Recent developments in cultivated meat production

Words by Dr Robyn Warner

Cell-based or 'cultivated' meat has attracted much media interest recently as a proposed solution for food security, provision of safe and affordable protein and as a solution for the unsustainable impact of animal production on the environment.[1]

The common terms used for this type of meat production include lab, cultured, in vitro, artificial, synthetic, clean, or most recently, cultivated meat. In this article, I use the term c-meat as it encompasses cultivated, cultured, cell-based and clean meat. C-meat is one aspect of cellular agriculture which involves the production of foods from cells, rather than from whole plants or animals, as well as a small part of the alternative protein landscape for future food.[2]

The definition of c-meat production is: meat made from stem cells which tries to mimic traditional meat.

Exactly when c-meat will start appearing in supermarkets and restaurants is uncertain, but it's predicted to be some time within the next ten years. The timing is reliant on the development of cost-effective procedures for scale-up from lab to commercial production and the development of regulation and labelling procedures.

Processes and techniques

The techniques for culturing cells are not new. The first successful culture of cells from a chicken embryo was in 1885 and the limited life span of stem cells in vivo – something that remains a challenge in c-meat production today – was first described in 1962.[1]

The processes and techniques required to make and scale-up c-meat production include cell line development and large scale cell cultivation.

Cell line development

Many potential sources of cells exist including biopsies from live animals, embryonic stem cells, and bone marrow or other inducible stem cells.[3] Stem cells have a unique ability to develop into many different cell types and all stem cells can self-renew (make copies of themselves through division) and differentiate (develop into more specialised cells).

Currently, the most successful approach has been achieved using stem cells derived from muscle satellite cells from mature animals. However, while these are the easiest cells to culture, they have a limited life span.

Cell cultivation

Growth of cells in culture requires nutrients, similar to cells in living tissue. In the absence of a blood supply providing nutrients and removing waste, cells are bathed in a culture media which provides important nutrients and growth factors. The culture media usually contains 10-20 per cent growth media traditionally derived from calf or bovine serum, which is currently prohibitively expensive.

Structured c-meat tissue can only be produced by cultivating fully functioning skeletal muscle cells. These need to attach to some form of mesh scaffold, such as collagen, which provides support and enables cell differentiation and growth.

The collagen scaffold can either become part of the product, if edible, or the cells can be removed and the scaffold recycled for the next batch. Research is ongoing globally to identify cost-effective, animal-free growth media and scaffolds that can be used in the scaling-up process.

Scaling up

Once a cell line has been established, production must move from the lab bench to large scale production in bioreactors. However, muscle is not composed only of muscle cells, but also fat cells, connective tissue and vascular tissue.

Currently, due to the complexity of cultivating each individual cell type, co-culture of all these cells has not yet been achieved. It is the lack of a vascular system in the current muscle cell culture systems that limits the width of the muscle cell tissue to just several cells thick.

Manufacturing products

Existing c-meat processes can produce a complex of muscle cells which can be formed into a burger or pattie. A c-meat pattie could be made of 100 per cent muscle cells, however, this would be extremely expensive and would not mimic the composition of real meat. So, a c-meat pattie would more likely be made of around 10 per cent muscle cells.

For food ingredient applications, it is possible to blend muscle cells with non-meat ingredients, such as cereals or pulses, to form complex food pastes that can then be structured using a process such as extrusion or bio-printing. However, a key challenge in the scaling-up process for c-meat is the formulation of products, as the simulation of texture, flavour and mouthfeel in animal-derived meat products is complex and is an essential consideration for consumer acceptance.

Sustainability

Sustainability of c-meat production, measured as reduced greenhouse gas emissions (GHGe), over conventional livestock production systems, especially beef, has been proposed as the most important advantage of c-meat.

Available data predicts that c-meat production will result in lower GHGe than beef, but equivalent to poultry or pig production.[1] Energy and water usage will likely be higher and, in times of increasing water scarcity[4] and increased need for decarbonisation of energy, these are important considerations. As c-meat production is not presently available at commercial scale, it is difficult to accurately predict the sustainability of the industry.[1]

Food security

Food security indicators show meat production increases of 50–100 per cent are required to maintain the future per capita demand of growing populations, and any increase would come at high environmental cost. C-meat production will therefore most likely supplement meat protein from animal sources.

Due to high demand for meat protein, and potential increased consumption in poor countries, some predictions include a scenario where meat-animal production from agriculture is maintained alongside a c-meat industry. Depending on the costs of production, it is also possible that c-meat products may become a niche product for affluent consumers.

Public health

Foodborne pathogens such as salmonella, campylobacter, listeria and escherichia coli are responsible for many cases of human illness and sometimes death.

As c-meat reduces human-animal interaction, it is expected to reduce the incidence of epidemic zoonoses and may also reduce the risk of foodborne pathogens. Conversely, antimicrobials will likely be required during c-meat production to eliminate pathogen growth, and the use of antimicrobials is a concern for public and consumer health and safety.

However, there will be reduced exposure to dangerous chemicals such as pesticides and fungicides in animal production, which can be harmful for humans as well as wildlife.

C-meat can also be engineered to be healthier and more functional by manipulating the culture media to change levels of nutrients, vitamins, fatty acids or fat content. It goes without saying that all compounds and chemicals used during production and processing will need to be documented for regulation and labelling.

A range of regulatory hurdles will need to be met before c-meat can reach the consumer. For the c-meat industry to succeed, companies will also need assurance their products will be responsibly regulated. To this end, in 2019 the USDA and FDA formalised a Memorandum of Understanding outlining their planned cooperative approach toward future regulation of c-meat.[3] Regulations presently being developed in the US will be watched closely as they will provide guiding principles for regulators in other countries.

Australian opportunity

With 45 companies worldwide involved in various aspects of c-meat production (and two in Australia since 2019),[5] the industry has an estimated projected value of US$23 billion by 2023.[6] Large multinational meat processing and food companies, as well as governments in some countries, are investing in the category[7] and, as such, there is no doubt a healthy c-meat industry is emerging.

The role Australia chooses to play will be pivotal in whether we become a product-importer or global collaborator and exporter of c-meat technology and products. Given Australia is internationally recognised for world-leading food and medical research, government support for innovation alongside start-ups - and timely development of regulatory guidelines - should make the development of c-meat technologies, and a c-meat industry, possible in Australia.

References

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