Review article

Plant based meat products: A sustainable, promising alternative to conventional red meat

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ABSTRACT

The demand of the red meat is continuously increasing leading to biodiversity damage and pollution. To overcome this, plant-based meat offers a promising option due to its organoleptic qualities that resembles closely to those of an animal-based meat product. There are a variety of plant protein sources that can be used as an alternative to meat products. Plant-based diets are affordable and have several health benefits like it regulates blood pressure, diabetes, cardiovascular disease risk and lower mortality. The popularity of plant-based meat substitutes has increased because of their credibility as functional and healthy alternatives. In addition to providing a similar nutritional value, the creation of animal meat analogues is focused on altering the physical features of meat products to increase the sustainability of these products through appropriate sensory attributes. The composition of meat alternatives is influenced by the dosage and functioning of plant proteins. It is proven that meat alternatives contain 30% of protein and a low level of fat which is a fantastic substitute for meat from a nutritional standpoint. The physicochemical characteristics of the meat alternatives are manipulated by functional plant protein. In the present review, we have discussed various types of plant-based meats available, their physicochemical properties, environmental impact of animal-based meat and future prospective to increase demand and business of plant-based meat.

Keywords: Plant protein; sustainable; alternative meat protein; meat substitutes.

INTRODUCTION

A daily diet should include meat since it provides critical nutrients for the body, such as protein, lipids, vitamins and minerals etc. The global meat market expands by 7.35% yearly during 2020-2025. Since consumer attitudes regarding meat are constantly changing, trends in meat consumption are unpredictable. Cost, appearance, suitability, quality and well-being, as well as public, personal, economical, and cultural issues can influence customer choice. However, consumers are considering consumption of plant-based meat products as a more safe, healthy and environment friendly choice over red meat (1).

The popularity of plant-based meat substitutes has increased because of their credibility as functional and healthy alternatives. The creation of meat analogues is focused on altering the physical features to increase the sustainability of these products by building appropriate sensory attributes, to provide a similar nutritional value. Products made using plant-derived elements that have characteristics like those found in meat from animals and cannot be distinguished from their meat-based counterparts are considered to be plant-based meat (2). Plant-based meat has organoleptic qualities that meet up nearby to those of an animal-based meat product (3). For obtaining meat-like texture, plant- proteins must have micro and macro-fibrous structure and must be aligned, cross-linked, and unfolded. Techniques like extrusion, spinning and simple shear flow for texturized plant-based meat have been used (2).

Although there is nutritional advantage of eating animal originated meat, it is also associated with health risk viz., high-level cholesterol and saturated fatty acid substance (4). It may also cause pathogenic infection of zoonotic origins. Furthermore, the production and consumption of large amounts of red meat could damage biodiversity, environment, pollute water and emit greenhouse gases. According to reports, plant-based diets are affordable and they lower mortality, blood pressure, diabetes and cardiovascular disease risk (5). Plant-based meat analogues can be a better source of daily protein requirements, and a healthier and more sustainable option (6). Despite the negative consequences, the increase in global consumption of animal products reveals the fact that consumer choices towards food are not driven mainly by debates regarding the ethical or environmental issues. Somewhat taste, health, availability, and cost are the main reasons for food selection. To overcome these limitations, plant-based meat products are proving a promising alternative (7).

Current issues about red meat

Red meat is produced by raising animals for slaughter and is becoming challenging due to three reasons 1. Environment - producing meat from animals harms the natural environment, 2. Human well-being- red meat eating is linked to several health hazards, 3.

Ethical issues- animals raised for slaughter are frequently subjected to cruel treatment (8). According to a new United Nations report, the world population is projected to reach 9.8 billion in 2050, and 11.2 billion in 2100, the amount of meat we currently produce will need to be at least doubled. Both population expansion and the economic progress of developing nations are blamed for the sharp rise in the demand for meat on a global scale. In the past, industrialising livestock husbandry allowed for the fulfilment of the rising demand for meat and its by-products (9). It is not possible to increase the production of animal meat to meet further demands because of scarcity of native land and water for livestock farming, the quick rise in concerns about animal welfare, the unfavourable influence on the ecosystem, and the change in the resulting climate. There is a need to increase the generation of plant-based meat as a protein source due to the gap between anticipated demand and the current availability of meat (10).

Plant-based meat products currently available in market

Tofu

The most well-known meat substitute is probably tofu, which is made from soybeans and is a great source of proteins and microelements such as calcium and iron. Typically, it comes in a block shape. Early studies on the protein content of soybeans showed that it can serve as an alternate source of protein for humans. The increased nutritional value of soybean is attributed to the high isoflavone content of the crop. Soyabean is rich in aglycone, glycoside, malonyl glucoside, and acetyl glycoside. Daidzein, genistein, and glycitein are the three primary isoflavones found in soybeans (11).

Tempeh

Tempeh is popular as an alternative to animal meat and commonly referred to as "mock meat" in the western countries because it is solid and can be moulded into patties. It is a fermented food produced from tempered soybeans that has been soaked and baked. Similarly, in sourdough bread, the cooked beans are mixed with a starter ingredient (*Rhizopus oligosporus*). After mixing and incubating overnight, the product becomes hard with chewy texture, like a mushroom texture with nutty flavour. It possesses the required qualities of a primary food since it is higher in protein, fibre, and other nutrients like Vitamin B12 (11).

Soy meat/ textured vegetable protein

Asian nations are the main producers of soy-based meat or textured vegetable protein. Despite the tedious production process, the finished product has a fibrous quality that is quite reminiscent of meat. Many diverse flavours can be produced using various seasonings. Over 50% of soy meat is made up of protein, however, when rehydration of vegetable protein takes place, the amount of protein decreases. The vegetable protein has increased in texture and quality during the past 40 years. Defatted soy proteins are being hot extruded to produce the textured vegetable protein, which is then formed into enlarged, high-protein nuggets, grains, chunks, strips, and other shapes.

Textured vegetable proteins have similar physical properties like meat due to denatured proteins in it. Vegetable protein with a fibrous, insoluble, porous structure can absorb many times its weight in liquids. The vegetable protein of this texture can be eaten on its own or combined with other ingredients to make meat substitutes. The fundamental distinction between meat extenders and meat analogues lies in their reliance on raw materials for the process of extruder texturing. Meat extenders refer to substances used to augment meat products, whereas meat analogues are designed to mimic meat but are not identical in appearance, texture, or sensory attributes. These textured goods are combined with meat substitutes for enhancing their sensory qualities. However, when hydrated and cooked, meat analogues remarkably look like the meat in appearance, texture, flavour and colour (12).

Seitan

Another vegetarian alternative to meat is seitan, often called wheat meat or wheat gluten. They are manufactured by repeatedly washing dough made of wheat flour until it becomes chewy in mass, or proteinaceous gluten is created. Although those with gluten sensitivities shunned the product, seitan is a chewy and tasty meat substitute that is a great choice for a population without sensitivity. Seitan-based meat alternatives, such as vegetarian burgers, sausages, and nuggets, are regarded as being the least expensive because they are made from basic ingredients (12). Products manufactured of seitan are simple to handle and can be seasoned and processed in a variety of ways. Since, wheat is very familiar to most nations worldwide; seitan production is feasible on a global scale. Seitan's consistency is very comparable to the chewy fibres that ensure homogeneity in meat (13).

Sufu

Sufu is a derivative of fermented soybean curd, having characteristics comparable to cheese in terms of its versatile applicability. It shows a diverse array of flavours, having a mild and creamy texture. Sufu is a fermented soybean curd by mould that may be used in the same ways as cheese. It has a wide range of flavours and is mild and creamy. It is a native and popular food of China, and the mould-fermented variety is the most extensively consumed. Chinese bean cakes and fermented tofu are some other names for Sufu. During its preparation, soybeans are normally washed, soaked, and then ground in a 10:1 water-to-dry bean ratio the next day. A cotton bag is

used to filter the hot mass after the ground mass has boiled for around 2 minutes. For the curdling process, magnesium and calcium salts are used (12).

Nuggets, patties and burgers

The goal of plant-based meat that resembles pulverised and bound flesh from animals is to replicate their distinctive firmness, bite, succulence, and chewiness. Nuggets, patties, and burgers made from animal products are mostly composed of proteins and fats, with smaller amounts of salt and binding agents (such as fibres, starches and wheat crumbs). The structure of proteins has been altered by salt and hardened products, though in lower amounts (14). A product's texture and appearance are improved by binders, which also help to retain water and fat. The recipes of the comparable animal products are closely mirrored in plant-based minced goods (15). Majorly the protein ingredients are initially transformed into textured vegetable protein (TVP), a fibre composition resembling grounded meat, before being blended with the remaining components to create the final formulation (14,16).

Physicochemical characteristics of plant-based meat

Appealing to customers who typically eat animal-based meat, its analogues must resemble the same smell, flavour, appearance, and texture. By comparing the efficacy of the soy-based protein isolate and rice-based protein isolate to formulate the meat analogues, it was found that the mixture of both proteins' isolates developed the meat analogues' ability to absorb water, their penetrability, and specific energy (17). Textured vegetable proteins, the most important component of meat analogue formulation, mimic the fibrous structure of meat muscle. In another study, it was shown that combining soy protein isolate increased the finishing product's chewability and hardness while utilising total wheat gluten to create meat analogues results in poor chewiness (18).

The physicochemical characteristics of plant-based meat alternatives are manipulated by the dosage and functioning of plant-based proteins. Numerous studies have looked into how various plant proteins can alter the functional characteristics of meat substitutes. Some physicochemical characteristics of plant-based meat products like tofu, tempeh, soy meat, seitan and Sufu are given below in Fig.1.

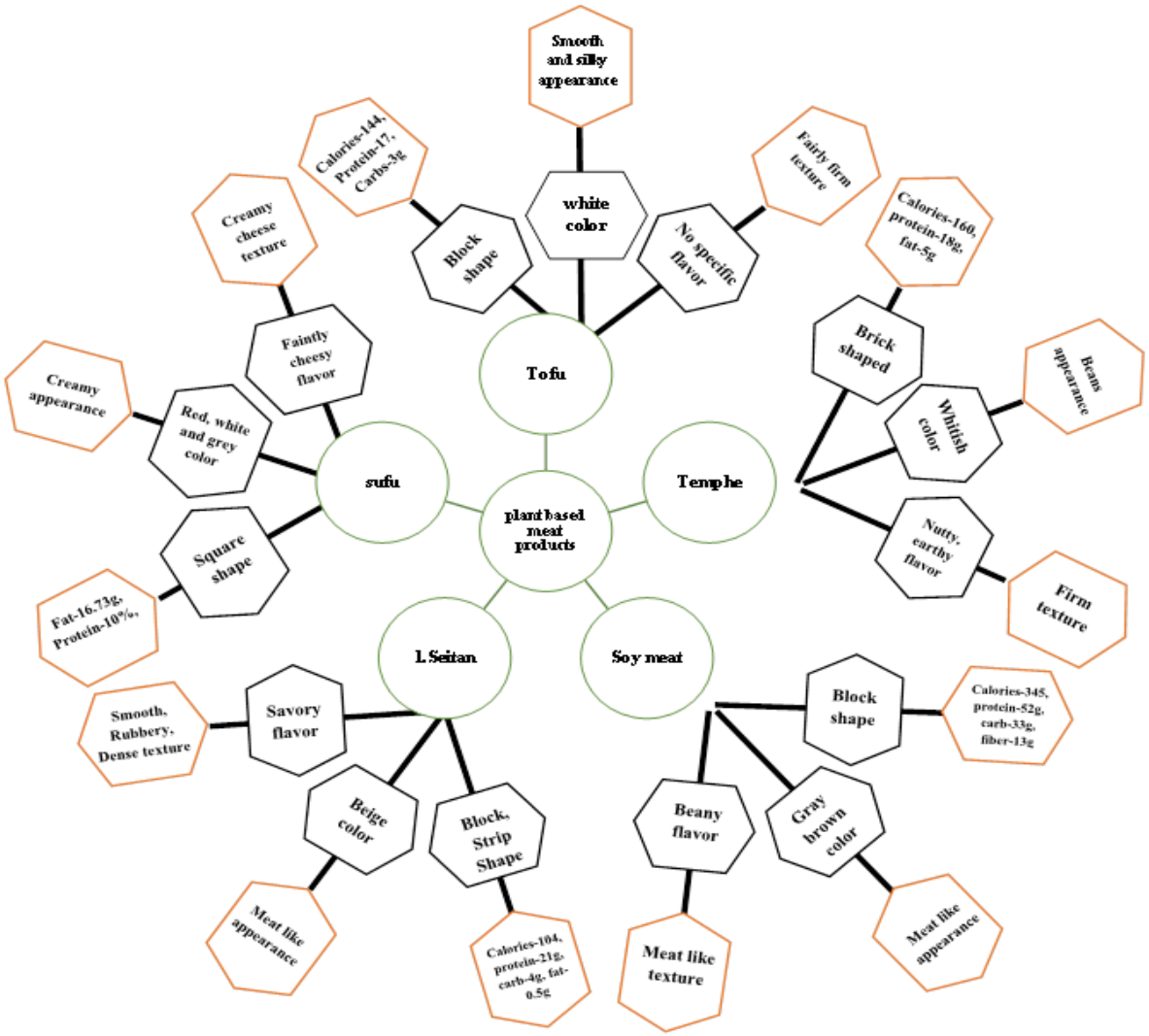

Fig.1: Physiochemical characters of plant-based meat products

Vegan product formulations

Meat is an essential component of human food intake; therefore, vegetarians also eat meat substitutes to fulfil protein needs. Humans always have different nutritional requirements depending on food availability, location, and climatic circumstances (19). However, for reasons of health, environment, and culture that are getting support in food marketplaces all over the world, plant-based meat substitutes are replacing animal meat as a resource of protein. Mycoprotein, legumes, grains, soy, colouring agent, flavours, and additional additives are the main components of meat analogues (20). These plant-based meat alternatives are products of edible vegetable protein mixed with minor ingredients or chemicals (21). Plant based meat formulations are created by fusion of plant protein with minor ingredients which mimic sensory, structural and textural properties as consumable meats(21). These vegan products with sensory properties mimicking meat can be created by several special technologies, with extrusion being the most widely used method (3).

Palatability and nutritional value of a vegan meat product also varies with the source of plant protein. The techniques used during formulation are focused on the creation of fibrous structures via altering moisture content during the extrusion process. Meat alternatives prepared high moisture extrusion having well defined fibre structure and enhanced sensory properties (22). Meat analogues having similar appearance to real meat can be obtained by mimicking colour. However, most plant-based protein ingredients, such as gluten and soy, are originally yellow or beige in nature (23). Meat like appearance can be obtained by adding colouring agents. However, these colouring agents or precursors should be able to withstand high cooking temperature and harsh pH of the cooking medium. These colouring agents could be mixed with the plant protein during their structuring or with the semi-structured plant protein. Reducing sugars can also be used as colouring agents because they produce brown colour after heating. Although lots of colouring agents are available these days still, there is a need for further research to produce superior quality colouring products so that appearances of meat alternatives can be further improved.

Benefits of plant-based meat over traditional meat

Nutritional and health aspects

The main nutritional benefit of meat is to provide top-notch protein. Therefore, to replace conventional meat with a plant-based meat, it should meet nutritional content comparable to the animal-based meat. It is proven that meat alternatives contain 30% of protein and a low level of fat, therefore, these can be a fantastic substitute for meat from a nutritional standpoint. Meat substitutes also have a lot of potential in terms of the advantages to public health (23).

The biological value of meat proteins is very high, and they also contain a good amount of minerals and vitamins but high-fat content in meat doesn't allow it to be recommended. Additionally, meat has more saturated fatty acids and cholesterol. Saturated fat in meat causes blockage of the arteries, which causes cardiac arrest (24). The benefits of plant-based meat for health include lowering the risk of obesity-related metabolic dysfunction, cardiovascular disease, and cancer while maintaining immunological and anti-cancer function. Thus, enhancing clinical indicators in Type 2 diabetes results in better weight maintenance and loss (25).

Environmental features of plant meat alternatives

There is a harmony that using either plant-based meat products instead of regular beef has good environmental consequences. Traditional meat production utilises a lot of water and land and generates and releases a lot of greenhouse gases. Most assessments indicate that plant-based meat products emit less greenhouse gases and require significantly less land and water to produce (26). The ability to produce meat alternatives closer to consumer markets also has the indirect benefit of lowering the adverse environmental effects. Taking this into account, environmental benefits of transitioning to plant-based meat alternatives might not universally align as indicated (27). While the primary concept of shifting away from conventional meat production holds advantages, the secondary concern arises from the need to prioritize plant-based meat substitutes with proven high sustainability potential. This entails addressing issues related to farming, system development, managing expectations about transformative impacts, financial-technology innovation, and optimizing the technological production systems involved in the process (28).

An environmental disaster known as a greenhouse gas is caused by the food industry, which is contributing up to 30% of greenhouse gas emissions. In general, animals produce many gases like greenhouse gases, including 9% of CO_2, 39% of CH_4, and 65% of N_2O. Nowadays, consumer awareness has significantly increased and are more attracted towards safe food without environmental pollution (26).

According to total soy and grain output, around 40% of whole grains and 75% of soy are used as animal fodder. Approximately 70% of the planet's total arable land, or 30% of the total amount of land, is used for animal production. A major contributor to the destruction of forests and other vegetation is the vast production and development of cattle, which had a significant impact on the earth's finite natural resources (23). Thus, meat substitutes are viewed as the finest options to limit the overpopulation of cattle

and provide meat products that are kind to the environment and the planet's natural resources (29).

Future prospects

The improvement of the health and nutritional properties, cost, and sensory characteristics of plant-based meat substitutes to animal meat should be the leading research goal in the future. Long-term customer acceptance will indeed be fostered by further improvements to these product features, which are doable with a small research investment. Priority should be given to the creation of new components and administrating techniques that will make plant-based meat substitutes more delectable, affordable, and beneficial for consumers (7).

The current methods for producing meat have several limitations; therefore, new technology and strategies are needed to develop to enhance production levels further. There are very few types of traditional and conventional meat alternatives available in the marketplace (20). As the need for meat is increasing, the number of resources available declining and the monitored environment is likewise changing, animal-based meat is becoming more expensive (12).

Although plant-based meat alternatives seem to fall extra into the "niche" class, alternate proteins have generally evolved from a speciality item to a widespread experience. Future demand for plant-based meat is continuously increasing evidently, especially in India and China (30). Enthusiasm and demand of plant-based meat in other geographical areas including South Africa, North America and Europe is also increasing. Asia-Pacific area may offer the greatest prospects, the most developed market for alternative proteins (31). The market in this area is driven by expanding protein consumption, rising incomes, and population expansion. Since the higher performance of plant-based diets is mostly the product of a fictitious large-scale adoption, the speculative nature of the estimates must be considered (32).

CONCLUSION

A daily diet should include protein, lipids, vitamins, and minerals etc. which can be fulfilled by meat-based food products. However, consumers always prefer safe, healthy and affordable options for the same. High intake of conventional meat may have negative effects on people due to high-level cholesterol, saturated fatty acid substance, chance of zoonotic infections etc. The production and consumption of large amounts of red meat could damage biodiversity, cause pollution and is also associated with ethical issues. Therefore, this red meat related issues can be addressed by promoting consumption with plant-based meat products. According to reports, plant-based diets propose several benefits such as affordable price and lower mortality, regulates blood pressure, diabetes, and cardiovascular disease risk. The popularity of plant-based meat substitutes has increased because of their credibility as functional and healthy alternatives with reasonable cost. However, as discussed earlier, to achieve meat-like texture plant-based meat should form micro and macroscopic fibres, which must be aligned, cross-linked and unfolded. It should also possess similar taste and appearance which can be achieved by various techniques like extrusion, spinning and simple shear. In depth research is needed to develop more and more plant-based meat products which can serve an increasing population of the world.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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