Meat alternative gaining importance over traditional meat products: A review

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The whole world is the witness to, how environmental pressure is increase and the greenhouse effect is also a major concern because of the exponential increase of population. Considering all these reasons, humans become health conscious and also worried about the environment and also convince to adopt meat alternative instead of animal meat. Due to the current scenario, the market for artificial meat is at its peak. The concept of Meat analog is not new, it was followed by ancient times but it is now in the trend. Some examples of it are as follows: Plant-Based Meat Analogs, Cultured meat, Pulses, Algae, and Insects, etc. [1] This article mainly covers Plant-based meat analogs, cultured meat, Algae, and pulses

Keywords: meat alternative, artificial meat, meat analog, cultured meat

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Introduction

As today's world's population becomes more health-conscious and thinks about environmental sustainability, people use to adopt meat analog over traditional meat. Meat analog defines as the replacement of the main ingredients other than meat. Meat analog also referred to as a meat alternative, meat mimic, substituted meat, etc. [1] Meat consumption increase globally has both pros and cons: Meat is an important source of proteins and other nutrients so meat consumption is the increase per capita relate to increases in income of developing countries, however, on the other hand, meat production is responsible for environmental burden such as increasing pollution, reduce greenhouse gas emission, require a larger amount of livestock and agricultural freshwater. Other reasons to accept artificial meat are that traditional meat has a larger amount of fat, an increase in animal disease, etc.[2]

The advantages of eating meat analog are that it is a healthier choice in terms of fat content and protein and other nutrition is also in good amount, also reduce environmental pressure and also move towards environmental sustainability and also affect the economy. However, the development of a new product that satisfies the consumer’s requirement specifically to replace traditional meat is very challenging and also considers sensory properties and nutritional value before developing plant-based meat. [1] This review includes types of meat mimics and their examples, Ingredients used for manufacturing, the technology used for processing and it also include Texturized Vegetable Protein (TVP) as by applying this process, a variety of all-vegetable meat analogs can be prepared easily, having the texture, cooking and eating quality closely resembling the meat product being replicated. [3]

History of meat alternative

Meat replacement is a concept in which animal meat is replaced by plant-based meat, also known as artificial meat is not a new concept, and In the 1960s it was started, and as tradition soy protein was used as a major ingredient in meat analogs such as tofu and tempeh. (Fermented soybean cake) These products made by simple processing

Or fermentation techniques and consumed as traditional dishes for centuries.[1] Below process flow diagram of Tofu is given

![Diagram of Tofu production process]

Fig. 1: Production technology of Tofu (Adopted from Bakshi et al. 2013)

Types of meat analogs

In the current era many options available as a food alternative. It includes Plant-based meat alternatives, cultured meat, Pulses, Insects, Algae, etc. But this article mainly focused on Plant-based meat protein and cultured meat.

- Plant-Based Meat Analogs:

Definition of plant-based meat is as follows:

These products use plant-derived ingredients such as wheat gluten, soy protein concentrate, soy protein isolate, and pea-protein concentrate and they have same attribute to animal-derived meat and there is no significant difference in their appearance from their animal-based equivalents. Some of the techniques such as Extrusion, Spinning, and simple shear flow are used to texturize plant-based meat and to form microscopic and macroscopic fibers in plant-based meat, it must be unfolded, cross-linked and aligned. To solidify the structure of the product, heating cooling, drying or coagulation is applied after texturizing the product. [2]
As PBMA has a different chemical composition, their nutritional value also differs. They can enhance dietary fiber content in food as they have usually a positive effect. On the other hand, somehow exact replacement of meat by PBMA cause unbalanced amino-acid composition and create a deficiency of iron and vitamin B12 in diet and leads to a weak correlation between vitamin B12 in food and blood plasma. The available solution is the inclusion of grains and food supplements in the diet respectively. [2]

These products have good water binding capacity and rheological properties as it content high protein levels in their recipe. Although, non-proteinaceous ingredients plays also an important role in solidification, as hydrocolloids solidified through coagulation and not based on protein gelation. In current scenario, PBMA industries mainly develop their interest in development of sausages, burger patties and mince.[1]

Mycoprotein:

Mycoprotein can be used for production of plant based meat as it is grown from fungus and can give fibrous texture like meat to the final product. As mentioned above it contains high fibre, low in fat and also contain high-quality protein so it is poses an excellent pattern of amino acids.[1]

The mycoprotein which is filamentous fungus is grown under strictly controlled conditions in bioreactors, following by moulding unordered filamentous fungus such as forming, steaming and texturizing. In current time, commercial minced-type products made from mycoprotein are available such as chunks, sausages and burgers.[1]

Examples:

In U.S.A some of the food company launch their meat alternate products and gardened more public attention. For e.g. Impossible Foods with its Impossible Burger and Beyond Meat with the Beyond Burger have gaining much media attention by creating meat analogs that simulate the cooking properties, juiciness, and even the bleeding of ground beef as well as its taste and aroma.

01. The Impossible Burger after several years of R&D phase, determined that hemo-globin is a critical component of ground beef’s flavour, texture and performance. So that they sought out plant based source of heme, by finding it in soy root nodules, the company inserted snippet of the soy DNA that codes for heme into a standard yeast strain instead of harvesting soy roots. As of today, proprietary yeast in fermentation tanks produce red heme that tastes like blood. In addition to heme, the impossible burger contains mixture of texturized wheat protein, coconut oil, potato protein and other natural flavors and also adding a small amount of ingredients such as yeast extract, salt, soy protein isolate, xanthan gum and konjac gum.[4]

2. As the beyond burger covers the retail market, it is intended to be placed in meat case rather than in a store’s vegan section. The main ingredient in the burger is 20 grams of protein, which comprises of pea protein isolate, with added beet juice to mimic bleeding. Other ingredients in patties are as follows: vegetable oils, yeast extract, plant fibre, binders and natural flavours.[4]

3. Beyond Meat continued that successful journey by launching new plant- based product called as Beyond Sausage, which has primary ingredients such as pea, fava bean and rice protein to simulate unique texture of pork sausage. A little amount of beet juice contributes to meaty red colour, on the other hands coconut oil provide juiciness, as said by the company. The beyond sausage also wrapped in a 100% plant based casing made from algae. [4]

Developing appetizing right color is very critical in realistic meat analogs such as plant-based burgers as well as for analogs for pork, chicken and seafood. Caramel color can give the same color as meat but you have to be careful about concentration because at very low concentration you get a yellowy tone and concentration increases to get reddish tone and slightly higher from it, get a brown tone which perfect suits the meat analog.
01. Upton’s Naturals’ latest plant-based meat substitute known as “The Classic Burger” which contain of seitan, tofu and eggplant. There are different types of seitan is there and so it create somewhat realistic mouthfeel due to shift in texture when you bite into it. On other hand to break up dense texture of seitan they added tofu and eggplant to the formulation as eggplant provide lots of unique flavour, as it impart slightly more smoky taste.[4]

- Quorn meat alternatives are made up with mycoprotein, single cell protein derived from fungus Fusarium venenatum. As of today Quorn developer Marlow foods manufacturing mycoprotein in large tanks using large tanks using continuous fermentation process fed with with oxygenated water, glucose and other nutrients. Fifteen Quorn products are available in United States which also include three new refrigerated items: Meat free sausages, Meat-free chicken and Apple sausages. Quorn products has been criticized for being highly processed, not having enough vegan items and cause allergic reactions and digestive problems in some people.[4]

- Cultured meat:

Cultured meat also refer as In vitro which is obtained by collecting stem cells, followed by proliferating them with cell engineering. The meat is manufacture without process of raising livestock and this process is part of cellular agriculture. Alternate name are as follows: clean meat, In vitro meat, lab-grown meat etc.

In 2013, Mark Post invent this novel meat alternate without livestock and he was first in production of lab-grown burger.[2]

The very first process for manufacturing cultured meat is excised a small piece of tissue from living animals, done by a small biopsy giving by anaesthesia. From satellite cells culturing of skeletal muscle cell can done by proliferation and differentiation phase. In the nut shell, animal cells are first separated from tissues followed by developing into other new muscle tissue during Proliferation stage. In general, stem cells create new muscle tissue by its own until growth factors available as cells have self-renewing ability. The specific liquid media which contains some specific nutrients are used to culture the cells so as to provide required conditions for tissue growth. The 50 cell population was doubles in 7-8 weeks in proliferation process and it continuing in bioreactors till trillions cells are produced.[1]

When sufficient number of cells have been manufacture, the differentiation stage took place and when no growth factors are supplied in medium, the satellite cells differentiated. Subsequently, cells are submerged in a collagen gel with a central hub located in the middle of culture dish to form a donut-shaped muscle fibre of 1 mm diameter. Within only three weeks of harvested, the production of muscle fibre took place and to prepare 85 gm. of hamburger it required 10,000 muscle fibres. [1]

As cultured meat did not contain allergenic substance such as present in meat analog, so it can be safer than other types of meat analog products. In addition, by replacing saturated fatty acids with beneficial polyunsaturated fatty acids it can be made healthier. Moreover, this product also got public attention. [1]

Regulation of cultured meat was an issue, it is under novel food category, so it is regulated by European Food Safety Authority (EFSA). In the USA, it is co- regulated by the FOOD and Drug Administration (FDA) and U.S Department of Agriculture (USDA). [2]

In future, cultured meat require substantial Research and Development before launching in the market. The control of cell and tissue development, safe-guarding hygiene, scaling up of laboratory-condition production, finding a cheap and well-defined plant-based growth medium, growing more complex tissue etc. are challenges ahead. It also include development of product which is attractive in texture, colour, taste, safety, price and emotional resonance. So as to scientists are working on these issues.[1]

- Algae:

As discussed above plant
Based proteins are primarily extracted from dry vegetables plant materials like soy, wheat and beans, as far as more research and development take place, use of wet materials such as algae and leaves are in trend and they can be produced on land locations with large amount of water availability, on coastal locations or in algae park on sea. Algae have higher amount of protein and oil. In 1990s, for first time algae produce on industrial scale. In current time, algae mainly produce for biofuel, with major by product such as cell wall material and proteins. In ancient time, several species of algae are consumed in Japan, Korea and Scotland. [2]

Algae is promise source of fish feed, biofuel and for human consumption. As their strong cell walls cannot be digested by human so as to protein from cell wall need to be extracted which is still challenging as technical part and is under investigation. [2]

Algae production for food and feed is pioneered by a small number of companies of various sizes (e.g. Roquette). Experimental algae parks are testing optimal conditions for growth and yield. As extraction of protein from cells is difficult, algae production is not yet viable alternate protein source. Other obstacles include consumer responses to a green protein product caused by presence of chlorophyll; de-greening is also technological challenge. [2]

As more complexes are in the production of algae, In future, production of algae probably more efficient at larger scales, which implies complex organisation and planning and also require a nitrogen source. Waste water should use as economic source for nitrogen but it involves hazards in open systems such as algae parks on sea. The strong cell walls require more processing for e.g. with enzymes, to render available proteins. Also, in harvested products dry matter content need to be increased. Consequently, energy requirements are also high for these processing steps so as it might limit potential sustainability of this pathway. [2]

Texturized Vegetable Protein:
This is a process for the production of a low cholesterol all-vegetable meat analog

From texturized vegetable protein (TVP) resembling a natural meat product in appearance, texture, flavor, cooking characteristics, and eating qualities. In the given method, an alkaline protein solution is prepared which is extruded through spinnerets into an acidic coagulating bath which causes precipitation into a filament form. These filaments are assembled into a meat analog by use of binding materials.[3]

The process is described by forming a solution of protein and followed by precipitation under agitation at elevated temperature by lowering the pH of the solution to about 6.0. As result, get precipitate and then it may mixed with a binder and stirred into a uniform piece which can be shaped into any desired form, such as strands. The resultant strands are autoclaved to give rise to the chewy protein mass.

By employing the given process of the present invention, a variety of all-vegetable meat analogs can be prepared easily, having the texture, cooking and eating quality closely resembling the meat product being simulated. In the specification and claims, the term “texturized vegetable protein (TVP)” is intended to include a defatted product which can be prepared from soy flour, soy protein concentrate, soy protein isolate or the like that may optionally be mixed with starch and/or wheat gluten, and which has texture imparted by a thermoplastic extrusion process under conditions of high temperature and high pressure generated from an extruder. [3]

According to the process of TVP, a wide variety of products may be made with a relatively simple process. For example, all-vegetable meat analogs which resemble hamburger patties, meat loaves, hams, and sausages, as well as cooked meat blocks of mammals, fowl, or fish are prepared easily. [5]

Processing technology using for meat alternatives

Different Processing technologies used for plant-based meat alternatives to achieve organoleptic properties as approx. same to animal meat which includes extrusion technology, and shear cell technology.

Extrusion Technology:
High moisture extrusion technology should use to create plant-based meat. In which protein
Undergo thermal and mechanical stresses by heating of barrel and shearing of screws. In the end, as a result, the protein structure is altered and which is leading to the formation of soluble and/or insoluble aggregates. To aligned protein in flow direction, attach a long cooling die to the end of the extruder.[6]

Shear cell technology:

High temperature and shear-induced structure formation of protein mixture can also be achieved by the high-temperature conical shear cells. Wageningen University developed a larger-scale Couette shear device based on the concentric cylinder rheometer concept. The sample material is placed in shearing zone space between the two cylinders; both inner and outer cylinders are heated by means of steam and cooled by air and/or water. Advantages of new technology are the production of larger pieces of fibrous meat analogs with simple, mild, and cost-effective technology. [4]

Conclusion

In the nutshell, as more people move towards meat alternatives because of environmental burden and health issues, the market of meat analogs grown up day by day. Artificial meat such as Plant-Based Meat Products, cultured meat, Algae, Pulses, insects, and Texturized Vegetable Protein is now in the market but as innovation take place in the future more products will come into the market and more research are required in this field to replicate the meat as meat alternative including properties such as texture, color, flavor and also emotional resonance.

Reference


