A REVIEW ON CRUCIAL ASPECTS IN UP-SCALING CULTURED MEAT PRODUCTION

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Abstract: Current meat consumption pattern is putting a lot of burden on the environment by taking up a lot of resources and releasing emissions from activities such as rearing animals that cause environmental pollution. One of the alternatives on the market is plant-based meat which is made from plant ingredients which is favourable among vegetarians. However, meat eaters are not satisfied with plant- based meat and are looking for other options. Cultured meat is introduced to overcome the issue related to conventional meat and provide a better alternative to meat. No massive animal rearing is needed to produce cultured meat since it is produced by cell culturing methods from cells obtained through painless biopsy on living animals. Many studies are conducted to produce cultured meat for commercialization and to up-scale the production of cultured meat. Current method to produce cultured meat is on the lab-scale and very expensive. Up-scaling of cultured meat must ensure that it is cost- effective, sustainable, and acceptable. This review paper highlights the important aspects in up- scaling cultured meat production from maintaining the stemness of satellite cells to sustainable alternatives of cell growth medium and scaffold as well as components that improved the cell growth. The cost for cultured meat is still expensive, but by making changes through possible alternatives on the materials used can reduce the cost and make cultured meat acceptable by the public.

Keywords: Cultured meat, cell culture, stem cell, cell growth medium, scaffold

1. Introduction

Serious consequences from conventional meat production that contribute to environmental pollution have initiated scientists to look for meat alternatives that could give the similar sensory experience as meat. One of the meat alternatives that could imitate conventional meat is cultured meat. The environmental problems related to conventional meat are large requirements of global land surface up to 38% (Alexander, Reddy, Brown, Henry, & Rounsevell, 2019), green gas and methane emission, and 8% global freshwater usage (Bhat, Bhat, & Kumar, 2020). Meat alternatives, especially cultured meat, could overcome the problem stated above and support the growing global meat consumption that is expected to increase up to 465 million tonnes by 2050 (Bhat et al., 2020). This study aims to provide information about meat alternatives and contribute to the development of cultured meat which is currently in the research phase.

2. Discussion

2.1. Overview of cultured meat

Cultured meat is produced from cell culturing method that aims to produce meat without requiring animal breeding and slaughtering (Bekker, Fischer, Tobi, & Van Trijp, 2021). Cell culturing method produces cultured meat by obtaining muscle stem cells via small biopsy on the animals and the cells will undergo two phases which are proliferation and differentiation phases.

2.2. Production of cultured meat

There are 4 essential components for cultured meat production which are stem cells, cell culture medium, scaffold and bioreactor to produce meat from stem cells into edible tissues.

2.3. Essential component 1: Starter cell lines

Cell culturing method requires stem cell lines from animals to begin the process. There are few types of starter cells including muscle satellite cells, embryonic stem cells and mesenchymal stem cells (Ketelings, Kremers, & De Boer, 2021). Muscle satellite cells can be isolated from muscle tissue and have multilineage potential which is promising for cultured meat (Bhat et al., 2020). Whereas, embryonic stem cells and mesenchymal stem cells can be isolated from the embryo or umbilical cord of the animals (Ketelings et al., 2021).

2.4. Essential component 2: Cell growth medium

Growth medium is an essential component for cell growth in cultured meat production. Fetal bovine serum is a serum added to culture medium to supplement nutrients for cell growth. However, since the serum is obtained from the clotted blood of the bovine fetus has led to ethical issues regarding the method to obtain the serum (Liu et al., 2016). An example of substitute for the serum is sericin which is a major component of silkworm silk protein that could promote cell viability (Hajarian, Aghaz, & Karami Shabankareh, 2017).

2.5. Essential component 3: Scaffold for cultured meat

Scaffold is a three-dimensional biodegradable material used in cell culturing as a temporary template for promoting and guiding the neo-tissue formation in a pre-determined manner. The properties of a scaffold able to guide cells into a desirable organization (Werner, Kurniawan, & Bouten, 2020). Scaffolding is required to mimic in vivo environments of tissues such as porosity, flexibility and stiffness to allow cells to grow, proliferate and differentiate (Orellana et al., 2020). Another option of scaffold other than biomaterial scaffold is plant-derived scaffold which has shorter developmental time and is cost-effective (Fontana et al., 2017).

2.6. Essential component 4: Bioreactor

Bioreactor is an equipment that provides a suitable environment and condition to support cell growth into tissue culture. It creates a mechanical environment that resembles the niche

environment of the cells during development and maturation of tissue culture (Cook et al., 2016). Up-scaling off cultured meat production will require large-scale bioreactors to generate high cell numbers (Bhat et al., 2020).

3. Conclusion

Cultured meat is a novel product that serves as one of the meat alternatives to support the growing meat demand. Production of cultured meat via cell culturing method eliminates the requirements of large land surface and water resources as well as reduced green- house gas emissions. Cultured meat production is still in its infancy. In addition, many studies are needed in this field to produce a convincing, safe and acceptable product and to make large-scale bioreactors available to support mass production of cultured meat

References

Alexander, P., Reddy, A., Brown, C., Henry, R. C., & Rounsevell, M. D. A. (2019). Transforming agricultural land use through marginal gains in the food system. *Global Environmental Change, 57*. doi:10.1016/j.gloenvcha.2019.101932

Bekker, G. A., Fischer, A. R. H., Tobi, H., & Van Trijp, H. C. M. (2021). Stuck in the middle with you: The role of similarity information on categorizing cultured meat. *Food Quality and Preference, 93*. doi:10.1016/j.foodqual.2021.104265

Bhat, Z. F., Bhat, H., & Kumar, S. (2020). Cultured meat—a humane meat production system. In *Principles of Tissue Engineering* (pp. 1369-1388).

Cook, C. A., Huri, P. Y., Ginn, B. P., Gilbert-Honick, J., Somers, S. M., Temple, J. P., . . . Grayson, W. L. (2016). Characterization of a novel bioreactor system for 3D cellular mechanobiology studies. *Biotechnology and Bioengineering,* 1825-1837. doi:10.1002/bit.25946

Fontana, G., Gershlak, J., Adamski, M., Lee, J. S., Matsumoto, S., Le, H. D., . . . Murphy, W. L. (2017). Biofunctionalized plants as diverse biomaterials for human cell culture. *Advanced Healthcare Materials, 6*(8). doi:10.1002/adhm.201601225

Hajarian, H., Aghaz, F., & Karami Shabankareh, H. (2017). Replacement of serum with sericin in in vitro maturation and culture media: Effects on embryonic developmental competence of Sanjabi sheep embryo during breeding season. *Theriogenology, 92*, 144-148. doi:10.1016/j.theriogenology.2016.12.027

Ketelings, L., Kremers, S., & De Boer, A. (2021). The barriers and drivers of a safe market introduction of cultured meat: A qualitative study. *Food Control, 130*. doi:10.1016/j.foodcont.2021.108299

Liu, L., Wang, J., Duan, S., Chen, L., Xiang, H., Dong, Y., & Wang, W. (2016). Systematic evaluation of sericin protein as a substitute for fetal bovine serum in cell culture. *Scientific Reports, 6*, 31516. doi:10.1038/srep31516

Orellana, N., Sanchez, E., Benavente, D., Prieto, P., Enrione, J., & Acevedo, C. A. (2020). A new edible film to produce in vitro meat. *Foods, 9*(2). doi:10.3390/foods9020185

Werner, M., Kurniawan, N. A., & Bouten, C. V. C. (2020). Cellular geometry sensing at different length scales and its implications for scaffold design. *Materials, 13*(4). doi:10.3390/ma13040963