Background

The human population reached an approximate total of 7.3 billion people in 2015, and it is anticipated to reach 9.7 billion by 2050. Concerns have arisen over the increase in population in conjunction with the current rate of poverty, hunger, and climate degradation. These have led to a prioritized interest in improving our food production systems to meet the needs of our population in the most sustainable manner. In particular, the focus has been placed on meeting the growing dietary demand. In the most likely case, the amount that the protein production demand will change between now and 2050 will be an increase between 32-78% from the current 202 million tons.

One of the most recent solutions proposed carries many names to which will be primarily referred to as in vitro meat in this analysis. The objective of this review is to evaluate the potential commercialization of in vitro meat as a global protein source. The opportunities and challenges of this process will be assessed with reference to sustainability in the four domains outlined by the framework for the Global Forum for Food and Agriculture (GFFA). The four domains being (a) climate and natural resource use, (b) livelihoods and economic growth, (c) food and nutrition security, and (d) health and animal welfare.

Methods

The team compiled extensive literature relating to the topic of in vitro meat production as it relates to the previously stated four domains. Interviews from international experts, academics, and journalists were conducted. From the collected information, the team authored a comprehensive literature review and created other media for sharing the information.

How is in vitro meat produced?

Currently, this technological process begins with the harvest of embryonic or adult stem cells from the respective livestock species. The muscle cells must grow and proliferate and then be placed on scaffolding inside of a bioreactor with growth medium to provide a desirable environment for cell growth and differentiation. The major components in the medium consist of vitamins, amino acids, pH buffer, manganic salts, and growth factors. Differentially myoblasts and fused myotubes are removed from the scaffolding after they are formed. Once enough muscle cells have been cultured, they can be ground together with other additives, such as artificial or natural colors, artificial or natural flavors, and nutrients to give it a similar appeal of conventional meat.

The most common form of in vitro meat is currently ground beef though pork, poultry, and seafood have also been cultivated.

Health and Animal Welfare

FBS is collected from a fetus, typically when a pregnant female bovine is harvested for meat. If in vitro meat is to become the new mainstream source for animal-derived proteins, the potential for a reduction of livestock breeds is possible and probable. There are certain breeds that carry useful genes such as disease, insect, and parasite resistance, as well as heat and drought tolerance. If these certain genes are lost, it could become very difficult to ever improve the efficiency and well-being of livestock.

Climate and Natural Resource Use

In vitro meat has been marketed as a solution for mitigating the environmental impacts of conventional meat production. Existing quantitative data are limited as there are only three existing life cycle analyses (LCA) assessing the environmental impacts of in vitro meat. The measures used across the LCAs include greenhouse gas (GHG) emissions, land use, energy use, water use, and eutrophication potential. Environmental gains are observed in land use and eutrophication potential while environmental losses are anticipated for water and energy use. Projections of GHG emissions lead to an ambiguous conclusion; however, this may also be true of the other measures, because these LCAs are estimates of the industrial-scale production that currently does not exist.

Climate Impact Comparison of in vitro Meat Life Cycle Analyses and Conventional Meat

Food and Nutrition Security

Although it may add to the availability of a food protein source, the cost may not contribute to food accessibility. Many authors have discussed the beginning of in vitro meat to be in the form of exotic meats. “At first, according to experts, it might be a luxury item, maybe in the form of exotic treats such as snow leopard burger or rhino sausages” (Bhat and Faysal, 2011). Nutritional components including Vitamin B12, heme iron, and fatty acid profiles are subject to be different than conventional meat. Additionally, the growth medium additives could pose a human health issue. Different supplemental and chemical additives, such as dexamethasone, estrogen, and antimicrobials, may be added throughout the growth process. The rate and extent to which these additives are metabolized are unknown. Overall, continued research is necessary in order to make in vitro meat an equally safe and nutritious product.

Livelihoods and Economic Growth

Since the first in vitro meat ground meat patty was produced in 2013, the production costs of in vitro meat have steadily declined. Improvements in production efficiency are ultimately expected to reduce the projected retail cost. These production systems are more likely to be capital-intensive rather than land- or labor-intensive, so in vitro meat production will likely primarily succeed in developed nations with greater GDP. Adoption of this technology in developing nations is constrained by challenges regarding cost, sterilization maintenance, and climate impacts. The use of in vitro meat for conventional meat in developing countries may also lead to displacement and hunger, as livestock provide income, food, and capital to families. Downstream loss of livestock byproducts such as natural fertilizer, clothing, and pharmaceutical products may also be a consequence of reduced livestock production. Outside of the impact this new industry would play on the livelihoods of different communities, cultures present both challenges and opportunities in terms of the acceptance and integration of the products into the daily lives of their members. In considering communities with dietary restrictions like Halal or Kosher, this new protein source could be determined to be unacceptable leading to significant restrictions of the consumer base.

Conclusion

The ability to use cells taken from live animals instead of traditional slaughter practices could reduce the number of animals currently being slaughtered for meat production. The potential for in vitro meat may be honed by technological, societal, and environmental challenges. Despite in vitro meat’s contribution to the world’s available protein, lack of accessibility may diminish the impact of increased availability. There are health, ethical, economic, and environmental challenges that the in vitro meat industry must address before successfully commercializing these products. Implementation of this technology on an industrial scale will require serious development. There are many projections for the future of in vitro meat, but the future of this emerging technology remains undefined.

References

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