New Protein Sources

Lab-grown meats, plant-based meats, single-cell proteins, and edible insects

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Key messages

- Since 2017 there has been growing consumer and investor interest in alternative proteins, such as lab-grown or plant-based meat, single-cell proteins including mycoprotein and microalgae, and insects, which have the potential to play a major role in reducing the impact of our current food and agriculture system.
- Alternative proteins generally have good nutritional profiles compared to meat and also promise significant advantages in helping to reduce pressure on dwindling natural resources and to cut down emissions. However, many of these sources face significant barriers to scale in the form of consumer and regulatory skepticism. Ongoing investment is also required to scale up product development, production, and marketing.
- At the same time, traditional plant-based proteins such as beans and legumes should not be forgotten: they are cheaper, more accessible, and familiar to consumers, and they offer other nutritional benefits.
- The prospect of converting the world's population wholesale to vegetarianism is unrealistic, but the increased availability and affordability of alternative proteins will help consumers diversify their diets in order to ensure a more secure food and environmental future for all.

The year 2017 saw an explosion of interest in alternative protein. Exciting new innovations such as lab-grown meat or plant-based "meats" captured public imagination and turned the spotlight on new opportunities to provide protein to the world's growing population in a way that is healthy, affordable, and good for the environment.

Together with increasing awareness and understanding of the full impact of the food system, and of animal protein production in particular, we have seen growing interest in alternative proteins that have recently attracted significant investments from high-profile investors such as Bill Gates and Richard Branson, as well as big food companies like Tyson Foods in the United States. There is significant potential for alternative proteins to play a major role in reducing the environmental and social impacts of the current food and agriculture system, and this will be crucial in meeting the second Sustainable Development Goal (SDG) of ending all forms of malnutrition by 2030, as well as contributing strongly toward the achievement of many of the other SDGs.

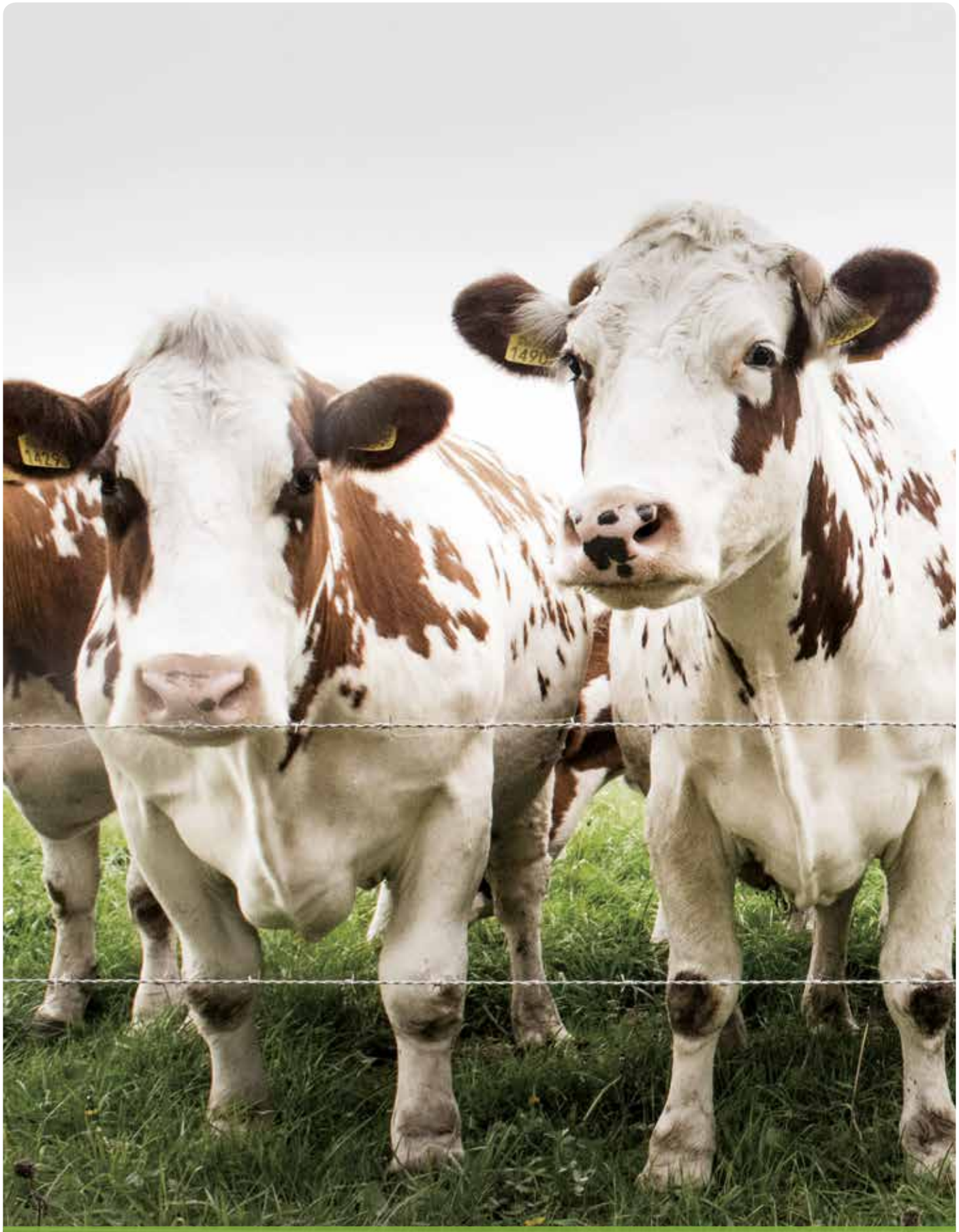
> "Alternative proteins have the potential to play a major role in reducing the environmental and social impacts of the current food and agriculture system"

What are these alternative proteins, and how can they contribute towards providing nutritious protein sources for a population of 9 billion? This article presents some examples of the innovators behind these novel protein solutions and explores how close they are to delivering truly scalable nutritional solutions.

Lab-grown meats

Cultured meat, also known as *in-vitro* or lab-grown meat, is created in a lab by using stem cell technology to create muscle tissue that is biologically identical to meat tissue from animals.

Once seen as a futuristic food concept, cultured meat has now been proven, and there is a network of start-ups across the world, such as Memphis Meat (US), Super Meat (Israel), and Mosa Meat (Netherlands) that are working on displacing the cow completely. And the cow is not the only animal that might



Lab-grown meat could hugely reduce pressure on the world's scarce resources

be displaced in this way. Finless Foods aims to develop and mass-manufacture seafood in the lab for human consumption. Other cultured animal products are being developed in Silicon Valley, such as Perfect Day's dairy-based milk without cows, created through a yeast fermentation process, and Clara Foods' animal-free egg white replacement.

A key argument for lab-grown meat is that by eliminating the need for livestock and feed cultivation on land, it could hugely reduce pressure on our scarce land and water resources, mitigate deforestation, eliminate inputs such a fertilizers and antibiotics, and reduce greenhouse-gas emissions. Development in a highly controlled environment creates opportunities to engineer "healthier" meats by adding nutrients and fats, such as omega-3 fatty acids, as required. This would cut down the need for livestock farming and its consequent animal welfare concerns: only one "harmless" biopsy of an animal is required to extract muscle to grow 20,000 tons of cultured beef.

Yet, while *in-vitro* meat production offers immense potential health and environmental benefits, it also presents significant social and cultural challenges. Consumer skepticism around product safety, health concerns, and ethical issues about eating meat from cloned tissue will be barriers to adoption. Also, while lab meat might provide a means of substitution for animal-based meat, it risks promoting overconsumption of meat, with negative impacts on human and planetary health.

Going forward, acceptance and uptake will be heavily influenced by how the media frame the discussion of this alternative protein source. Innovators will need to find ethical and safe ways to scale up manufacturing and reduce production and supply costs in order to bring prices down. Furthermore, ongoing investment will be required for continued research and development (R&D), as well as the creation of market conditions conducive to rapid scaling. Regulatory frameworks will also need to be robust and adaptable to mitigate potential ethical and health risks for consumers, while preserving companies' competitive advantage. These will be tough barriers to overcome – yet they can be overcome, with the right support.

> "Acceptance and uptake will be heavily influenced by how the media frame the discussion of lab-grown meats"

Plant-based meats

There has also been a spurt of innovation around "plant-based meat," using a combination of food science, biotechnology, and tissue engineering to process vegetable protein ingredients such as proteins from soy, pea, wheat, and potato into products that mimic meat in taste, mouthfeel, and flavor profile.

Unlike lab-grown meat, products of this nature are already widely sold, with fairly widespread market acceptance by consumers. Some companies leading this space include US-based Beyond Meat and Impossible Foods, whose plant-based burger products are widely available in the US and are coming to markets elsewhere. Other innovators include Wageningen University in the Netherlands, which is creating a "vegetarian" steak with support from Unilever and seven other food giants.

Single-cell proteins

Single-cell proteins are basically proteins derived from single-cell microorganisms, such as algae, fungi, yeasts, and bacteria.[1] There are significant environmental benefits to using these sources, a crucial one being that they utilize low-cost feedstock and wastes as sources of carbon and energy for growth to produce biomass, protein concentrate, or amino acids. They also do not have to be cultivated on fertile soil, have a very low water footprint, and often have excellent nutritional profiles.

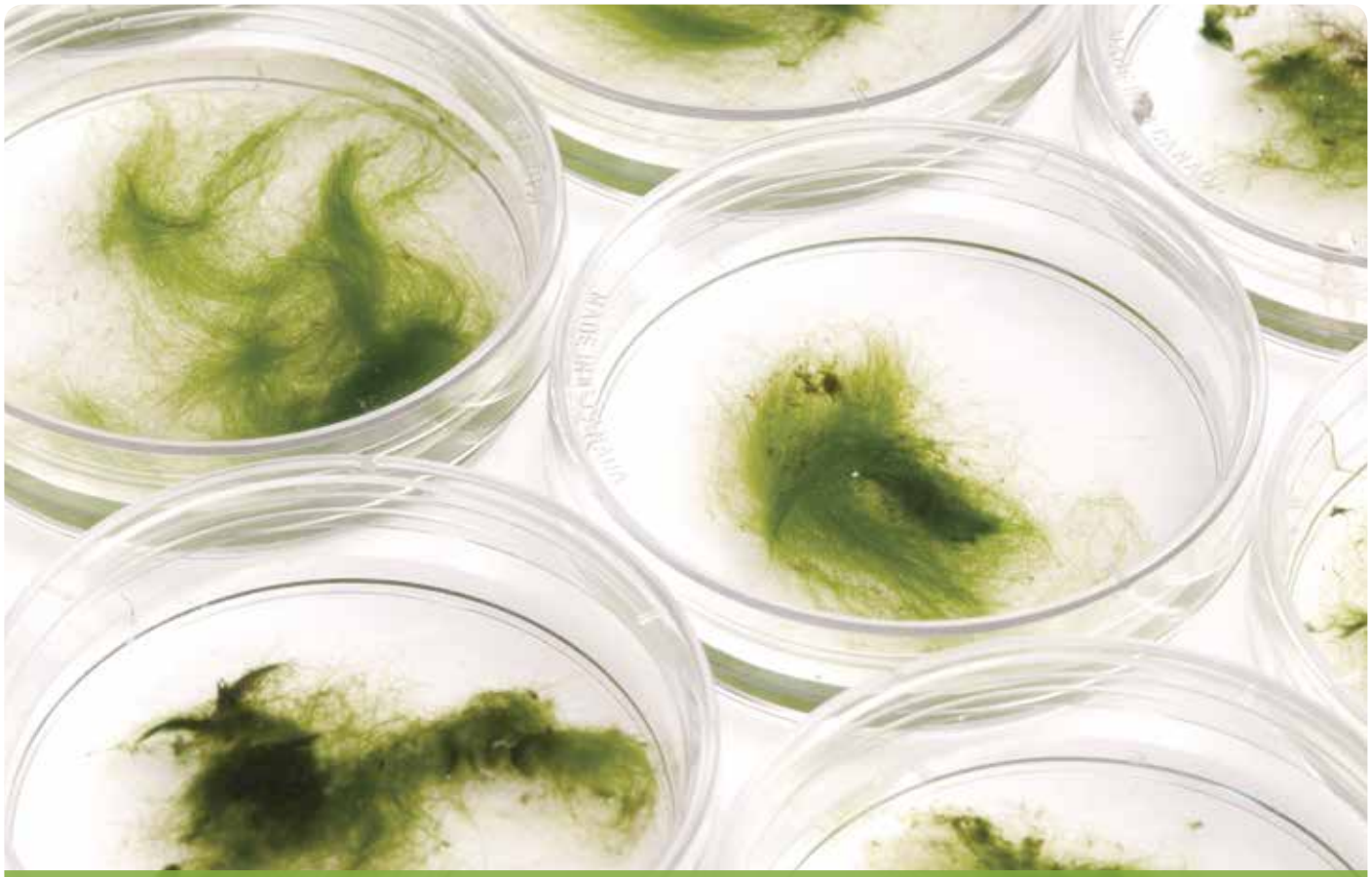
The best-known form of single-cell protein is the mycoprotein, derived from fungi through fermentation. It is rich in fiber and protein but very low in fat. Many consumers in the UK and elsewhere have consumed mycoprotein as the key ingredient in the highly successful Quorn-branded products, sold as a meat substitute. New start-up 3F Bio is aiming to produce 1 million tons of mycoprotein as a sustainable protein food ingredient by 2030.

Another emerging source of single-cell proteins is algae: simple plants that can range from the microscopic (microalgae), such as chlorella, to seaweeds (macroalgae) like kelp, which can be cultivated in seawater all over the world. In a closed fermentation production process, algae are used to convert a wide variety of plant sugars into oil, food ingredients, and other products.

Historically marketed as a niche health food in the form of chlorella or spirulina, algae have recently received more mainstream attention due to their immense potential viability as a source of food, fuel, and animal feed. They can reproduce very rapidly and have an amino acid profile that is superior to that of soy and other plant sources. They do not compete with traditional crops for land and resources and provide vital ecosystem services during their lifecycle, such as carbon dioxide absorption and the purification of waste waters.

Currently, algae are commonly marketed as a key additive to food products. For example, Corbion's AlgaVia uses algae powders with protein content of up to 63% as an ingredient for cereal, shakes, dressings, and more.

Challenges to scale include the fact that microalgae protein extraction and production is still expensive, in its infancy, and at small scale. More R&D is also required to address issues around digestibility, as well as better production, ex-



Single cell microorganisms such as microalgae often have excellent nutritional profiles

traction, and processing systems in order to improve efficiency and reduce costs.[2]

> "Algae do not compete with traditional crops for land and resources"

Edible insects

Entomophagy, the eating of insects, is an age-old practice among humans. Insects are consumed widely by over 2 billion people in Asia, Africa, and Latin America. They are high in protein, at levels comparable to meat sources, and are generally rich in minerals and vitamins. Large-scale production can take place with minimal space and water consumption and can utilize organic waste streams. In 2013 the UN recognized the significant potential and scale of insects as a source of both food for humans and feed for animals in an FAO report.[3]

On the whole, innovation in using insects for animal feed, particularly for chickens and fish (which consume insects as part of their natural diet), seems to be growing more rapidly. For example, Protix cultivates insects using local organic byproducts from the food and feed industry, keeping its impact low by recycling low-value waste products in a closed loop system. The resulting insect protein is used to produce feed for pets and fish, while insect-derived lipids are used in piglet diets. Initial results are promising, with pigs fed on insect lipids displaying better growth rates, lower mortality, and a reduced need for antibiotics.

Despite a relatively widespread aversion in the West to the consumption of insects, there has recently been a proliferation of insect farming and food manufacturing start-ups capitalizing on the use of insects as food ingredients to create novel products such as insect protein bars and crisps. These are currently niche markets, but should the cultural aversion be overcome, insect-based products could eventually move into the nutritional mainstream.

> "Edible insects are high in protein, and are generally rich in minerals and vitamins"

Conclusion

Given the sociocultural and geographical aspects of food consumption, converting the world's population wholesale to veg-

etarianism is unrealistic.[4] A more pragmatic goal is to make alternative proteins more widely available, affordable, and accessible, which will enable consumers to diversify their diets and will also have direct positive implications for global food security and for reducing pressure on the world's limited natural resources such as arable land and water.

On the whole, global consumer diets need to shift significantly from those dominated by animal proteins, as prevalent in the West, to ones containing a much higher proportion of plant-based foods. In the discussion of alternatives, we should not forget the plant-based proteins that are already widely available and familiar to most and, in comparison, are more affordable than the alternatives described above. Legumes such as beans and lentils are just a few of the many plant-based food options that come highly rated for nutritional qualities of fiber-packed protein. Encouraging consumers to increase the proportion of protein they acquire from plant foods will also bring about nutritional benefits in increasing fiber uptake and reducing saturated fat consumption.

> "Consumer diets need to shift from those dominated by animal proteins to ones containing a much higher proportion of plant-based foods"

Insect-based products could eventually move into the nutritional mainstream

The protein source options listed in this article are just some of the promising and exciting solutions out there that may offer affordable, healthy, and sustainable alternatives that can be taken to scale. Animal protein will remain a vital part of the future balanced plate of food, but with growing awareness of the environmental and health costs of meat, consumers may be more willing to give alternatives a chance. A mix of many factors – ranging from the right marketing mix, research, and product development, to continued investment, favorable market conditions, behavior change, and government legislation – will be of utmost importance not only in making alternative proteins relevant, aspirational, and desirable, but also in scaling up the most promising solutions to hit the critical mass required to truly meet our future health and nutritional needs within environmental limits.

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