HISTORY, PROSPECTS AND CHALLENGES OF LAB GROWN MEAT: A REVIEW

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Abstract
Lab grown meat is meat produced by in vitro cultivation of animal cells, instead of from slaughtered animals. So-called "cultured" or "synthetic" or "in vitro". Growing muscle tissue in culture from animal stem cells to produce meat. It is a form of cellular agriculture. It is being developed as a way of addressing many environmental and issues associated with conventional meat production. The technique to generate cultured muscle tissues from stem cells was described since 1932, however has not yet been developed for the commercial production of cultured meat products till late 2020 in Singapore. The technology is at an early stage and prerequisites of implementation include a reasonably high level of consumer acceptance, and the development of commercially-viable means of large scale production. Recent advancements in tissue culture techniques suggest that production may be economically feasible, provided it has physical properties in terms of colour, flavour, aroma, texture and palatability that are comparable to conventional meat. Although considerable progress has been made during recent years, important issues remain to be resolved, including the characterization of social and ethical constraints, the fine-tuning of culture conditions, and the development of culture media that are cost-effective and free of animal products. Consumer acceptance and confidence in in vitro produced cultured meat might be a significant impediment that hinders the marketing process.
Key words: artificial meat, consumers, progress, limitation, developmental stages

Introduction

According to FAO (2018), the global population of about 7.6 billion is expected to surpass 9 billion by 2050. The Food and Agriculture Organization (FAO) has forecast that in 2050, 70% more food will be needed to fulfill the demand of the growing population, which is a great challenge due to resource and arable land limitations. Even if meat consumption is decreasing in developed countries, its global consumption is increasing because consumers are generally unwilling to reduce their meat consumption, in particular in developing countries such as in China, India, and Russia (Tobler et al., 2011). These populations becoming more middle-class, they are looking for more luxury products, such as meat or other animal products.

Livestock systems will contribute to addressing the issue of global food and nutrition security in the world (Willett et al., 2019). Animal farming must produce larger quantities of high quality and affordable meat, milk, and eggs, through production systems that are environmentally sound, socially responsible, and economically viable (Scollan et al., 2011). Despite the wide range of economic, environmental, cultural and social services at local, regional, and global levels provided by livestock farming (Ryschawy et al., 2019), a significant proportion of livestock is raised nowadays within the factory farming model. Despite a lower contribution to greenhouse gases (GHG) and water usage than extensive agriculture, factor farming is mainly focused on efficiency (i.e., the quantity of milk or meat produced) rather than on other services and impacts such as interaction with the environment, climate change, less use of antibiotics, animal welfare, or sustainability (Aleksandrowicz et al., 2016).

As a consequence, more efficient ways of protein production are being developed to sustain the growing global population while complying with today's challenges, such as environmental and

animal welfare issues (Aiking, 2014). Among the solutions, cultured meat is presented by its advocates as a sustainable alternative for consumers who want to be more responsible but do not wish to change the composition of their diet (Shapiro, 2018). The history of cultured meat was detailed by Hamdan et al. (2018), and a bibliometric analysis of publications about this subject was carried out by Fernandes et al. (2019). Indeed, since the first publication about cultured meat in 2008, the number of publications increased considerably (89% of the total) after 2013. In August of that same year, the first hamburger produced with cultured meat was prepared and tasted on a television program (Post, 2014).

History

History of lab grown is dated back to early 90's according to the Strand Magazine when Winston Churchill suggested that: "We shall escape the absurdity of growing a whole chicken in order to eat the breast or wing, by growing these parts separately under a suitable medium" (Churchill, 1931). Table 1 shows a summary of lab grown meat as well as how and when genetically made meat came about.

Table 1: Timeline of lab grown meat from 1931 to 2020

Year	Event
1931	Winston Churchill predicted growing of the poultry parts under a suitable medium
1998	Jon Vein secures a patent for the production of lab-grown meat for consumption.
2001	NASA begins experiments producing cultured meats from turkeys' cells
2001	Dr. Willem van Eelen, businessman Willem van Kooten, and dermatologist Wiete Westerhof, file a patent for producing cultured meat for consumption.
2002	The first edible lab-grown meat sample is produced: a fish fillet made from cultured goldfish cells.
2003	Tissue Culture and Art Project and Harvard Medical School used stem cells from frogs to create tissue that resembled a steak.
2008	PETA offers one million dollars to the first company that can bring lab-grown chicken to the food industry.
2009	*Time* magazine labels cultured meat one of the breakthrough ideas of the year.
2013	The first lab-grown beef hamburger created by Dr. Mark Post at Maastricht University in the Netherlands was consumed at a press event in London, England.
2015	Maastricht University held their first International Conference on Cultured Meat.
2016	An engineered meat startup company, Memphis Meats, posts a promo video showcasing their lab-grown meatballs.
2016	An Isreali company, SuperMeat, runs a crowdfunding campaign to raise money for their efforts to bring lab-grown poultry products to market.
2017	Finless Foods announces that they expect to bring sustainable, lab-grown seafood to consumer markets within 2 years.
2018	Dutch startup company Meatable claims to produce cultured meat from stem cells sourced from animal umbilical cords, solving the problem of needing to kill an animal initially to get starter cells for production.
2020	San-Francisco based start-up won regulatory approval to sell its cultured chicken in Singapore, making the Southeast Asian city-state the first nation in the world to approve this meat alternative.

Source: Kadim et al. (2015); Amanda (2020); Chriki and Hocquette (2020)

Prospects

There are several prospects in respect to lab grown meat having a number of advantages relative to conventional meat in terms of efficiency of resource use (land, energy, and water), lower

greenhouse gas production, better animal welfare, and in the ability to manipulate the nutrient composition of the product (Kadim et al., 2015; Bhat et al., 2015).

Recent advancements in tissue culture techniques suggest that production may be economically feasible, provided it has physical properties in terms of colour, flavour, aroma, texture and palatability that are comparable to conventional meat (Jean-François, 2015; Kadim et al., 2015).

Furthermore, Kadim et al. (2015) and Arshad et al (2017) have outlines the prospects for combined cultures of photosynthetic organisms (single celled such as algae or cynobacteria) and animal cells, the former providing nutrition for the latter. Thus, the possibility of sourcing meat from insects in the nearest future and the economic advantages of this idea.

Therefore, the current advancement are making in vitro meat a real possibility now as opposed to 30 years ago. Some of these prerequisite technologies that are available to the researchers are the growing sophistication of stem cell isolation and identification, the development of ex-vivo cell culture and the development of tissue engineering techniques. Despite all the past, present and future challenges, there is optimism with the prospects for culture meat.

Challenges

Although considerable progress has been made during recent years, important issues remain to be resolved, including the characterization of social and ethical constraints, the fine-tuning of culture conditions, and the development of culture media that are cost-effective and free of animal products (Kadim et al., 2015; Bhat et al., 2019).

A key biological challenge is producing large three-dimensional blocks of muscle tissue when the cells require nutrients and oxygen to grow and the isolation/identification of suitable animal stem cells. A further challenge is the optimization of culture media and other issues such as the need for mechanical or electrical stimulation to be applied to encourage muscle tissues to take on the desired texture (Kadim et al 2015; Stephens et al., 2018).

Consumer acceptance of cultured meat might be a significant obstacle towards the marketing process. Consumers, may be cautious about accepting such products due to perceptions of "unnaturalness" and "artificialness". Meanwhile, a growing number of social sciences studies have focused on sociological, philosophical, moral and ethics arguments around the issue (Welin, 2013). Up to the present day, it remains largely unknown though how consumers will react to this new technology and, whether and under which conditions they would be willing to accept and adopt this novel food (Verbeke et al., 2015).

Consumer insight will be indispensable for future marketplace acceptance. Several recent examples, such as biotechnology and nanotechnology illustrate that consumers may not embrace novel agro-food technologies as enthusiastically as hoped for at the times when the technologies were developed and adopted (Verbeke 2011).

However, most of the challenges facing the culturing of meat are believed to be solvable at some point in time (Datar and Betti 2010; Post, 2014).

Conclusion

It seems clear that research projects on cultured meat have had a limited scope as in vitro meat development is still in its infancy stage. However, if successfully produced, it is possible that cultured meat products could play a useful complementary role alongside conventional meat products in meeting predicted increases in the global demand for meat. The product will evolve continuously in line with new discoveries and advances that optimize the production, quality and efficiency of cell division. It remains to be seen whether this progress will be enough for artificial meat to be competitive in comparison to conventional meat and the increasing number of meat substitutes.

References

Aiking, H. (2014). Protein production: planet, profit, plus people. *Am. J. Clin. Nutr*. 100:483S−9S.

Aleksandrowicz, L., Green, R., Joy, E.J.M., Smith, P. and Haines, A. (2016). The impacts of dietary change on greenhouse gas emissions, land use, water use, and health: a systematic review. *PLoS ONE*. 11:e0165797.

Amanda, M. (2020). Lab-Grown Meats Will Change the Food Industry Forever. CRISP Publication. Acessed from https://www.synthego.com/blog/lab-grown-meats#history

Bhat, Z.F., James D., Morton, S.L., Mason, A. A. and Bekhit, H.F.B. (2019) Technological, Regulatory and Ethical Aspects of In Vitro Meat: A Future Slaughter-Free Harvest. *Comprehensive Reviews in Food Science & Food Safety*. 18(4): 1192-1208.

Chriki, S., and Hocquette, J. F. (2020). The Myth of Cultured Meat: A Review. *Frontiers in nutrition*. 7, 7. https://doi.org/10.3389/fnut.2020.00007

Churchill, W. (1931). Fifty Years Hence. The Strand Magazine. Retrieved from https://quoteinvestigator.com/2017/01/22/meat/ on 12/12/2020

Datar, I. and Betti, M. (2010). Possibilities for an in vitro meat production system. *Innovative Food Science and Emerging Technologies*. 11: 13–22.

FAO. (2018). The future of food and agriculture – Trends and challenges. Rome

Fernandes, A.M., Fantinel, A.L., de Souza, Â.R.L and Révillion, J.P.P. (2019). Trends in cultured meat: a bibliometric and sociometric analysis of publication. *Braz. J. Inf. Sci. Res. Trends*. 13: 56–67.

Gerber, P.J., Mottet, A., Opio, C.I., Falcucci, A. and Teillard, F. (2015). Environmental impacts of beef production: review of challenges and perspectives for durability. *Meat Sci*. 109: 2–12.

Kadim, I.T., Mahgoub, O., Baqir, S., Faye, B. and Purchas, R. (2015). Cultured meat from muscle stem cells: a review of challenges and prospects. *J. Integr. Agric.* 14:222–233.

Moritz, M.S.M., Verbruggen, S.E.L. and Post MJ. (2015). Alternatives for large-scale production of cultured beef: a review. *J. Integr. Agric.* 14: 208–16.

Post, M.J. (2014). Cultured beef: medical technology to produce food. *J. Sci. Food. Agric*. 94:1039–1041.

Ryschawy, J., Dumont, B., Therond, O., Donnars, C., Hendrickson, J., Benoit, M., et al. (2019). Review: an integrated graphical tool for analysing impacts and services provided by livestock farming. *Anima*l. 13:1760–1772.

Scollan, N.D., Greenwood, P.L., Newbold, C.J., Yanez, Ruiz, D.R., Shingfield, K.J., Wallace, R.J., et al. (2011). Future research priorities for animal production in a changing world. *Anim. Prod. Sci*. 51:1–5.

Shapiro, P. (2018). Clean meat: how growing meat without animals will revolutionize dinner and the world. *Science*. 359-399.

Stephens, N., Di Silvio, L., Dunsford, I., Ellis, M., Glencross, A., and Sexton, A. (2018). Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. Trends in Food Science & Technology. 78: 155–166.

Tobler, C., Visschers, V.H.M. and Siegrist, M. (2011). Eating green. Consumers' willingness to adopt ecological food consumption behaviors. *Appetite*. 57: 674–682.

Verbeke, W. (2011). Consumer attitudes and communication challenges for agro-food technologies. *Agro-Food Industry Hi-Tech*. 22: 34–36.

Verbeke, W., Pierre, S., Ellen, J. and Van L. (2015). Challenges and prospects for consumer acceptance of cultured Meat. *Journal of Integrative Agriculture*. 14(2): 285–294.

Welin S. 2013. Introducing the new meat. Problems and prospects. Etikk i praksis: *Nordic Journal of Applied Ethics.* 7: 24–37.