MEAT FROM LABORATORY-NOT A FANTASY ANYMORE

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Research on stem cells have bestowed us with new opportunities and potential applications in the field of regenerative medicine, basic science research, gene targeting, cloning and transgenic animal production etc to name a few. Its potential application in livestock production include enhanced reproductive performance, improved growth rate and feed utilization, improved carcass composition and increased disease resistance, improvement in milk and meat production and their composition. Recently it has opened up an exciting new window of opportunity- production of meat in invitro conditions. i.e. from lab itself!.

AN ALTERNATIVE TO CONVENTIONAL MEAT PRODUCTION.

In recent years, the notion of finding an alternative to meat production from livestock is gaining strength. Conventional meat production is getting more undesirable because of concerns about environment degradation, sustainability, public health and animal welfare. With increasing human population and rising living standards, especially in developing economies the demand for meat is expected to double by the middle of this century. This necessitates further intensification of livestock rearing for meat purpose. This scenario could worsen the threats posed by impending climate change. Livestock meat production accounts for considerable portion of green house gas emission, land usage, water and energy consumption. Of the three major green house gases specifically carbon dioxide, methane and nitrous oxide, the contribution of livestock to their total emission is 9%, 39% and 65% respectively (FAO 2006). Livestock is far less efficient in terms of converting feed to protein. Public concern about animal welfare is also on increase and it may affect the consumer behavior. Lastly public health concerns- diabetes, cardiovascular disease and colorectal cancer are associated with red meat consumption.

NOVELTY OF CULTURED MEAT.

One of the many alternatives under investigation is culturing meat based on stem cell technology. There is scope for novel products. Blends of meat from different sources could create hitherto unimaginable meat. Physio-biochemical composition of meat can be altered to make it healthier or specialized meat product. With cultured meat, meat production can be made more efficient because they can keep all the variables under control. There is no need to slaughter any livestock. Desirable factors (for eg- poly unsaturated fatty acids) could be increased in content. It might be appealing to vegetarians who are against slaughtering of animals for meat.

CURRENT STATUS OF CULTURED MEAT

Meat is nothing but skeletal muscles and associated mesenchymal tissues like bone, cartilage, fat and fibrous tissue. Stem cell technologies *viz*- isolation and characterization of stem cells, ex vivo culture of cells and tissue engineering, have enabled production of bio-artificial muscles (BAM) from skeletal muscle resident stem cells also called satellite cells. Currently they are primarily used as research tools and are far from convincing meat alternative. But they are found to be valuable protein source.

Stem cells of various types can be used for culture of meat. Most suitable is the Myoblast or satellite cells which are responsible for muscle regeneration after injury. Advantage with these cells is that once cultured into sufficient number of cells, these cells could readily differentiate into myotubules and myofibrils. Negative side with these cells is that it is difficult to maintain the cells in replicative state in cell culture until sufficient number of cells are obtained. To overcome this problem, embryonic stem cells or induced pluripotent stem cells could be used as alternatives. Other components of meat like fat tissue, bone and cartilage could be made from cell types like adult adipose derived stem cells, adult tissue derived stem cells which has shown propensity for differentiating into osteocytes, chondrocytes and mature adipocytes.

Advances in large scale culture of mammalian cells have become possible due to advances in cell media, incubators and serum production. Biggest challenge in skeletal muscle cell culture is optimizing various variables in cell culture and controlling the interaction between them. Large scale high throughput analysis should be set up to optimize culture conditions. As of now serum based media is considerably superior to synthetic media in cell culture but eventually serum based media could be completely replaced with synthetic media which is devoid of any serum products. Serum free culture using surface bound substrate adsorbed signaling molecules like vitronectin and laminin was found to aid differentiation into myotubules. There are two phases in culture of muscle cells from satellite cells- the proliferative phase and the differentiation phase. Main aim is to achieve maximum possible doubling of satellite cells before differentiation phase. Currently with available technology 20 doublings can be achieved. Biologic modulators have been designed to optimize proliferation and delay differentiation.

After getting sufficient number of cells, next step is their differentiation into skeletal muscle and coerce them to produce protein. A combination of mechanical, biochemical and metabolic stimuli appears to be having effect on inducing hypertrophy.

Tissue engineering using collagen or matrigel scaffolds were found to help to anchor most mesenchymal cells and also skeletal muscle cells and organize them to develop tension within fiber. This static tension boosts protein production and in addition with specific coatings electric current was also found to be a good agent that induces maturation of cells.

Application of these techniques has made generation of small BAMs feasible. Biggest challenge is creation of bigger BAMs with built in blood vessels or channels which could create continuous flow of nutrients and oxygen. With the development of technologies like bioprinting which could deposit cells and biomaterials into spatial orientation that simulate physiologically relevant geometries, there is hope that these challenges can be successfully dealt with.

WILL THE CULTURED MEAT BE APPETIZING?

Most people who are not onboard with the future of cultured meat doubt about the appetizingness of cultured meat. Contractile proteins comprise the bulk of skeletal muscles but other proteins are also there which are important for texture, color and taste of muscle tissue. Myoglobin is one such particularly important protein. It is haeme carrying protein particularly responsible for the pink color of meat and likely determines taste as well. The transcriptional regulators and activators of myoglobin have been identified and well understood. Contractile activation of muscle in hypoxia setting will maximally stimulate myoglobin production. It seems feasible to increase myoglobin content using stimuli that are compatible with tissue engineering of products that eventually should be consumed. With extension of research to other proteins which have some say in taste factor, meat mimic with acceptable taste is likely to be produced.

World noticed with awe when an artificial burger made of lab grown meat was unveiled recently by team led by Professor Mark Prost, scientist in Maastricht University, Netherlands. It was the culmination of research project of 5years. It was made from cow shoulder muscle stem cells and it did cost $ 3,00000. So definitely production of cultured meat in commercial scale further warrants refinement and extension of current technology and improving scalability. There is a long way to go and issues like scalability, quality control, prevention of disease/ contamination etc needs to be sorted out. But the concept and potential of cultured meat is never in doubt and in future one may not be surprised to see cultured meat being offered along with conventional meat in a supermarket and there won't be two minds in selecting the one with an element of environmental friendliness associated with it.

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