10.3.3. Cultured meat and milk

In the last few years an alternative to conventional animal production has appeared: meat and milk from cell cultures. The goal of the companies that are starting to produce cultured meat is to obtain for their products a similar appearance to conventional meat, so that they can be considered as an alternative to meat from farm animals.

At present it is not possible to predict how this industry will develop and whether cultured meat will widely be accepted by consumers, since the commercialization is just beginning and several production challenges need still to be adequately solved.

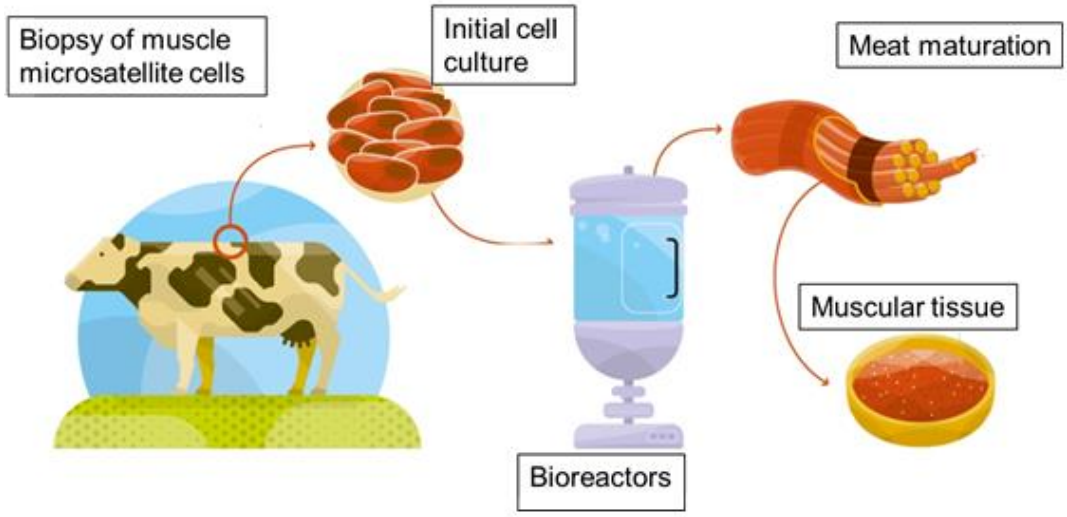

Figure 10.9. Process of cultured meat production. Adapted from Beefpoint (2022). https://www.beefpoint.com.br/carne-produzida-em-laboratorio-pode-estar-na-sua-mesa-nos-proximos-anos/

- ***How cultured meat is produced:*** The process starts with a biopsy of satellite muscle cells in live animals (Figure 10.9). These are the cells that reconstruct the muscle when it is hurt, they can proliferate rapidly in an adequate medium and they require little input to differentiate in skeletal myotubes. An initial culture is performed in regular culture dishes, then a seed train is used to expand from the initial 10,000 cells, through a series of bioreactors, until the culture has around 10,000 billion cells (10^{13}), enough to produce 1 ton of meat. Scaffolds of biomaterials serve to help differentiation and give a 3D structure to meat; collagen has been used for it, but polysaccharides are easier to obtain and add dietary fibre improving the nutritional quality of the cultured meat. (See Post et al., 2020 for a review of the process). Fat tissue culture follows a similar process from stem cells of adipocytes.

  For minced products, cultured meat is blended with cultured fat, flavorings, colorants and nutrients. The process for meat trying to reproduce natural meat is more complex because it needs the co-culture of muscle, fat another cells and the media for growing them is different, thus the co-culture is suboptimal.

- ***Advantages of cultured meat:***
  - *Good nutritional properties:* Fatty acids can be added to the adipocyte cultures, producing fat tissue rich in unsaturated and polyunsaturated fatty acids. Several nutrients can be added in order to produce “health meat” products.
  - *No need of antibiotics:* One of the major concerns of current animal production is the use of antibiotics, because of the growing number of cases in which some bacteria become resistant to them. Cultured meat needs not antibiotics.

- *Cultured meat and welfare:* Organizations for animal's defense prefer the use of this meat; for example, the Good Food Institute promote cultured meat and milk because that does not involve rearing and slaughtering animals. Cultured meat solves the problems related to animal welfare since no animals are used with the exception of the generation of the first cell cultures by biopsy.
- *Cultured meat and global warming:* In principle, cultured meat should have a much lower carbon footprint, be less contaminant and have a better use of land and water. However, assessment of carbon footprint and greenhouse emissions from cultured meat is nowadays highly speculative, because it is based on assumptions about the future development of an industry that is now starting, and on the use of more or less contaminant sources of energy. Energy is needed to maintain a warm temperature in bioreactors, and in the general process from cell culture to grounded meat tissue. Some authors (Lynch and Pierrehumbert, 2019) have developed computer models in which cell cultures were more contaminant than beef cattle in the very long term (their simulation extend up to 1,000 years). Their argument is that greenhouse effect from cell cultures comes from CO_2 when not clean energies are used for warming, but the greenhouse effect from beef cattle comes mainly from methane, which is removed from the air in 12 years, whereas CO_2 remains. However, these advantages start applying after 200 years, and it is difficult to guess which will be the state of technology at that time. Moreover, cultured meat can be produced using clean energies, whereas controlling livestock emissions is much more complex.

- ***Challenges for cultured meat:*** Cultured meat has arrived with the goal of competing with traditional meat from livestock. However, there are some challenges that should be solved before being able to seriously compete with common meat products.
  - *Technical limitations:* There are still technical challenges to be solved. Media for the cell culture is a major constraint. Nowadays it is often dependent on bovine fetal serum. It can be replaced by chemically defined components, such as proteins, growth factors, sugars and fatty acids (Van der Valk et al., 2010), and obtaining *serum-free media* is an intensive area of research.
  - *Meat quality:* At present there are not proper scientific studies on cultured meat quality compared with common meat. Cultured meat tries to be as similar as possible to common meat. This involves a complex tissue composition with muscle, fat and collagen among other ingredients. Moreover, muscle is transformed in meat through a complex biological process; muscular tissue has not the same properties as meat, although the process can be imitated. Processed meat can be a first solution for these difficulties, adding flavoring, texturizing and nutritional ingredients to the final product (see review on cultured meat quality by Fraeye et al., 2020), but the goal of producing cultured meat similar to meat from animal tissues is firmly established and it is the object of intense research of many labs and companies along the world.
  - *Cost of production*: Cultured meat is nowadays more expensive than common meat. As we are in the beginning of the industrialization process, it can be ventured that cultured meat could be in the future cheaper than its alternatives. If so, it can probably occupy a large sector of the market, particularly if its production is accessible in developing countries. One of the main reasons for eating more poultry or pork is their lower cost when compared to other alternatives.
  - *Problems in distribution:* If cultured meat has success, it will probably produce a reaction in the sector that may ask for removing the word "meat" from this product, in order to protect their market quota. Receiving a name different from meat will probably lead to offering just a new edible product, like "vegetable meat" or "soya milk". In this case, cultured meat will occupy a niche market that may be higher if its cost is lower than traditional meat and imitates common meat better than plant-based products.

- ***Cell cultured milk:*** Producing milk from cultured mammary epithelial cells from humans and dairy cattle is a new challenge that has recently been translated to the industry. The principles are the same as for cultured meat, but here the product comes from the secretion of the cells, so the process is not so complex. Besides, the additives are different; for example, the hormone prolactin is a main component of the media. Several companies are now starting their projects of cell cultured human milk and dairy milk.

- ***The role of genetics in cultured meat:*** At the moment of writing this book, there are few cell lines available for cultured meat, it is expensive to develop cell lines suitable for cultured meat production. Genetics can facilitate the task by introducing genes allowing the cultured cells faster biomass accumulation. A main challenge is to understand the role of genes in developing the cell culture. CRISPR editing techniques (section 10.1.2.A) will probably help in this process.

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