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The Future of Lab Fabricated Food in Securing Food Sustainability and its Practical Weightage in Commercial Kitchen

Moumita Bhaumik*

Abstract

Down the historical lane wars have been focused on control of precious resources like metals, minerals, oil, and land. This scenario has started to shift in the past few years, with armed conflict increasingly focused on control over depleting water resources and by association food. Climate change-linked droughts and growing world population is creating an imbalance in the food chain supply. Agricultural lands are decreasing, water availability is becoming scarce and due to increase in water pollution and over hunting sea food and cattle meat supply is steadily decreasing until a day when there will be none left for future generation. In addition to this according to statistics nearly one -third of the world's food produce is lost to wastage. A time has come when the eminent dignitaries of science and food world are stepping up to create a sustainable solution to meet the future food scarcity and stop food wastage by creating alternative solutions. This article is a study to understand the science, need, viability and realistic value of such innovative productions. It is also a study to understand, the acceptability of the new era food by the traditional in takers. It will reflect on the commercial value and acceptance of the same in commercial eateries.

Keywords: Lab Meat, Sustainable Food, Plant-Based Food, 3D Printed Food, Imitation Meat

INTRODUCTION

Growing opulence in combination with changes in food habits will mean that much of this demand will be for water concentrated food commodities such as meat, seafood, etc. According to statistics, production of cattle products has already overtaken cereals, and accounts for one-third of all agricultural outputs. Thus, growing prosperity will eventually lead to imbalance in nature – leaving those who live on less than 100 rupees a day unable to afford protein diets with requisite nutrients. If agriculture and food production continue its business in same direction, low income and vulnerable communities will likely only be able to access carbohydrates as staple.

Hence in reality to manoeuvre from a future of scarcity to a future of affluence – changes are needed in what we consider to be a food source. Plants and animals will be replaced by microbes, manipulated, and processed into food that imitates plant and animal foodstuffs in flavour and texture, but without slow growth.

The evolution has already begun as parts of the developed world adopt meat-like alternates to replace meat. These are grown using plant proteins and algae in industrial and laboratory setups, after a substantial amount of experimentation, and they taste so much like the originals.

Thus, for the sake of a future of abundance we need to understand the following futuristic food trends that may help to curb world food scarcity and create a regular healthy source of supply chain within affordable rights. The Following methods are a few emerging trends and scientific solutions towards creating sustainable food for future.

- Lab meat using microbes
- Plant based imitation food
- 3D printing of food

* Assistant Professor, Amity School of Hospitality, Amity University, Kolkata, West Bengal, India.
Email: moumita.rajput@gmail.com

Method 1: Lab Grown Meat using Microbes



Fig. 1: Image Taken from techquery.com

To meet the increasing demand for food by the growing human population, cultured meat also called in vitro, (Sghaier Chriki & Jean-Francois Hocquette, 2020) artificial, or lab-grown meat, is being produced as an alternative for consumers who want to be more pledged towards saving nature and humanity, however also wished to enjoy their meat. In August 2013, the first hamburger produced with cultured meat was prepared and tasted on a television program.

The purpose of this process is to recreate the complex structure of livestock muscles with a few cells. A biopsy is taken from a living animal. This piece of muscle will be cut to detach the stem cells, which can generate on its own, but can also transform as muscle cells and fat cells themselves. More than one trillion cells can be grown, and these cells naturally merge to form myotubes, the myotubes are then placed in a ring growing into a small piece of muscle tissue. This piece of muscle can multiply up to more than a trillion strands. These fibres are attached to a sponge-like scaffold that floods the fibres with nutrients and mechanically stretches them, to increase their size and protein content. Following this process, lesser cattle will be necessary to produce huge amounts of meat due to cell reproduction.

The main goals of the laboratory start-ups around the globe and working on cultured meat is to find a cheaper medium derived from plant ingredients and is as nutritive and edible, flavourful as animal cell-based reproduction. Once the researchers find a cost-effective method to produce vitro meat in large industrial scale, then lab meat could become competitive in terms of production costs, thus a lot of livestock can be spared from slaughtering for food.

Though the production of solid meat steaks are yet to be achieved, and is at a level of research at present, yet presence of burger patty, nuggets and other snack-based food items are already being sold in the commercial market.

Moreover, it has been suggested that the nutritional content of cultured meat can be controlled by adjusting fat composites used in the medium of production.

Method 2: Plant-Based Food



Fig. 2: Image Taken from sarakadeelite.com

As the term Suggests, meat which looks and tastes like real meat yet are actually made with plant protein are called so. Plant-based meat is produced directly from plants. Instead of depending on an animal meat, now plants can be converted into meat.

Like animal-based meat, (www.escofier.edu, 2021) plant-based meat is composed of protein, fat, vitamins, minerals, and water. The new era plant-based meat has appearance, flavour, texture, and taste like original meat products.

This includes plant-based meat, seafood, eggs, and dairy. This procedure focuses primarily on the science of plant-based meat and seafood.

The concept of plant-based meat is not a modern development. The popularity and variety of plant-based meat has slowly increased over years. Though initially plant-based meat products were designed with vegetarian consumers in mind. Initially, plant-based food did not concentrate on imitating the flavours of meat products,

however under recent circumstances when excess slaughtering of livestock is threatening a natural balance concern about sustainability is on the rise.

Thus recently concerns about sustainability, food security, and the environmental and public health impacts of industrial cattle farming for meat have triggered a sense of exigency to develop plant-based meats that appeal to a larger mainstream consumers rather than selected market of vegetarians only. This urgent situation an eruption of research launched by prominent brands during the last decade. Currently the plant-based meat options available in market now appeal to the fast-growing segment of experimental and new age consumers, who take health and balance seriously.

Animal body is essentially made of muscle tissue, whereas plants don't have muscles. Thus, the science behind the plants we see growing in a field become a piece of meat on our plate, that looks, smells, tastes, and cooks like real meat is a miracle.

Animal meat is simply made up of protein, fat, vitamins, minerals, and water. Though plants don't have muscles, they do contain protein, fat, vitamins, minerals, and water. Plant-based meat takes advantage of this biochemical similarity between plants and animals to convert plant into meat like food (www.gfi.org, Welch, 2018).

For every micronutrient functional compound in the animal species, we usually eat, we can look for a counterpart or replacement in the plant world. If a replacement is not found naturally, we can try to make it through mechanical, chemical, or biological treatment of a plant ingredient.

The rare dimensional structure of proteins in muscle tissue creates the unique texture of animal meat. Small dices or minced meat has a simpler texture since the tissues are broken down and is less complicated to replicate than larger pieces of animal meat like chicken breasts and pork chops which are made from intact muscle tissue. The dimensional arrangement of proteins in these whole-muscle variety of products is important for the texture. Thus, still there are many more struggles and research and technical challenges to overcome to bio mimic whole cuts of animal meat with plant ingredients.

Generally, there are three primary steps in producing plant-based meat (www.earth911.com, 2022). First the desired crop must be grown and harvested, next the plants are processed to get rid of the parts which are undesired. And then desired proteins, fats, and fibre ingredients will be derived, which will become the base of the plant-based meat product. Finally, these ingredients are amalgamated together then the mixture goes through a manufacturing process to create the muscle-like texture needed for meat.

No matter whether we are making plant-based burgers, meat kebabs, meat dumplings, or seafood preparation, the same generalised production steps will be followed.

At present the concentration is on crop development, ingredient optimization, and product formulation and manufacturing.

Consumers who really believe in their cause such as going healthy, saving nature, stop cruelty against animal are really trying their best to slowly increase plant-based diet and reduce animal meat consumption, however they are unable to give up completely on the taste satisfaction of consuming meat, egg, seafood. Despite the market for plant-based foods growing steadily, yet only a very small portion of the entire world population has completely moved towards plant-based food. Thus, there is a constant need to research and understand customer need, develop products accordingly. An aggressive drive and awareness campaign is also important for both sustaining existing customers' interest and driving in attention from new consumers, develop their interest, spread awareness.

And share importance and benefits of plant-based meat products. With proper financial, human, and technical support this could be the next generation supper food.

Method 3: 3D Printing of Food



Fig. 3: Image Taken from 3dnatives.com

The idea of food being printed for edible purpose would have sounded hilarious even a few years back, however with advance development in biotechnology, supported by superior quality machineries it is no more an unimaginable fete.

A three-dimensional (3D) printing, called additive manufacturing (AM) (Matec, 2018), established since 1980s, have been developed and applied in variety applications for many industries. Am creates model by adding material layer by layer from a computerized 3D solid model. An advantage of AM is to construct a complexity model without any mould and die, fixtures, cutting tools etc. The application of construction in AM model have been widely used in many fields of industry such as automotive, architecture, medical and fashion design and now food manufacturing is also applying this technology to fabricate food designs. And as discussed since a sustainable nutrition and food security are the global agenda and key themes, this is considered during, application of 3D food printing. There are several techniques to construct 3D food printing that are an extrusion-based printing, binder jetting and inkjet printing (Matec, 2018).

Though there are 3 different styles adopted in 3D food printing methods, but the most important guideline remains same for all, that is nutritive value of food can be controlled here by using the correct combination of ingredients and also a lot of food wastes can be reduced by reusing excess food material, waste parts of food to create new interesting products.

The 3D food printing technique has been classified into three categories that are an extrusion-based printing, binder jetting and inkjet printing, as shown in figure.

Extrusion-Based Printing

Extrusion is the name given to a specific 3D printing process where material is selectively dispensed through a nozzle or a small outlet. Extrusion is an "additive" technology commonly used for modelling, prototyping, and production applications. It creates an object by laying down material in layers; a plastic filament or metal wire, or food paste made from raw ingredients is unwound from a coil and supplies material to produce a part. The technology was developed by S. Scott crump in the late 1980s and was commercialized in 1990 (Matec, 2018).

This is a digitalised method in which 3D food structures are sculpted using designed shape, which is modelled using software or 3D scanner, this is also known as prototyping of food which can produce customised products regarding design, taste, and nutritive value.

As discussed before 3D printing is a method that is not only used in food industry but also fashion, engineering, and others. Thus, though the technique remains same the challenge in food industry the raw material to be used for food printing. The proportion of the ingredients as to be as such, which will have proper nutritive value, flavours taste yet be able to hold a proper shape after printing. Much research work is in process on the same. Researchers are not only concentrating the looks of the final product but also the content of it which will be desirable by the commercial customers. Extrusion based 3d food Printing is the most common among the three.

Inkjet Printing (IJP)

The inkjet printing dispenses a material stream of droplets from a thermal head to certain regions for creating the surface filling or decorating on food surfaces, such as cakes, pizza. This process generally operates by using thermal or piezoelectric heads. There are two types of inkjet printing methods: a continuous jet printing and a drop-on-demand printing. The inkjet printer normally handles low viscosity materials; therefore, it does not find application on the construction of complex food structure. Commonly deposited materials are chocolate, liquid dough, sugar icing, meat paste, cheese, jams, gels.

Binder Jetting

The binder jetting, which is an additive manufacturing technology, constructs model by using a binder to selectively bond layers of powders. (Matec, 2018) in this process, small droplets of binder are successively deposited on to the powder bed surface, which are a drop-on-demand print head based on scanning pattern. After deposition of the liquid binder, the entire surface of the powder bed is exposed to a fixed amount of heat.

These steps are repeated for each layer until the whole structure is completed. The binder must be suitably of low viscosity in which surface tension and ink density are suitable properties to prevent spreading from nozzles.

EXPECTED RESULT

Researchers from different start-ups are now working to create meat without using an animal to help meet future demands of meat consumers. Growing meat in a lab could cut down greenhouse gas emissions caused by animal harvesting to drop down to 78-96 per cent while using 99 per cent less land.

Greenhouse Emission Comparison Graph between Meat and Plant-Based Food Consumption

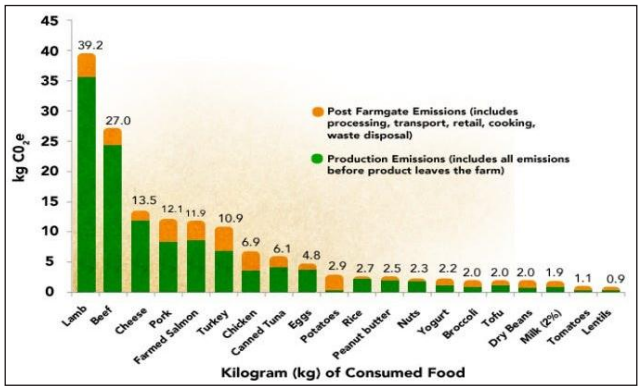


Fig 4: Image from Business insider.com

While the science can't yet create the texture of a fine steak, processed meat such as burgers, chicken nuggets and meatballs are getting good reviews and are increasingly becoming common on supermarket shelves.

Fast food chains are now adapting plant-based meat sandwiches and burgers and making them humongous in size to attract consumer attention. Weather its lab grown meat and fish, or plant based the resulting fact remains same that the opting for these new age fresh meat alternatives will give us a chance to live longer and protect our environment for the future. Thus, such initiatives, undertaken by start-up brands and researchers might eventually get more people prepared to accept meat alternatives when they are abundantly available at a much cheaper cost.

Using vegetable proteins, the meat" has been printed using a 3D printer. This technology also allows for customization of the ingredients to accommodate an individual's dietary needs. The most challenging part is to create a piece of meat that tastes, feels and looks like what consumers expect, and the results are getting better every day.

At present the researchers are focusing continuously on plant-friendly food made available at lowest cost possible for all and most especially concentrating on imitating meat and seafood to perfection including flavours, colour, texture and taste. The war is now about educating more people to reduce their consumption of meat due to animal welfare, health and environmental concerns and switch to plant based, or lab made meat, also control wastage by re using discarded ingredients through food 3D printing. The alternative proteins market is expected to grow by 25 per cent within coming five years (The Guardian, 2018).

Weightage of Sustainable Food in Commercial Kitchen

According to extensive market Research (www.marketandmarket.com 2022), the world market for mock meat and substitutes will grow from 7.9 billion US Dollar to 15.7 billion US dollars by 2027. The upcoming 5 years will experience a growth of nearly 14.7% CAGR (Compound Annual Growth Rate). Government bodies across the Globe are Promoting and propagating the benefits of consumption of meat alternatives, based from plants, or recycled food and even lab grown food, save the flora and fauna of earth. They are also streamlining the health benefits of such alternate superfoods.

Government bodies of various developed countries have also started investing in development of such food alternatives from research level to marketing and large scale production. Countries like US and Germany are already intricately involved into the production process of mock meat market to handle the rapid growth of health issues and environmental issues escalating the extinction of natural resources of the world.

Among the 3 methods mentioned previously for recreating meat without killing livestock the most popular process is plant based mock meats as it appeals to both the Vegetarian and non-vegetarian clientele. However the ingredients used commonly for deriving imitation meat are not equally popular among all segments. The most commonly used ingredients such as Soy protein, pea protein and wheat often leave an after taste and precise flavour of their own. Many customers do not prefer the musty flavour of soy protein. Thus, the fastest growing market of plant based mock food is that which is made from wheat as it is the most popular, cheap and easily available grain around the globe, this keeps the production cost lower and thus is

becoming highly popular among customers and are now being used commercially in Hotel and restaurant kitchens as well as easily accessible in departmental stores.

According to statistics collected from market research 2018, popularity of plant-based meat replacements sales grew ten times faster than all foods in 2018. At the same time while the sales of animal meat grew 2%, plant-based meats grew by an astounding 24%. Thus we can safely conclude that in the past 3 years health conscious and environment friendly customers are accepting and driving both lab and plant based meat and beverage products whole heartedly and paving a path for commercial use of meat alternatives for future.

Plant-based meat, dairy and egg replacements have already been and survived in the market for a while. Vegan cheese Brand like "Daiya" and plant-based eggs like "JUST" have been available commercially in the market for past years.

Though it will probably take another decade bring this revolution in full circle, however already the use of these plant proteins in commercial kitchens and continuous growth in demand is eventually and steadily bringing down the cost of production and making it possible to reach out to all and every household (Volpe, 2019).

Compared to plant-based products lab grown meat has a smaller market and is growing at a slower pace as the production cost is still quite high and the process is still under research and development. Though According to market researchers the growth in In vitro meat market will be nearly 33.75% CAGR by 2026 (www.knowledge-sourcing.com, 2022) which is produced in lab through cell culture, yet the major constraint comes from its high cost of production which makes it difficult to afford for common people. However many Lab restaurants around the globe are opening their doors to familiarise the concept of lab meat to common people and working continuously with various brands in making the production cost cheaper and thus easily available for all. The most popular propagation for use of Lab meat is to reduce cruelty against animals, reduce carbon print thus leading to a safer, cleaner and better earth. Slowly the concept is catching up and many brands such as Upside Foods, Future Meat Technologies, Mosa Meat, SuperMeat, Finless Foods, Impossible Foods Inc., New Wave Foods Inc., Integri Culture Inc., BioFood Systems, Higher Steaks, New Age Meats, Aleph Farms (www.knowledge-sourcing.com, 2022) are investing in large scale for research and development for making a commercially available product for all. Some of the recent developments in the commercial kitchen has been mentioned below:

"The Chicken," which opened its door in 2020 Tel Aviv Israel claims to be the first restaurant serving only lab grown chicken (also known as cultured or cell-based) the chicken meat is made from protein grown from cells in a bioreactor. The restaurant is situated next door to the production plant, which also allows the customers to witness the process of growing chicken in lab. The brand was founded by food tech Company SuperMeat, which started by dishing cost free food to their customers in exchange of valuable research feedback, which would help them to commercialise the product in large scale. The company says it has addressed the three key challenges in commercializing lab meat, which includes a "scalable manufacturing process, a clear path to cost parity with animal products and the production of high quality, nutritious, and tasty chicken products" (www.livelindly.co, 2020).

The Impossible Burger is now a featured item on the Burger King menu. It's served in trendy restaurants and found on over 9,000 restaurant menus (Volpe, 2019).

Finally the rapid growth of 3D printed food must be discussed to understand its immediate need and supply chain. According to research conducted, (www.expertmarketresearch.com, 2021) "the global 3D food printing market is driven by the spreading recognition among food innovators for the need to update food processing technology. Aided by hiking demand for personalised nutrient-based food items and growing commercial food industry, the market is expected to witness further growth in the forecast period of 2023-2028, growing at a CAGR of 18.2%." This technology not only helps to develop customised products but also helps solving a bigger issues such as food waste, by using pulp of ingredients, skin , husk and other parts of the plants to turn them into edible, food as well as cutlery crockery exacted to ones on desired designs. Though the printers are highly priced but they affordable by high end corporate commercial hotels and restaurant brands, who in the long are making a profitable bargain as food waste declines and maximum utilisation of ingredients can be done while pleasing the customers with innovative products and displays.

We can now safely proclaim that though some of the methods are still unaffordable for all and under research stage but with every passing day the popularity of these meat alternatives and food waste reuse methods are increasing with growing awareness and according to research in the upcoming five years there will an immense growth and revolutionary changes in the food chain of future human. Thus the weightage of sustainable meat alternatives are weighing heavier by each passing day, as more commercial food outlets are adopting these methods for future economical benefits, health benefits and also making their contribution towards social factors such as changing climatic conditions.

CONCLUSION

Environmental crisis threatens the very basis of our existence, as great tracts of cultivable land lose their fertility through erosion, compaction, and contamination. Mineral deposits, crucial for agriculture, are depleting fast. "the global land outlook report, published in September, found that productivity is already declining on 20% of the world's cropland". Other factors such as industrial fishing and rapid decrease in insect population due to use of pesticides, destruction of forest, climate change threatens "catastrophic pollination failures".

The near future seems, extremely grim and unimaginable even to feed world population for another 20 years. Thus, an urgent need to shift food habits to more unconventional, yet more responsible methods is the call of the day.

The current conventional method of food production is tearing the living world apart. Fishing and farming are, by far the biggest cause of destruction of natural resources and loss of the diversity and abundance of wildlife. Farming is a major cause of climate breakdown, river pollution and a major source of air pollution.

Everything we eat now from nature is costing us the destruction of environment.

But just as hope appeared to be evaporating, the new technologies popularly called lab food or farm free food create unimaginable possibilities to save both people and planet. Lab made food will allow us to hand back vast areas of land and sea to nature, permitting regeneration and healing of the environment on a massive scale. Lab made food are not only nutritional since its content can be controlled exactly according to the need of the human body but also free of chemicals and pesticides. This will not only enable us to return, the sea and land to nature but also give us time and opportunity to rebuild what's almost lost.

All said and done, eating habit inculcated over centuries cannot change with immediate effect however, since the present generation is running out of time we need to aggressively propagate, promote and practice the new food alternatives being prepared in the lab, both ourselves and teach the next generation from a very early stage in their life. At present more and more responsible food brands needs to come forward and invest in research work for production of safe and healthy lab made food, with more precise nutritive value, hygienic product, affordable pricing, and easy availability for all. If lab made "farm free" food must unwaveringly replace regular fresh available vegetable and meat, the cause has to be supported by the entire human society as one and a steady drive has to be made for the same to save life on earth.

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