begun to cast animal proteins in a controversial light.

A / Historical dietary patterns in the Western world and protein quality of selected protein sources

Western diet[1] over time
Average consumption per day [calories/person/day]

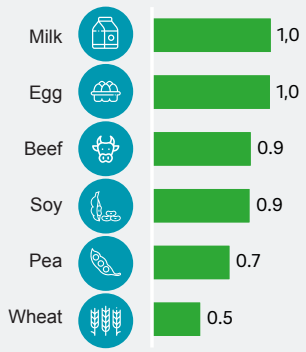


1) Includes most countries in Europe, US, Canada, Australia and New Zealand
2) Also includes animal fats
3) Protein digestibility corrected amino acid score

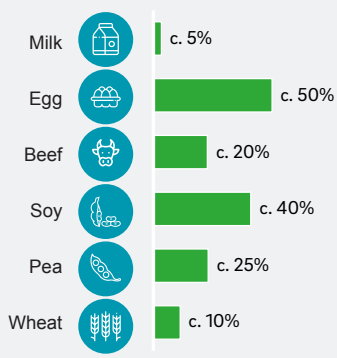
Meat (incl. fish)
Dairy & eggs
Cereals & grains
Oils & fats[2]
Sugar
Fruit & vegetables
Alcohol beverages
Starchy roots
Pulses
Other

Source: FAO, Meticulous Research, Wageningen University, FAO, USDA, Desk research, Roland Berger

PDCAAS[3]
Completeness of essential amino acids in protein composition [1= 100% or more]



Yield [%]
Estimated protein concentration in raw material (based on dry weight)



"We shall escape the absurdity of growing a whole chicken in order to eat a breast or a wing, by growing these parts separately under a suitable medium"

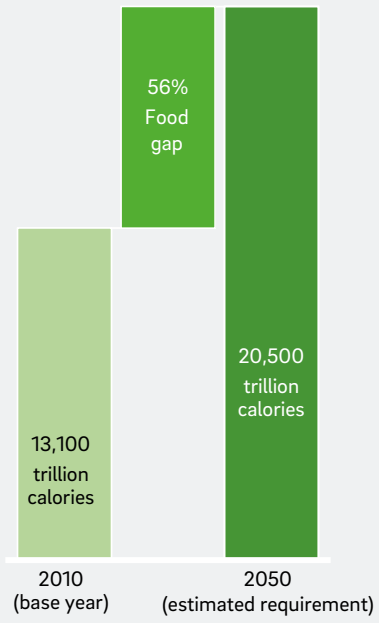
Winston Churchill (December, 1931)

As the human population grows towards 10 billion by 2050, overall food demand is expected to increase by more than 50%. And as wellbeing improves in developing countries, animal protein intake will follow, as there is a direct correlation between prosperity levels and dairy and meat consumption. → **B**

In the Western world, we are seeing the social acceptance for scaling up animal protein production diminish. If we are to meet this future food demand in a sustainable way for our planet and future generations, sources of proteins need to become more efficient and diversified around the world.

B / Expected food gap and increase in protein intake correlated with economic prosperity

Annual calorie consumption from crop production



Meat consumption vs. GDP per capita, 2017[1]

1) The size of the bubble indicates the total population of a country

Source: WRI, OECD-FAO Agricultural Outlook 2015, UN FAO, World Bank, World Development Indicators, Roland Berger

2/ The rise of alternative proteins

How alternative proteins are moving from niche to mainstream food

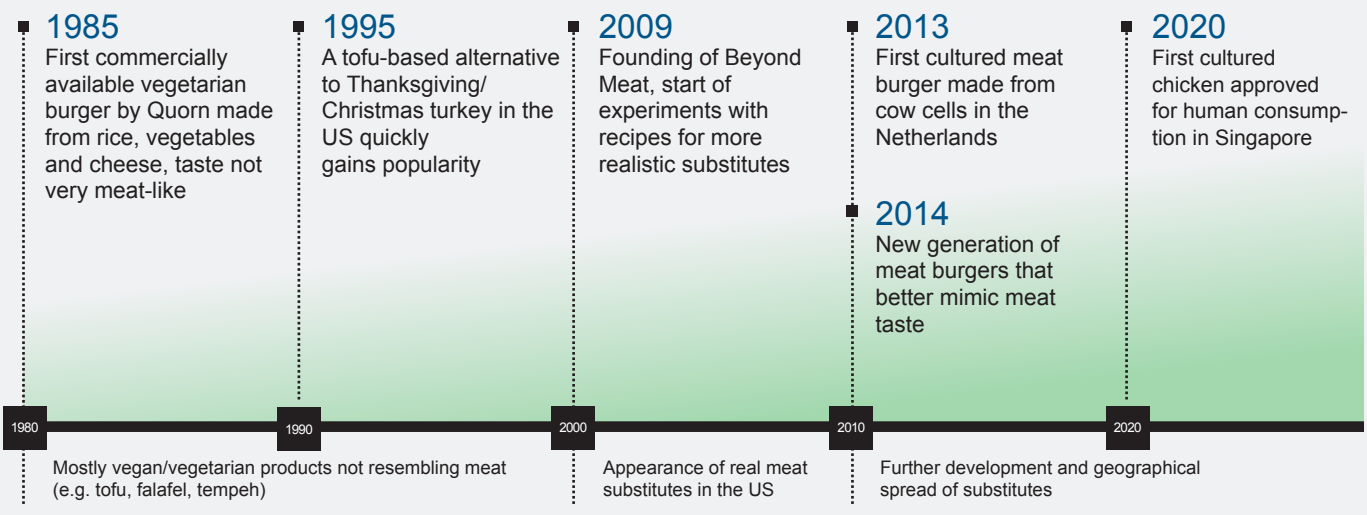
Shifting diets to foods that are less land and natural resource-intensive is fundamental to a sustainable food production system. The first alternatives to animal proteins have been around for decades, but realistic substitutes are a fairly recent development. → C

Today's alternative protein sources mainly come from plant proteins, but the range of sources is expanding with innovation in fermentation, animal cell culture, edible insects and hybrid products that combine several sources. → D

Compared to animal proteins, alternative proteins have a strong value proposition: they aim to be more sustainable, healthier, provide an improved shelf life, are often less labor-intensive, and are animal-friendly. Alternative proteins are used and often combined in a wide range of applications, from meat analogues to dairy alternatives, nutritional supplements, baked goods and sports nutrition.

Additionally, alternative proteins are increasingly customizable thanks to techniques such as fermentation, which enable the creation of very specific types of proteins, and 3D printing, for texturization.

C / History of meat substitutes



Source: Pacific Standard, BBC, Technology Review, Roland Berger

MARKET SCOPE

This chapter focuses on alternative proteins as ingredients for food & beverage products. References to the market are specific to the market of alternative protein ingredients used in food & beverage end-products, not to the market of alternative protein end-products itself (e.g. veggie burgers, tofu, etc.), nor to the market of alternative proteins that are consumed as whole foods (e.g. nuts, beans, etc.). This also excludes traditional protein sources (e.g. meat, dairy, etc.).

D / Overview of alternative protein sources

Product type	 Plant proteins	 Animal cell culture	 Fermented proteins[1]			 Insect proteins
	Plant-based	**Cultured meat and other cultivated animal proteins**	**Fermented foods**	**Biomass (whole cell)**	**Precision (purified)**	**Edible insects (whole or extracted)**
Description	Plant-based food with similar texture and taste of animal-based food 3 generations: + 1st generation (soy, wheat) + 2nd (pea, rice, potato, canola) + 3rd (sea-/ duckweed, hemp)	Animal proteins produced by in-vitro animal-cells culture, using same tissue engineering techniques traditionally used in regenerative medicine	Modulated plant-derived products with unique flavors, nutritional profiles and modified texture using microorganism (e.g. tempeh, tofu)	Pure culture of microbiological cells (microalgae, fungi, yeast, bacteria) serving as a predominant or one of several primary ingredients in a blend	Production of a specific type of functional protein (e.g. heme) through microbial host organisms (microalgae, bacteria, yeast or fungi)	Edible insects with high protein content (crickets, soldier flies, mealworms, etc.) and extracted insect protein
Closeness of end- product to animal-based product[2]	Replication of taste and mouthfeel of animal-based products ◕	Similar to tradi-tional proteins, but challenges remain (e.g. blood vascularization and fats) ●	Protein replacement (no biomimicking) ○	Replication of taste and mouthfeel of animal-based products ◕	Protein ingredient only ◑	Protein replacement (no biomimicking) or protein ingredient only ○
Diets	Vegetarian	Flexitarian (grown from animal cells)	Vegan	Vegan	Vegetarian	Flexitarian
Maturity	First generation(s) commercialized	First commercial sale approved in Singapore in Dec 2020 (Eat Just)	High (ancient technique)	Very low for protein production	Very low for protein production	Widespread in Asian countries – Low maturity in Western countries

1) excluded for market scope
2) Closeness of end-product to animal-based product: ○ Low ● High

Source: Roland Berger

The alternative protein ingredients market size is estimated at USD ~14 bn, although valuations vary widely. Across all estimates, however, it is clear that the market is on the rise, with annual growth rates varying between c.5-50% over the coming years → E.

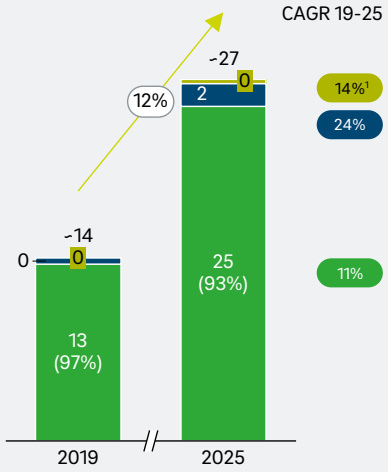
Thanks to improvements in taste and texture, diversification of protein sources and an ongoing shift to more plant-based diets, alternative proteins are moving from a niche food for vegetarians and vegans to a more mainstream food purchased by flexitarians and meat eaters.

The market of alternative proteins still represents a small fraction of the global traditional protein market. The global meat market and dairy market are currently valued at around USD 1.2 trillion and USD 0.8 trillion, respectively, and are expected to see moderate growth over the coming years.

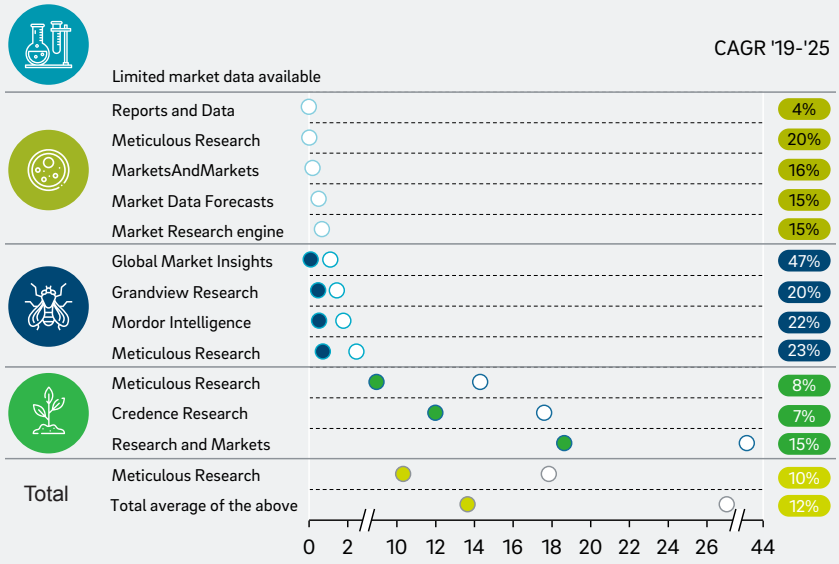
But as consumers increasingly look to replace or reduce animal protein in their diets, food companies are rapidly diversifying their protein portfolios away from animal agriculture. Although still a marginal market, alternative proteins are a disruptive force for the food industry and can be a driver of business growth.

E / Alternative protein ingredients market size estimates, by source (excluding fermented proteins)

Market size by source [USD bn] – Based on average of all estimates



Overview of market size estimates [USD bn]



Fermented proteins[2] | Animal cell culture | Insect proteins | Plant-bases proteins | Total | ● 2019 | ○ 2025

1) Average 2) Excludes sub-segment fermented foods
Source: Market reports, Roland Berger

IMPACT OF COVID-19

The trend towards alternative proteins has been resilient, and even increasing, during the COVID-19 crisis. In the US, retail sales of plant-based meats grew by 206% in the first week of March 2020 and by 280% in the second week. Sales of oat milk also grew by 477% in early March, while dairy milk sales grew by only 32%. This trend continued past the first weeks of panic purchasing. From February to April 2020, a 264% increase in plant-based meat products was reported while overall US retail sales plummeted (source: Meticulous Research). Countries in Europe also saw sales of plant-based products explode. COVID-19 thus seems to have led to skyrocketing sales for alternative protein products, but why?

Firstly, global meat supply was disrupted as major meat plants were shut down due to the virus outbreak. Combined with consumer stockpiling tendencies, this led to a shortage of meat which in turn encouraged consumers to look for other protein sources. Alternative proteins are less labor dependent, which makes them less sensitive to worker scarcities. Furthermore, their longer shelf life makes them ideal for long-term storage and stockpiling. Regulations on plant-based protein were also temporarily eased at the start of the outbreak (e.g. the FDA started allowing direct-to-consumer sales of Impossible Foods' plant-based burgers), which further supported the trend.

Secondly, COVID-19 has underlined the link between food and health, and many consumers have changed their diets accordingly. With reports that COVID-19 is especially dangerous for individuals who are over-weight, hypertensive or who have diabetes, many consumers have looked to alternative proteins to improve their health. The growing awareness of zoonotic viruses has also contributed to this trend, and is expected to lead many consumers away from animal protein, especially in China.

These apparent short-term effects of COVID-19 may very well leave their mark on the human diet, and consumers' growing familiarity with alternative protein products is expected to have a ripple effect on demand for years to come.

3/ Consumers are king

How the alternative protein shift is backed by strong demand drivers

Consumers have demonstrated a willingness to rapidly embrace new foods, as seen in recent years with the explosive growth of super foods like quinoa. The alternative proteins market has also seen rapid growth, backed by strong and rising consumer demand. This growth is driven by, among others, shifts towards healthier diets, awareness of sustainability and more respect for animal welfare, especially among younger generations → **F**.

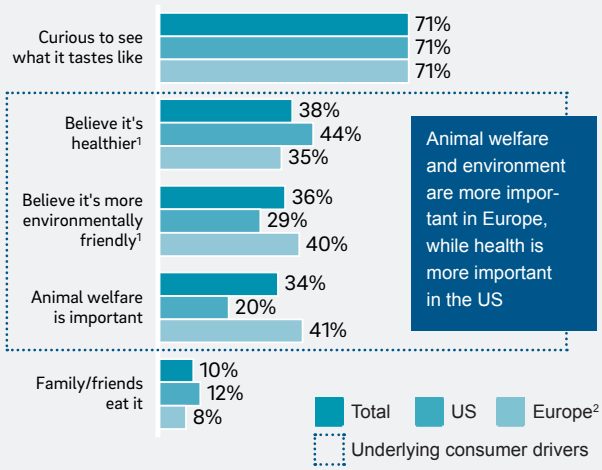
This increasing demand goes beyond that of vegetarians and vegans, and is driven by a wider consumer group, "flexitarians", which includes meat eaters. Although definitions vary, flexitarians tend to eat less meat or to eat it only on occasion. This trend is spreading quickly across the US and (Northern) Europe → **G**.

Especially the younger generations, Millennials and Gen Z are a predominant force shaping this industry. We believe the alternative protein trend is going to accelerate as the income levels of these generations increases over time → **H**.

Despite the clear pull from consumers in this space, in order to reach mass market adoption, supply needs to catch up and its offerings have to match broader customer preferences. Generally speaking, the key purchasing criteria in food are taste, cost and convenience. Only after a food product is perceived to be delicious, affordable and accessible, will the average consumer consider health benefits, environmental impact and animal welfare in the decision to purchase the product – although the latter criteria are gaining ground. The significance of key purchasing criteria for alternative proteins varies among

F / Consumer demand drivers of alternative proteins

Why would you try plant-based meat?



Animal welfare

+ 89% of Europeans believe there should be EU legislation that requires people to care for animals used for commercial purposes, e.g. meat production
+ 59% of all European citizens are willing to pay at least a 5% premium for animal-friendly products

Environment & Resources

+ In the US, 62% of Gen Z and 54% of Millennials indicate they are willing to spend more on food products that do not harm the environment (compared to 44% and 32% of Gen X and Baby Boomers, respectively)

Health & wellness

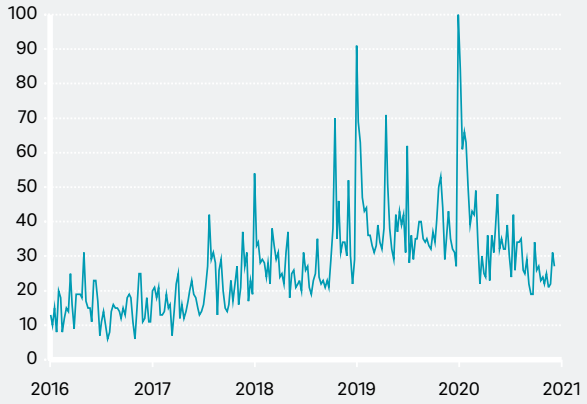
+ In the US, >40% of Gen Z'ers indicate that they are willing to spend more on healthy products, compared to 32% of Millennials and 21% of Baby boomers

1) Compared to animal meat; 2) Germany and UK

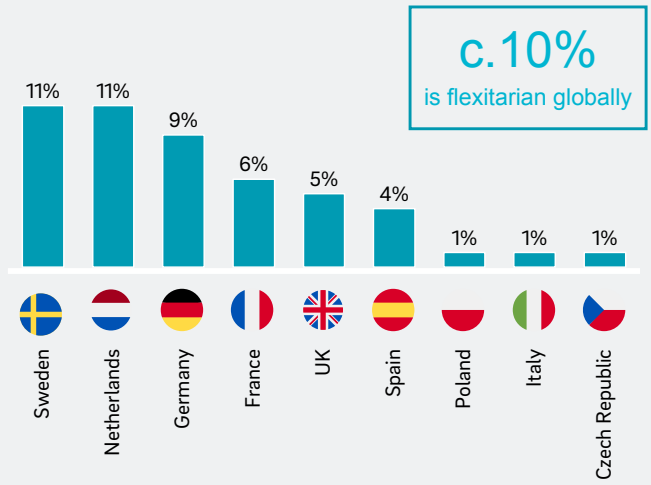
Source: UBS, Impossible Foods: Kids in the Kitchen, Roland Berger

G / Rise of "flexitarianism"

Increase in attention for flexitarianism globally[1], 2016- 2020 [max=100]



Share of flexitarians in Europe, 2018 [% of total population]



1) Google Trends search for "flexitarian"

Source: ComRes, Ipsos, Google Trends, Roland Berger

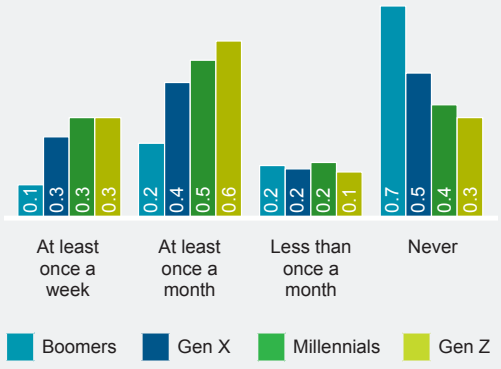
consumer segments, but the foundational and value-driven motivators of taste, cost and convenience do apply to all segments to some extent (source: GFI).

Often, existing plant-based products do not fully meet this basic threshold, because matching the taste or texture of animal proteins is difficult or requires high levels of processing, which then goes against clean label and natural trends. Despite consumers' best intentions, price does play a major role for them, and reaching price parity with these products is challenging for manufacturers given the relatively low prices of animal proteins.

In any case, for consumers it is not a one time purchase decision. CPG companies and food manufacturers should offer greater variety in products, utilize wider international cuisine and consider what else sits on the plate (i.e. meal construction) to ensure repeat buys.

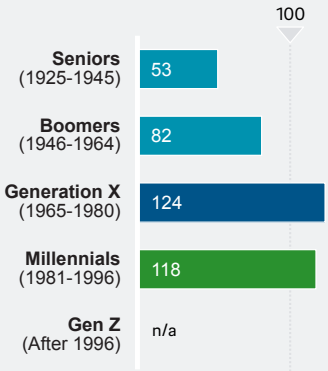
H / Younger generations as driving force of alternative proteins consumption

Frequency of consumption of plant-based meat in the US[1], 2019

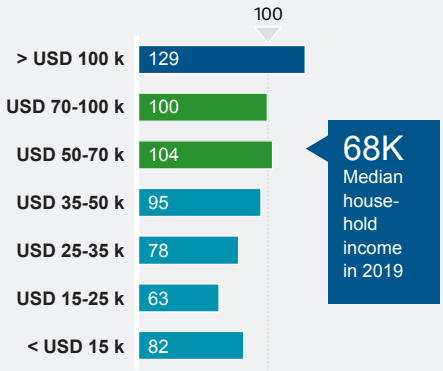


Plant-based meat dollar index for households in the US[2], 2019

By age group



By household income level



1) Based on Impossible Foods survey of 1,000 respondents in the US
2) Dollar index computed as (% of dollar / % of household)*100; based on IRI panel on total US outlets, 52 weeks ending 11/03/2019

Source: Impossible Foods: Kids in the kitchen, FMI - IRI, Roland Berger

4/ A crowding field

How industry players are shaping the alternative protein space

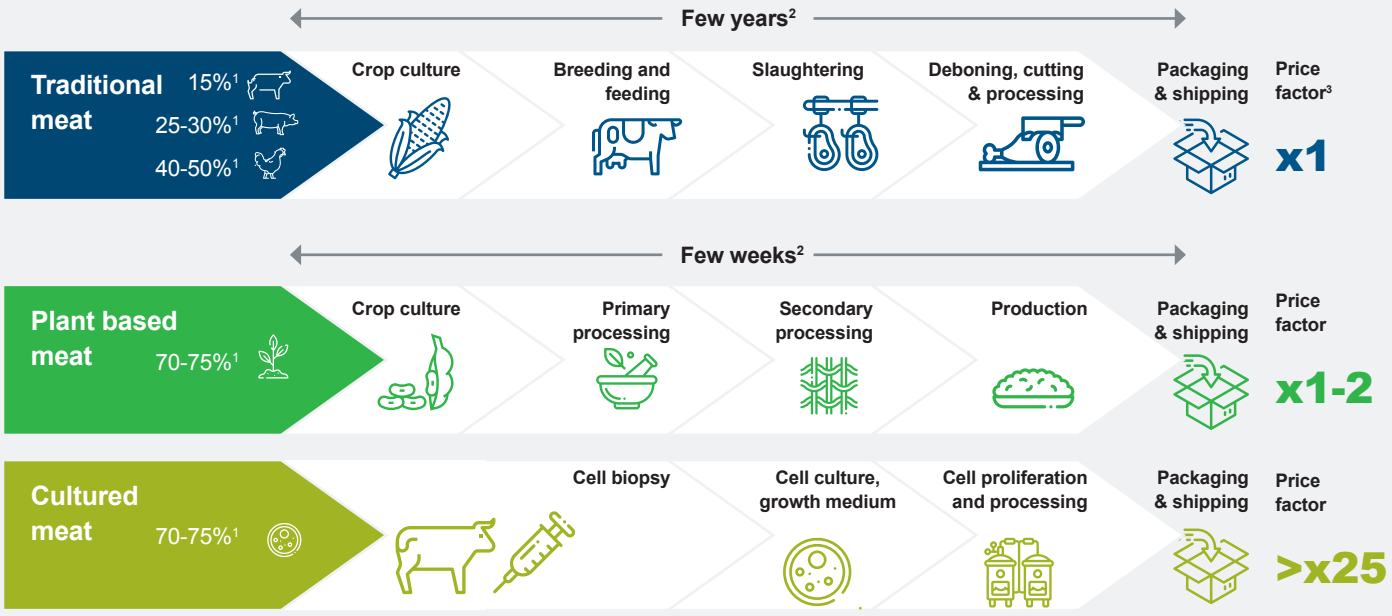
Though manufacturers generally target the same or similar end-products, the value chains of protein sources vary widely, including activities, timing and conversion rate. → I

If we zoom in on the more mature value chain of plant-based proteins, we see that many legacy players have started the transition to protein diversification away from animal sources. They are doing this both within their own legacy businesses or by launching new business models. → J

In general, we can distinguish four business models in the alternative proteins value chain. → K

1. **Supplying raw materials** for alternative protein ingredients or end-products
2. **Providing ingredients and solutions** for alternative protein end-products
3. **Manufacturing** alternative protein-based **end-products**
4. **Investing in next-gen** alternative proteins

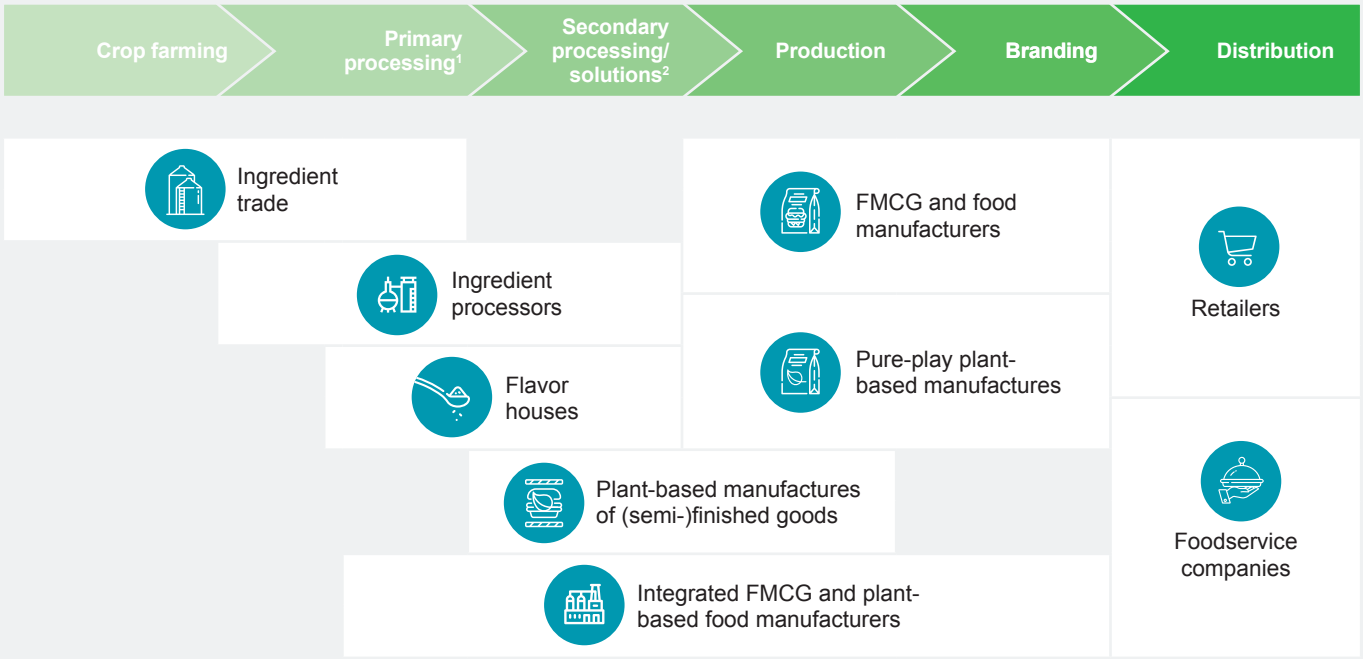
I / Example meat and meat substitute value chain ILLUSTRATIVE



1) % Conversion ratio defined as amount of food produced per kg of input
2) Typical lead time from the farm to the end-product
3) Compared to traditional meat

Source: FAO, Food Climate Research Network, Beyond Meat, Merk, Delhaize, Roland Berger

J / Meat and meat substitute value chains ILLUSTRATIVE



1) For example, crushing, extraction
2) For example, extrusion, blend distribution

Source: Expert interviews, Roland Berger

4.1 / Supplying raw materials for alternative protein ingredients or end-products

Soy dominates the alternative protein ingredients market. This is expected to continue despite growing skepticism around allergies, estrogenic effects and genetically modified crops. Wheat is another commoditized source of alternative proteins. Due to ongoing consolidation efforts as a consequence of relatively low margins and capital intensity in this step of the value chain, these markets are characterized by large integrated players like Cargill and ADM.

Pea protein is expected to become the next boom in plant-based proteins, driven by consumer trends in gluten-free, health benefits and sustainability, and further fueled by large players establishing new manufacturing facilities and sensory capabilities. For example, Roquette is opening the world's largest pea protein plant in Portage la Prairie, Canada, and Cargill has formed a joint venture with PURIS for pea protein production.

Rice is another second-generation plant protein, but due to its limited nutritional content, it is not suitable on its own for major end-uses such as meat replacement; it must be mixed with e.g. peas. Other second-generation plant proteins like canola could further complete the portfolio of plant-based proteins in order to propose a wide variation of products/solutions to customers. And we are seeing the first players, notably DSM, investing in large-scale production facilities.

K / Alternative protein business models

	Business model	Description	Type of players	Average margin
1	Supplying raw materials	+ Suppliers and traders of commoditized proteins: soy, wheat + Investors in sizeable alternative protein categories, most notably pea, and others like canola, rice and chickpea	+ Ingredient traders + Ingredient processors	10- 30%
2	Providing ingredients and solutions	+ Extractors of plant proteins from (raw) input that often also extrude the proteins to produce end-products + Producers and suppliers of functional ingredients and flavors/ fragrances and protein solutions	+ Ingredient processors + Flavor houses	40- 60%
3	Manufacturing end-products	+ Manufacturers of plant protein (semi-)finished and finished products + Brand and marketing organizations bringing end- products to the consumer	+ Plant-based manufacturers of (semi-)finished goods + FMCG and food manufacturers + Pure-play plant-based manufacturers	30- 40%
4	Investing in next gen alternatives	+ Investors in novel proteins, either based on new raw materials such as water lentils, or insects, innovative technologies such as fermentation or meat cultivation, or side-products such as substitutes for blood or fat	+ Start-ups + Investment arms incumbents	

Source: Expert interviews, Roland Berger

4.2 / Providing ingredients and solutions for alternative protein end-products

As taste is key to create successful plant-based alternatives, large ingredients players (e.g. ADM, Kerry) and flavor houses (e.g. Givaudan, Symerise, Firmenich) are positioning themselves as key partners in the plant-based protein trend. These players have launched portfolios of ingredients and delivery technologies designed to create great-tasting plant-based foods and beverages. For example, Kerry's "Radicle" or Firmenich's "Smart" portfolios of plant-based ingredients and solutions aim to help manufacturers create sustainable products with the right nutrition levels, cleaner labels and better taste and texture.

Firmenich's acquisition of Campus in 2018 has enabled it to further expand its naturals and protein solutions. IFF and DuPont even used a plant-based burger in their investor presentation as a prime example of how their combined offering after the merger can meet manufacturing needs and create value in this field.

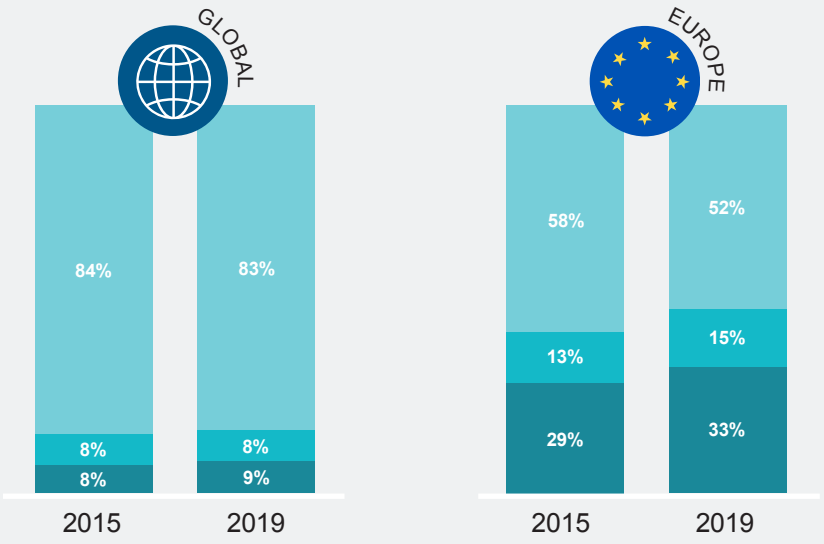
Technology plays a large role for these players and margins are relatively high, due to the high degree of value pricing, especially for specialty ingredients (ingredient extraction has much lower margins).

4.3 / Manufacturing alternative protein-based end-products

Interest in alternative protein-based end-products has steadily increased in recent years. While early innovations came from new stand-alone players, FMCG and food giants are now also conscious of the shift. Due to large investments, paralleled with strong media marketing campaigns, both new and existing players have been able to expand their offering rapidly, so that plant-based alternatives have become indispensable on most supermarket shelves. This trend looks to continue. For example, Unilever recently communicated it wants to increase its plant-based sales to USD 1 bn within the next 5-7 years, driven by the accelerated availability of plant-based and dairy alternatives.

Plant-based alternatives are also gaining popularity among retailers and fast-food chains, with players like Burger King, McDonald's, Ahold Delhaize and Tesco introducing private label product lines → L. This makes room for B2B manufacturers of (semi-)finished goods. An example is Plant & Bean, a spin-off of Brecks Foods, which is opening Europe's largest plant-based factory in the UK and in several other regions to offer a broad range of plant-based products to international clients at scale.

L / Meat substitutes share of Top-5 companies and private label [2015-2019; % retail value]



Top-5 includes:
- Sagamiya Foods +
- Monde Nissin (through Quorn brand) +
- Asahi +
- Kellogg's (through Morningstar and Gardenburger brands) +
- Takano Foods +

Top-5 includes:
- + Monde Nissin (through Quorn brand)
- + Nestlé (through Garden Gourmet and Herta brands)
- + Rügenwalder Mühle
- + Orkla (through Anamma and Naturli' brands)
- + Hain Celestial (through Linda McCartney brand)

Top-5 companies | Private label | Other

Source: Euromonitor, Roland Berger

4.4 / Investing in next-gen alternative proteins

Due to the highly competitive and saturated markets of first generation plant-based protein alternatives and ongoing demand, protein sources are diversifying rapidly and protein creation methods are improving (e.g. fermentation, cellular farming, 3D printing). Recent years have seen an endless number of start-ups launching in the alternative proteins space, a momentum that continues to be fueled by an influx of investments → **M**. Since 2010, global venture capital investments in cultured meat, fermented proteins and insect proteins have been estimated at more than USD 3 billion, with major investments particularly in 2019 and 2020. Although the next-gen alternative proteins market is still nascent, the increasing number of later-stage funding rounds in this field implies that companies are moving from proof-of-concept to pilot-scale manufacturing and commercialization.

M / Landscape of newcomers with significant funding

Cultured meat[1]

Just	220
Mephis Meat	181
Mosa Meat	85
Blue Nalu	25
Shiok Meats	20
Cubiq Foods	18
Future Meat	17
Wild Type	16
Aleph Farms	14
Meatable	14

Total funding[2]
c. $660M
>90 deals

Fermented proteins

Perfect Day	360
Calysta	129
MycoTechnology	123
Motif Foodworks	118
Geltor	114
Nature's Fynd	113
Cellana	100
Clara Foods	55
Meati Food	31
3FBio	28

Total funding[2]
c. $1,400M
>110 deals

Insect proteins

Ynsect	425
Innovafeed	230
AgriProtein	123
Protix Biosystems	51
nextProteins	c. 14
Protifarm	11
Entocycle	11
Enterra Feed	10
Nutrition Technologies	9
Goterra	6

Total funding[2]
c. $940M
>130 deals

1) Excluding other animal cell culture companies
2) For funding reported in EUR m an exchange rate of 1.17922 USD/EUR is used.
Disclosed funding rounds until December 2020, including grants and reported deals of which funding amount is undisclosed – Excludes acquisitions

Source: GFI (pitchbook), Crunchbase, Dealroom, Press releases, Roland Berger

N / Examples of strategic moves from large industry players

Venture capital
February 2019

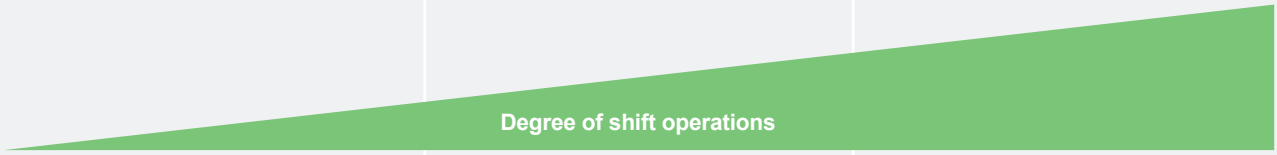
Nature's Fynd (formerly Sustainable Bioproducts), developing fungi protein using fermentation, raised USD 33 m from, among others, the venture capital arms of Danone and ADM

Joint venture
July 2020

Royal DSM and Avril announced the launch of their joint venture, Olatein, to produce canola (rapeseed) proteins for the global food market

Acquisition
April 2018

Kerry acquired plant-based protein manufacturer Ojah and its proprietary High Moisture Extrusion (HME) technology



Source: Press releases, Roland Berger

As newcomers begin to disrupt the traditional proteins landscape, large food corporations and food ingredients processors are also protecting their future position in the next-gen protein space. Even if alternative proteins do not account for more than a fraction of their businesses, these incumbents recognize the growing importance of next-generation proteins. They are developing novel solutions through venture capital, joint ventures, acquisitions, or through a combination of these → **N**. Importantly, these companies can benefit from their operational and strategic expertise and well-established downstream distribution channels.

Companies are not necessarily choosing between the four business models described in this chapter; some are following hybrid models, some are more vertically integrated (e.g. commodity players) and some maintain a solution approach (e.g. flavor houses). The highly specialized and capital-intensive nature of these products is also leading many companies to enter partnerships for knowledge sharing, investing in innovation and to safeguard capacity.

> *„As always in the Food industry, the end game of alternative protein will be all about the combination of „cost price", „technology" and „demand". Players who know how to address all three appropriately, will emerge as winners."*
>
> **Alexander Belderok**
> Senior Partner

THE NEXT BUBBLE?

Although still a nascent market, the potential of alternative proteins has not gone unnoticed among investors. In March 2019, the sector saw its first IPO (Beyond Meat), raising more than USD 240 m – the most successful IPO in the US that year (source: GFI). Series-A investors made a 400-fold return on their investment, signaling an opportunity in this space ahead (source: Jefferies University). In fact, most of the funding in this space was raised in the last 18 months. Why is this industry so hot?

The alternative proteins market has received investments from a number of high-profile individuals, as well as financial investors and companies. Investors see fundamental shifts in eating patterns among the traditional meat eaters across demographic groups, believing that alternative proteins have become a lasting component of the broader protein-consumption landscape. Investment volumes still lag behind other technology sectors, thus providing extensive opportunities for capital deployment.

However, given the emerging state of the market, capital inflows have largely concentrated on early-stage private startups, some with questionable valuations. Critics are now concerned about the risk of a potential food-tech bubble, arguing that some of these early-stage companies do not have the right fundamentals (i.e. IP/technology levels) to succeed in the long term, while more and more unexperienced investors enter the space, further driving up valuations.

Time will tell, but we expect the larger food corporations and food ingredients processors to continue their investments in this space to stay close to innovation. For them, investments in alternative proteins are of a more strategic nature.

5/ Managing the transition

How players will crack the case

Each of the business models mentioned entails different factors for success. However, there are four common areas that will elevate alternative proteins to the next level, no matter the business model:

1. **Product quality**
   Improve sensory and functional properties while managing nutritional levels and a clean label
2. **Cost efficiency**
   Achieve low production costs and the scale to move from niche to mainstream
3. **Consumer adoption**
   Secure access to consumers and gain their trust
4. **Maturity in value chain**
   Ensure security, traceability and sustainability of supply

The level of importance of these key success factors varies. → O

O / Key success factors and importance[1]

			Importance: Low – High
#1 Product quality	Sensory properties	+ Degree to which a business model can provide a product of superior quality (i.e. taste, texture and quality of ingredients)	
	Nutritional levels	+ Degree to which a business model can keep the product or ingredients natural and nutritious, and the label clean	
#2 Cost efficiency	Low production cost	+ Degree to which a business model can allow for producing at low cost, including the valorization of by-products	
	Scalability	+ Degree to which a business model is scalable in terms of production and respond to demand	
#3 Consumer adoption	Access to consumers[2]	+ Degree to which a business model can secure access to consumers (trade leverage with high rotation and large volumes)	
	Consumer trust[2]	+ Degree to which a business model can educate end-consumers and gain their trust	
#4 Maturity in value chain	Security & traceability	+ Degree to which a business model can keep its production consistent and transparent, including sourcing of raw materials	
	Sustainability	+ Degree to which a business model can keep its promise on being a sustainable protein source	

1) Key success factors for the winning business model in 10 years
2) Mostly for solution providers and end-product manufacturers

Source: Expert interviews, Roland Berger

5.1 / Product quality – Improve sensory and functional properties while managing nutritional levels and a clean label

Sensory requirements (taste, texture and color) are the number one hurdle for consumers to try and repeatedly buy alternative proteins (source: Fooddive). Additional ingredients are typically added to consumer products to ensure a pleasant taste, for example to mask bitterness, and mimic the sensory feeling of animal-based products. However, adding additional ingredients is counter intuitive to the health image of alternative proteins and to the clean label trend. The first Beyond Meat products consisted of 21 different ingredients, and it is questionable whether they were ultimately healthier than traditional animal protein. Today, the nutritional value of alternative burgers, although there is some variance across brands, is quite comparable to their beef counterparts, but the number of ingredients is usually twice that of their beef counterparts. → P

Innovation will be key to realizing the right product improvements. We are already seeing companies actively managing taste without adding too many ingredients to the label. For example, Daring Foods, makes a chicken alternative with just five ingredients on the label: water, soy, sunflower oil, salt and natural flavoring.

To achieve the preferred product quality, companies follow two strategies. One, they work together with flavor houses. For example, Givaudan and Bühler are opening an Innovation Center in Singapore, where food processing companies, startups and researchers can develop novel plant-based products. Or two, they try to improve their products by using specific cooking techniques or novel ingre-

P / Comparison of nutritional values and number of ingredients of alternative and traditional meat burgers

	Price [EUR/kg]	Nutritional value (per 100 gr.) Calories [kcal]	Fat [gr]	Carbs [gr]	Fiber [gr]	Protein [gr]	Salt [gr]	Number of ingredients
Beyond Meat	26	252	19	3.5	N/a	17	0.8	18
De Vegetararische Slager	16	170	9	6.5	<0.5	17	1.2	19
Garden Gourmet	16	198	13	2.3	6.0	14	0.7	13
Plant-based burger (private label)	15	202	10	7.2	7.4	17	1.2	26
Beef burger (private label)	10	281	22	2.6	N/a	18	1.2	10
Premium black angus beef burger (private label)	14	167	10	1.3	0.0	19	1.2	9

Source: Dutch retailers, Store visits January 2021, Roland Berger

Saturated fat Sugar

dients. Examples include MycoTechnology's mushroom-based "ClearTaste", a bitter blocking ingredient, and Impossible Foods' precision fermentation-based heme, which provides the meaty taste and juicy "bloody" appearance.

But again, companies must remain aware of consumer perceptions around these newer technologies. For example, there is still a lot of resistance to GMO, especially in the Western world, and fermented proteins often fall under GMO legislation. Another example is the fetal bovine serum that is currently used as a growth factor in cultured meat, which also faces controversy, in part due to ethical concerns around its extraction. It is for this reason that some technologies might actually have the opposite effect of what companies are trying to achieve in the alternative proteins space, ultimately harming the adoption of their products.

5.2 / Cost efficiency – Achieve low production costs and the scale to move from niche to mainstream

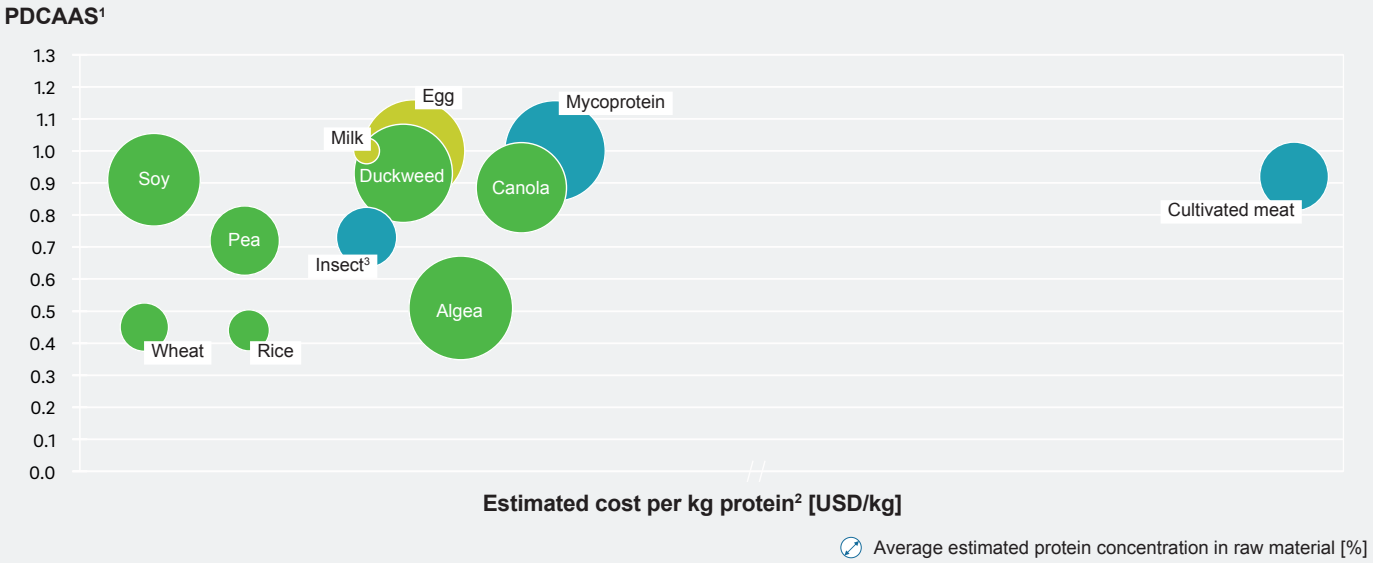
For companies engaging in alterative protein production, achieving cost efficiency is one of the most important factors in moving from a niche product to mainstream. This is achieved by scaling up, but also by improving the production process with higher yields (in all steps of the value chain); valorizing by-products such as starches, fibers, oils and sugars will be key. We see large players like ADM, Cargill and Roquette investing heavily in technical and industrial capabilities to process second-gen pea protein in a more (cost-)efficient way. Another example is Scale-up 3F Bio, which is bringing costs down by co-locating their production facility with bioethanol production plants to leverage their residues as feedstock for its mycoprotein fermentation process (source: GFI). This means players not only need in-depth knowledge on the food market, but also the markets of other value streams (e.g. feed, pharma). → Q

At the solution or end-product level, it is not only about bringing down the cost of the primary protein content. The price of a solution or end-product can vary widely based on the protein source used. For example, the bitter off-taste of pea might need certain masking ingredients (see success factor #1).

WHAT OTHER POSSIBILITIES ARE OUT THERE?

One could ask why we are trying so hard to mimic and replace traditional proteins, when we could focus on completely new food concepts that contain higher levels of protein and other nutritional elements direct from the source? One good example comes from the recently formed partnership between David Zilber (former head of fermentation at Noma, named the number one restaurant in the world seven times in the last decade) and bioscience company Chr. Hansen. Together, they will leverage the 40,000 microbial strains of Chr. Hansen and try to find the right microorganisms to create new tasty, healthy and sustainable food solutions. So it could indeed be said: we are only limited by our own imagination – and a chef's ability to realize new visionary products.

Q / Estimated average price and protein quality of selected protein sources



1) Protein digestibility corrected amino acid score
2) Does not consider the cost of added ingredients, which can vary widely based on the protein source used
3) Based on Black Soldier Fly

Source: Meticulous Research, FAO, Wageningen University & Research, GFI, Nutrition journals, Expert interviews, Roland Berger

Besides scaling up production capacity, especially for manufacturers of end-products, scale in distribution is also very important. Legacy players have a clear advantage here, because these large incumbents can leverage their knowledge and experience in scaling up, production facilities and distribution networks, whereas new entrants need to attract large capital investments before they can begin to build up scale.

However, novel fermentation techniques promise to deliver highly scalable, low-cost proteins, as they can potentially build on existing infrastructure and knowledge of industrial-scale fermentation in combination with high-speed replication, low input costs and preferable functional properties in products. Fermentation-based proteins could therefore become the cheapest protein available.

5.3 / Consumer adoption – Secure access to consumers and gain their trust

For manufacturers of alternative protein-based end-products, consumer adoption entails customer access, as retailers are the ones to distribute their products. Manufacturers must convince retailers to buy their products, and this is facilitated by large volumes, high product rotations, and potentially existing partnerships in other categories. But access does not stop there – it is also about delivering and getting the products in the right place on the shelves to remain listed and to guarantee consumer adoption in the long run. This means getting the entire supply chain right (see success factor #4). We have also seen that mainstream availability in popular restaurant chains can accelerate consumer adoption. However, as with

retail, manufacturers need to be able to deliver on several metrics to be successful in foodservice, including scale, performance and cost flexibility.

Besides taste, price and availability, consumer food decisions are also heavily rooted in intrinsic beliefs about what is good and bad – beliefs that do not always have to be rational or scientifically substantiated. Companies in the industry are thus trying to influence these beliefs and win consumers' trust, investing heavily to get into the market and create a brand that consumers connect with. Social media has proven to be very effective in creating a space for newcomers, especially among Millennials. For example, Beyond Meat has been very active on social media, using user-generated content (e.g. reviews), celebrities and spokespeople to educate consumers on plant-based proteins and what they contain. Beyond Meat also worked with a professional agency to make it a "hot topic" in established media, and did face-to-face marketing in the form of sampling at supermarkets and malls to convince the more skeptical consumers. → R.

Gaining consumer trust is especially important for novel protein sources like insects and cultivated meat, where neophobia still prevails. However, the first studies on cultivated meat prove that awareness and the availability of positive information about the product improves acceptance and willingness to try, and to even pay a premium for it (source: Food Navigator).

R / Case example of Beyond Meat – Gaining consumer trust ILLUSTRATIVE

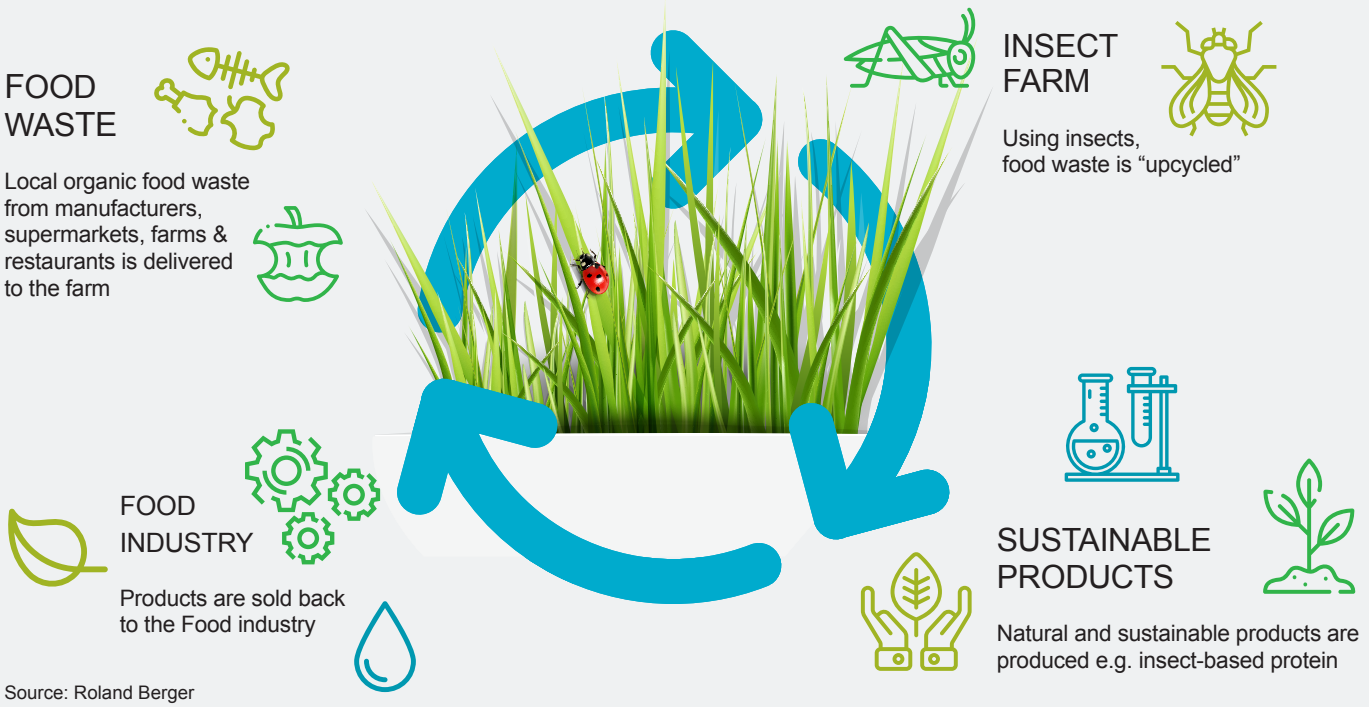
Beyond Meat has educated customers and won their trust via digital media advertising ..

... as well as with the help of strong public relations via established media channels ...

... which was further substantiated with face-to-face advertising in the form of sampling at supermarkets and malls

Source: Expert interviews, Press releases, Roland Berger

S / Circular micro chain of insects ILLUSTRATIVE



Source: Roland Berger

5.4 / Maturity in the value chain – Ensure security, traceability and sustainability of supply

As alternative proteins gain scale, other challenges begin to arise. Ensuring security of supply at relatively constant prices, especially for the specialty ingredients, can be challenging given the increasing pace of consumer demand. At the same time, driven by increasing consumer demand for knowledge about the food they eat, complete value chains need to be more transparent. Companies are therefore setting up direct relationships with local farmers and reliable primary processors to ensure traceability and quality of the raw material. For example, ADM signed contracts directly with farmers to buy and grow yellow peas.

While alternative proteins are generally perceived to be more sustainable, unsustainable production practices, such as the deforestation linked to soy production and the energy-intensive extraction and spray-drying of plant-based products, or the production of cultured meat, have led to questions about the environmental benefits of these products. Especially that next-gen alternative proteins research has yet to show whether these products can deliver on their promise. Such questions force companies to consider sustainability when scaling up their production methods.

Companies could also consider rethinking the entire protein value chain by establishing circular micro chains. Take, for example, insects that are fed locally with food waste. Such an initiative could be a game changer in the alternative proteins landscape, as it would be a more sustainable, local solution with high traceability and security of supply → S

6/ The bet is on

Who will win in the alternative proteins space?

We believe that in the long run, all alternative protein segments have predominantly positive arguments that speak for them, particulalry fermented proteins → T. But for fermented proteins, animal cell culture and insect proteins, it will take time and considerable investments before wide-scale commercialization and price parity with traditional animal protein (ingredients) are reached.

T / Advantages and disadvantages per alternative protein source

	Plant proteins	Animal cell culture	Fermented proteins	Insect proteins
What we like	+ Responds to consumer demand for sustainable food free from animal cruelty + Plant-based is "fashionable" leading to an influx of investments + Proven industrial production processes already in place + Products are improving rapidly, while there is still a lot of potential for innovation	+ Offers real animal products free from animal cruelty (sustainability to be proven) + First cultivated meat approved for consumption in Singapore + Controlled and clean production processes shielded from zoonotic diseases + Potential to deliver end-products that are closest to actual animal meat	+ Responds to consumer demand for sustainable food free from animal cruelty and potentially with better nutritional levels + Already widely used in other applications (including GMO-enabled fermentation, e.g. enzymes, antibiotics, vitamins) + Efficient and controlled processes shielded from volume and price volatility (independent form climate/ economic/political factors) + Can act as enhancers of plant-based proteins and enablers of new technologies (e.g. growth media in cultivated meat)	+ Responds to consumer demand for sustainable food + Great conversion mechanism to create high-value protein ingredients from low-value material input (including waste streams) + Offers complete nutritional solutions which are tasty with few additives + High in other valuable content (e.g. oil) with more animal-like characteristics
Barriers to overcome	+ Often still (highly) processed food, both nutritional benefits and clean label to be improved + Debate about sustainability and health risks with some protein sources, including GMO, allergen, deforestation + Capacity challenges, mostly in secondary processing (extrusion)	+ Does not adress negative health perception of animal products + Time-consuming and costly regulatory approval process in large markets, especially in Europe + Questionable consumer acceptance (e.g. preceived as unnatural) + More time and investments required to bring production processes to scale and bring down prices (including of growth factors)	+ Precision-fermented proteins that are not processing aids currently fall under GMO legislation and have not been authorized yet (EU only) + Time-consuming and costly regulatory approval process, especially in Europe, can build on successful product introductions (notably in North America) + More time and investments required to bring production processes to scale and bring down prices	+ Growth potential in the short term mostly in animal feed, pet food and aqua feed, given strict legislation (although changing) + Low consumer acceptance in Western countries + Non-vegetarian and falls under shellfish (allergen) + More time and investments required to bring production processes to scale

Source: Expert interviews, Roland Berger

Compared to the other alternatives, plant-based alternative proteins are already widely commercialized and are getting closer to the operational efficiency and manufacturing capacity needed to produce high volumes at competitive prices – especially now that the legacy giants are awake to the challenge and are investing a lot of money to build up scale. That is why, in the short term, our bet is on plant-based proteins. In the short term, we also see significant potential for next-gen technologies that will enhance these plant-based products, such as fermented proteins that complement plant-based foods (e.g. Impossible Foods' heme ingredient).

Whatever alternative protein source wins, we believe clear winners will be the technology-driven B2B players: ingredient suppliers that are able to deliver a variety of novel ingredients with improved functionality more cost efficiently, able to valorize other value streams, and/or able to offer complete solutions tailored to consumer needs.

7 / Conclusion

The recent and ongoing zoonotic pandemic has put in sharp relief the rising imbalance between food demand and supply, particularly when it comes to protein. Though acceptance of animal protein production is on the decline in the West, global protein intake is only set to rise as our population multiplies and income levels climb. To meet this demand in a sustainable way, now and for future generations, we must diversify and safeguard our protein sources; in fact, our entire food supply must become more efficient.

Many companies are taking an active role in this challenge, investing heavily to build up scale. But potential regulatory restrictions on food ingredients, subsidies for traditional proteins, labeling, branding and lack of uniformity can have a big impact on the success of scaling up the alternative proteins industry. Already, many stakeholders are joining forces to lobby for better policies. Regulatory bodies should also look for collaboration in order to be able to quickly respond to market needs and facilitate innovation while also guaranteeing food safety.

To really lead the transition, however, governments and stakeholders need to think about the food system as a whole – from farm to fork. Together, they must invest in national or regional R&D ecosystems where ingredients suppliers, food manufacturers, retailers, research institutes and the general public collaborate to develop ready-to-use solutions for a healthier and sustainable diet. Such efforts will make our food system agile and responsive – to population growth, dietary shifts, technological developments, and to adverse dynamics such as food shortages, trade disputes, and future global crises like pandemics.

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03.2021

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Publisher:
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RB_REP_21_005