Cultured Meat: Opportunities and Significant Challenges

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With the prediction that there will be two billion more people by the year 2050, the consequences of not taking action to mitigate the numerous challenges are formidable, with a critical concern being how to feed the growing population. The United Nations Food and Agriculture Organization estimates that about 815 million people of the 7.8 billion people currently in the world, or 10.5%, are suffering from chronic undernourishment. With future population growth, this situation will worsen. However, cultured meat, ie in-vitro meat (or lab-meat) is a fast-developing source of meat, supported by investment from financial backers such as Bill Gates and Richard Branson. Cultured meat has advanced from its proof of concept a few decades ago, to its current stage of scaling-up to industrial production and retail distribution. So, could this be the way forward in meat production? How is this in-vitro meat produced, and what is the underpinning science? Furthermore, what will be the significant barriers to its acceptance for public consumption?

Consequences of Livestock Farming

Meat consumption, derived from killing and processing animals, has maintained its popularity over the ages. However, more recently consumers have voiced growing concern over some consequences of meat consumption and its production. For example, meat-related illnesses, such as cardiovascular disease and diabetes – now responsible for a third of global mortality – associated with animal fats. Additionally, pathogens found in meats, such as Salmonella, Campylobacter, pathogenic E.coli, Avian influenza, and Bovine spongiform encephalopathy (BSE), are responsible for over 76 million episodes of illness, 325,000

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hospitalisations, and 5000 deaths globally each year. The annual medical costs related to the consumption of meat are estimated to be between $50 and $70 billion for the US, UK and Australia combined[1].

Moreover, there is a likelihood that the Coronavirus, COVID-19, pandemic originated from a wet-market in Wuhan, Hubei Province, China, where one or more animals at that market possibly transmitted the virus to humans[2].

Rearing livestock for meat requires considerably more pasture land, water, fertiliser, pesticides and energy, than all other arable crops combined. Given the direct-resources required to manage, transport, and slaughter animals, then to transport, store and distribute products to retailers, intensive meat production is only 25% as energy-efficient as other arable crops.

There is extensive pollution associated with livestock farming, with feed and meat production responsible for the emission of nitrogen and phosphorus, pesticide contamination of groundwater and aquifers, heavy metal contamination of soil, and ammonia emissions.

Globally, some 25% of the greenhouse gas, methane, is created by farm animals and their waste products[3].

There are approximately 19 billion chickens bred for consumption (three per capita), cattle are the next most populous farm animal with 1.7 billion, with sheep and pigs at around 1.3 billion[4].

Animal grazing uses 26% of the world's land. Much of this land has required deforestation[5].

More recently, meat consumption in the western world has plateaued, while in developing countries eating meat continues to increase – having doubled over the last 20 years[6]. The likely consequences of this increase in meat consumption when coupled with a growing global population hold significant concerns. Conventional meat production may be capable of feeding most of the current population of 7.8 billion, but will it be able to meet the demands of the future? Perhaps, due to increased pricing, we will reduce our consumption of meat. Alternatively, we may choose the option of adopting meat that is not from animals but produced in an industrial process using in-vitro techniques using tissue engineering systems.

Consumer Product Choices

Humans have hunted and killed animals for meat since prehistoric times, with the advent of civilization allowing the domestication of chickens, sheep, rabbits, pigs and cattle.

This eventually led to their use in meat production on an industrial scale with the aid of slaughterhouses and complex supply chains. The development of national retailing added yet another burgeoning dimension to intensive farming, mass production and consumer supply.

The numerous faux-meat products in the market are trying to be substitute meat; often referred to as a meat-analogue that approximates certain aesthetic qualities – texture, flavour and appearance. These substitutes often use soybeans (tofu), and other pulses and legumes, all of which require extensive use of land and water. However, and understandably, there is a (growing) demand from those wishing to supplement their diet or opt-out from eating meat. However, lab-meat is meat, not a faux product.

There is a great deal of psychology underpinning our preference to consume animal meat rather than eating alternative food types and substitutes. Eating a sirloin or rump steak, for example, has a status and a prestige associated with the choice of cut, not just the nutritional element. The choice to eat meat is not exclusively based on taste nor its nutritional value[7].

Since demand for faux meat is on the rise, there has been an influx of competition in this space. Beyond Meat is one example of a company that is disrupting the meat industry with its alternatives. It produces plant-based meat substitutes. The initial products were launched in the US and are now distributed world-wide. The company has products designed to emulate chicken, beef and pork sausages, amongst its range of products. It was one of the first to enter the market and has achieved significant popularity.

Whilst there is inconclusive discussion around the size of the alternative meat industry and its growth projections, some analysts estimate that its annual value is anywhere between $10 to $40 billion. Estimates for alternative meats suggest they currently make up less than 1% of the $1.4 trillion meat industry, but could grow to 9% by 2040[8]. Growth projections remain positive. More established brands, such as Nestlé, Conagra Foods, Kraft Heinz Company, Kellogg, Maple Foods, and many more, are also moving into vegetable-based faux-meat.

Cultured In-Vitro (Lab) Meat

The notion of eating meat that has not been taken from killing animals, will not be readily accepted by most people – so there are some interesting and significant challenges ahead if in-vitro produced meat becomes readily available. One of the (appealing) benefits of lab meat is that no animal dies, and that will undoubtedly be a significant marketing point of differentiation.

Cultured meat is produced by taking cells from the live animal, and cultivated and grown using in-vitro technology. Undoubtedly, it is meat – with the same protein as meat produced from farmed animals – not, though, with the same texture. But once it is turned into a finished product, such as a beef burger, mince, meat balls, or, say, used in a pie, there is no way to tell the difference; the taste is the same as conventional meat.

The underpinning science involves recreating the complex structure of muscles found in animals, using initially a few cells. A culture is taken from a live animal to remove stem cells, which have the ability to proliferate and develop into muscle cells and fat cells[9]. The cells will start to divide after they are cultured in an in-vitro medium, which will provide nutrients, hormones and growth factors. These cells merge to form myotubes (measuring approximately 0.3mm) that grow into a small piece of muscle tissue[10]. This piece of muscle multiplies in size from increasing strands of fibres. The fibres are attached to a sponge-like scaffold that floods them with nutrients and mechanically stretches them, thereby exercising the muscle cells that in turn, increase their size and protein content[11].

Conclusions and Future Direction

Cultured in-vitro meat is now being sold in retail outlets in Singapore[12]. We have gone well beyond proof of concept.

In Australia, there are 12 organisations currently developing commercial products[13]. Worldwide, there are hundreds of companies at the upscaling stage and preparing for commercial opportunities[1], with the largest and most advanced being in Israel and the US.

In terms of its acceptance to mass markets, a comparison might be drawn with the adoption of electric vehicles. EVs in future will have numerous advantages over the combustion engine, but the battle for minds, heart and sentiment will be an uphill slog!

Cultured in-vitro meat is unlikely to completely reproduce the vast variety of meats derived from animal species and breeds. Moreover, the control of its nutritional composition is still unclear, especially for micronutrients and iron content.

With regards to environmental issues, the potential advantages of cultured meat for greenhouse gas emissions are a matter of debate, although undoubtedly less land will be used and emissions

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will be reduced when compared to the farming of livestock.

Cultured meat will have to compete with the increasing number of other meat substitutes, especially plant-based alternatives. But, consumer perception and final acceptance of cultured meat will be influenced by numerous factors – not solely those based on health benefits.

Ethically, mass production of in-vitro cultured meat will allow considerably fewer animals than conventional livestock farming; albeit some animals will still have to be reared to harvest the cells for production of in-vitro meat.

It remains to be seen which of the alternative meat producers – conventional live-stock farming or lab-based in-vitro cultured – has the greatest appeal to consumers. It may, finally, all be determined by the better strategy and marketing tactics.

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