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A review on plant-based meat: An ecofriendly futuristic approach in food industry

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Abstract

A meat analogue, also known as a meat substitute or replica of meat, is a substance that closely resembles the visual and chemical properties of various types of meat. Animal diseases, a global shortage of animal protein, high demand for healthy food, and economic factors have all contributed to an increase in the usage of vegetable proteins in food products in time. A meat-based diet uses substantially more natural resources per calorie than a grain-based diet, requiring 2 to 15 kilograms of plant foods to produce 1 kilogram of meat. Creating new food products that will be gaining attention. Concerns about the environment, human health, and animal welfare have all influenced the development of Plant-based meat alternatives. Improvements in overall appearance and flavour, biological and chemical safety control, and the selection of protein sources are all critical for Plant-based meat alternatives manufacturing. Consumer acceptance of Plant-based meat alternatives is still modest, but it is improving all the time. Future research opportunities based on this knowledge include developing more effective consumer education strategies, providing more scientific evidence for Plant-based meat alternatives health properties, and finding more suitable protein sources to improve end-product quality.

Keywords: Plant based meat, meat analogue, meat, plant protein, health benefits

Introduction

Meat consumption has increased over the world due to the rising global human population and changes in food preferences. Meat is always considered as an important part of diet due to its rich nutritional composition. Excess utilization of land resources, higher risk of livestock diseases, harmful influence on aquatic and terrestrial diversity, greenhouse gas emissions and other environmental difficulties are all issues related to meat production (González *et al.*, 2020) ^[10].

Furthermore, consuming animal-based meat exposes individuals to zoonosis, veterinary antibiotic exposure, and deadly diseases like colorectal cancer and cardiovascular disease. The enormous change in cattle feed has resulted in a shift in food culture toward sustainable consumable human food (Machovina *et al.*, 2015) ^[17]. Such issues have shifted the point of interest of human beings from animal-based meat to plant-based meat because of health concerns, environmental sustainability and animal welfare.

Consumer demand for meat substitutes is growing day by day as lifestyles change, and plant meat has emerged as one of the greatest options for customers. Plant meat, also known as vegetarian meat, or meat analogue, is a meat substitute that contains meat-like components obtained from plant sources and has the taste, texture, flavour, and appearance of animal meat. Plant meat is a rapidly expanding business that caters to vegetarians, and vegans who want to consume less meat for health reasons, as well as those who follow religious food preferences. Many non-vegetarian consumers are switching to a plant-based diet for a variety of reasons, including animal welfare, environmental concerns, and general health concerns. (Anand *et al.*, 2015) ^[1].

The benefits of a plant-based diet include healthy weight management. According to research People who consume plant-based diets had a lower BMI and lower risks of overweight, hypertension and cardiovascular disease than those who consume meat. Fruit and vegetable-based diets are good sources of fiber, complex carbs, and water content. The presence of a large amount of essential components such as vitamins, micronutrients, macronutrients, cholesterol, and blood pressure control, a positive contribution to animal welfare organisations psychological effect (Grant and John 2017) ^[37].

In the United States and Australia, meat Products have the highest demand and have the highest annual meat consumption.

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Approximately in 2018, 320 tonnes of meat was consumed worldwide (Whitnall and Pitts, 2019) and it is predicted that by 2027 the market will expand up to 15% (OECD/FAO, 2018). Meanwhile, in recent years, the inadequacies of meat production compared to crop harvesting, as well as the adverse health effects of meat consumption, have become a source of concern. As a result of these growing concerns, the food industry is exploring ways to deliver meat replacements made from non-animal proteins to consumer markets that have similar appearances, mouthfeel and odours to traditional meat (Hocquette, 2016) ^[14].

The food research community is now focusing on two types of meat analogues: cultured meats also known as clean meat or *in vitro* meat and plant-based meat, which is made up of proteins taken from plants and structured appropriately (Joshi and Kumar, 2015) ^[15].

Meat analogues

A meat analogue is a meat substitute that mimics the meat that closely resembles the appearance and chemical properties of specific types of meat. These are created using non-animal protein and have a similar appearance and aroma to that of meat. Meat analogues are one of the methods which are suitable for introducing vegetable proteins including unconventional proteins and the underlying motivation remains the use of a broader range of proteins in human food. Plant-based protein foods have long been used as substitutes for animal-based protein sources. In terms of all nine amino acids, plant protein offers more minerals and fibres, but not all essential amino acids. As a result, the nutritional value of food is the most important factor in deciding on a human diet. Plant-based proteins are significantly healthier than meat-based proteins since they include more nutrients per calorie. Fruits, vegetables, grains, legumes, nuts, seeds, and any food product made from these ingredients are considered vegetarian products. Certain plants, when compared to animal products, plant protein intake, have a lower calorific value and have less negative effects (Kumar *et al.*, 2017) ^[16].

Physical properties of plant-based meat

Colour

Colour is generally the first attribute that people notice about food products, therefore it has a big role in the people's experience for acceptance of food products over the other physical properties. Uncooked fresh meat usually has a red colour due to the presence of myoglobin, a protein that is responsible for the majority of the red color in the meat that turns brown when cooked because during cooking myoglobin breaks down resulting in brown color meat.

Meat analogues have a realistic appearance by replicating both the initial colour and colour changes that occur during cooking. Most plant-based protein components, including gluten and soy, are typically yellow in their natural state (Kyriakopoulou *et al.*, 2019) ^[33]. By utilizing coloring additives or adding precursor components, the overall browning process of meat was mimicked. Heat stable coloring additives including such as caramel colours and malt extracts can give the end product a brown color (Malav *et al.*, 2015) ^[18]. The red colour of raw products has been produced in the new version of Plant based meat alternative by adding beetroot juice powder or soy leghemoglobin. Soy leghemoglobin is a genetically modified "heme". Impossible Foods uses heme as a colour enhancer to make its plant-based burger appears to "bleed" like meat (Bohrer, 2019) ^[28].

Flavour

Another critical factor that affects product acceptance is the flavour of the food. Flavor formation is more complicated than colour formation, and flavoring ingredients are separated into volatile and non-volatile substances, which are related to aroma and taste, respectively. The umami flavor of meat comes from the availability of monosodium glutamate and inosine monophosphate, as well as other minor organic acids. To replicate meat-like flavours, vegetarian substances such as hydrolyzed vegetable protein, yeast extract, spices and some vegetable oils have been used in meat analogues (Kim, Yang, and Chung, 2017) ^[29].

Texture

Food products produced from edible sources of protein that have structural stability and identifiable texture are known as textured vegetable proteins. Textured vegetable proteins are flour-like materials that have been transformed into a meat-like texture. The textured vegetable protein product outcomes have a chewy and fibrous texture. The most common materials for textured vegetable proteins are soy proteins. Corn, wheat, peanut and other similar proteins, can be texturized (Riaz, 2012).

For years, food scientists have attempted to replicate these distinctive structures, but significant advancements in texture have been made due to the development of innovative extrusion and shearing techniques, as well as the utilization of new raw ingredients. The key issue is to use globular proteins to create a fibrous, meat-like structure and plant-based oils and fats to form the fat phase (Dekkers *et al.*, 2018) ^[5].

Because of its greater productivity, low cost, versatility, and energy efficiency, extrusion has been the most traditional patented process for protein texturization and is still one of the most widely used (Boukid, 2021) ^[32]. Meat analogues produced with low moisture extrusion technology (35 percent moisture) have a sponge-like texture that requires further hydration to achieve the meat-like texture. However, due to better control of product expansion, high moisture extrusion (40-80 percent) imparted a fibrous meat-like structure, facilitating fat emulsification, protein gel formation, particle restructuring, and shaping (Alam, *et al.*, 2016) ^[35]. Extrusion at high temperatures (140-180 °C) ensures protein melting and polymerization, but it also causes colour changes due to the Maillard reaction, caramel flavors, hydrolysis, and pigment degradation (Guo *et al.*, 2020).

Freeze structuring can also help form a fibrous structure, but it is highly dependent on the plant protein source and properties (water-holding capacity, solubility and gelation), as well as freezing, and drying conditions (temperature and duration). Proteins are mixed with other ingredients until they form a uniform emulsion during this procedure. The mixture was then moulded, frozen (to create ice crystal layers), and left to dry. The protein fibrous texture (irreversible considerably insoluble form) is set by drying at high temperatures without melting the ice crystals. Modulating freezing conditions (rate of freezing, pH, the solids content of the material, surface effects, heat exchange effects, degree of confinement, and pressure effects) can customize the textural properties of proteins (Yuliarti *et al.*, 2021).

Animal-based proteins

The best quality protein source is derived from any animal or food obtained from them, as well as its by-products such as milk and eggs. Meat protein, egg protein, and milk protein all

contain all of the essential amino acids that the human body needs. Although, High consumption of red meat, such as smoked meat, sausage, hot dogs, bacon, and canned meat, increases the risk of cardiovascular disease and shortens life span. Animal proteins, such as casein, whey protein, gelatin, and egg proteins, are extensively utilized in the food industry to produce protein products (Richter *et al.*, 2019).

To begin with, there is a growing demand for protein. The world's population is increasing, with an estimated population of nine billion by 2050. Global food demand is already rising due to population expansion. In emerging nations, there seems to be a rise in per capita requirement for protein-rich foods-in particular, require for meat and dairy products are growing, in growingly urban populations, and in amongst the nutrition transition away from conventional dietary patterns, fueled primarily by income changes. The need for animal-sourced protein is predicted to expand with the increasing population. Demand for animal-sourced protein is predicted to rise by 50%, with some expecting an increase of as much as 80% (Nadathur *et al.*, 2017) [20].

Plant-based proteins

In Asia and other parts of the world, studies on plant-based proteins as an alternative protein source to replace traditional animal-based diets have increased in recent years. This could be owing to expanding global population and limited natural resources, making animal protein production an increasingly unsustainable approach. Moreover, environmental and ethical concerns about livestock farming, as well as health concerns about red meats, are common concerns when it comes to animal-based proteins (Dekkers *et al.*, 2018) [5]. The term "cultivated meat" refers to the application of biotechnology to generate laboratory meat by growing cells taken from an adult animal in a bioreactor with salts, growth hormones and nutrients until a structured meat, such as hamburgers and meatballs, is formed (Neill *et al.*, 2018). Global food security is in danger due to the rising global population and global warming. This has caused an increase in the global food supply from farmers to consumers in order to improve overall food production, storage, and transportation efficiency (Teng *et al.*, 2018).

Cereals are an important component of food crops, and grain-derived products play a significant role in the food processing sector. Cereal protein can be found in the form of seed, flour, or flakes. Wheat protein is made mostly from gluten that has been processed and extruded to resemble meat texture. Wheat gluten-based foods provide textured vegetable protein components that can be used as meat extenders and meat

mimic products. Wheat Gluten can be utilized as an extender and also bind chunks for trimmings to create rearranged elements in in-ground meat patties. Extruded, texturized and converted into fibres, hydrated gluten could be used to make a variety of meat alternatives (Malav *et al.*, 2018).

Soybeans are a popular meat substitute, and they've been utilised in Buddhist cooking for centuries. They used soy defatted flour, soy protein concentrate, and soy protein isolates to make the synthetic soy goods. The usage of soybean proteins as meat extenders has grown substantially as a result of the intriguing nutritional and functional features of soybean proteins (Geerts *et al.*, 2018) [9]. In addition to this, the introduction of soybean proteins into meat products is driven primarily by health and cost considerations. Regardless of the beneficial characteristics linked with soybean proteins. (Fukushima, 2011) [8]. Soybeans are high in fat, carbs, fibre, macronutrients, micronutrients, and vitamins, their protein concentrations mimic the fibres and it's made up to look like chicken or turkey breast fibres. The flesh mimic has fibrous firmness, chewiness and sensory mouthfeel thanks to the soy protein concentrate (Chiang *et al.*, 2019) [4].

Long before 1985, the first mycoprotein product was introduced to the market. Mycoproteins are cholesterol-free, have a low saturated fat level and a balanced fatty acid profile, and have a fibre content compared to other vegetarian protein sources. Because of its fibrous character, mycoprotein can significantly lower blood cholesterol levels. The fibrous arrangement of filamentous fungal mycelia is highly preferred as a meat substitute because it closely mimics the final product (Finnigan *et al.*, 2019).

Nutritional and health aspects

Many nutrient-dense plants and alternative protein sources are available in different degrees around the world. Legumes and pulses are two of the most common, nutritious and readily available protein sources. Meat analogues are created in such a way that the manufacturer's top priority is to create a product that has similar organoleptic properties to the targeted meat product while also meeting the targeted meat product's macronutrient specifications. Protein is likely to be the most important macronutrient when it comes to macronutrient specifications. Maintaining similar moisture and lipid levels makes sense from a functional and nutritional standpoint. As a result, meat analogue product lines are similar to the conventional meat products they mimic in terms of macronutrients (Kumar *et al.*, 2017; Kyriakopoulou *et al.*, 2019; Malav *et al.*, 2015) [16, 33, 18].

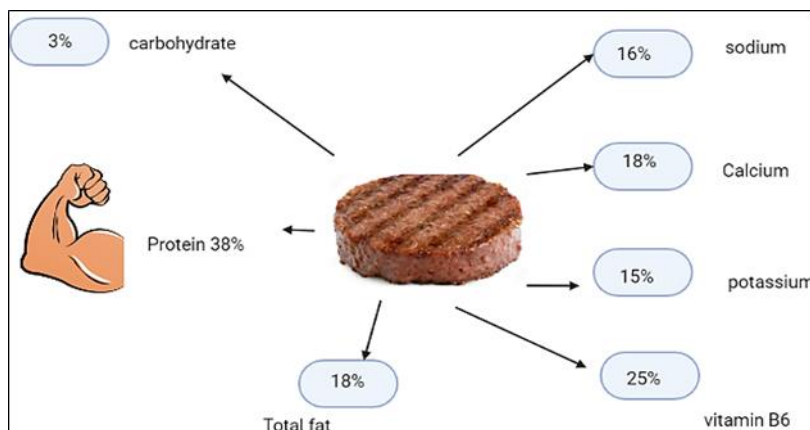


Fig 1: Nutritional component of Soya based alternative

According to research, Soy protein can reduce cholesterol levels to a small but statistically significant degree (5 to 6%) and isoflavones may perform a minor role in cholesterol reduction and heart disease prevention.

The link between excellent health and frequent eating of plant foods is becoming better recognized. Epidemiologic studies have shown that it is effective in preventing cancer, coronary heart disease (CHD), and a variety of other chronic disorders. Providing a high quality of protein in the diet is the primary purpose of meat in the diet. From a nutritional perspective, it has been suggested that meat substitutes consisting of 30% protein with a lower quantity of fat can be an excellent replacer for meat (Kyriakopoulou *et al.*, 2019) [33]. Iron is present in plant-based food, however, it is less available than iron present in meat. Foods derived from plants Amino acids

are the building blocks of proteins, and certain of them, known as essential amino acids, cannot be produced by the body and must be taken from the diet. Meat, dairy products, and eggs, as well as many plant-based diets, include amino acids. Vegetarian diets Improve blood lipid profile, Reduce diastolic BP, Improve blood glucose control, Reduce systolic BP, Reduce oxidative stress, Decrease endothelial inflammation, Help in maintaining normal BMI and Protect against plaque formation (Grac *et al.*, 2019).

Product examples of plant-based meat alternatives

Process able like raw minced meat. The inclusion of dry-textured proteins provides juiciness to the food. Nutritionally high-quality through the combination of different protein sources. Sustainable due to regional raw materials.

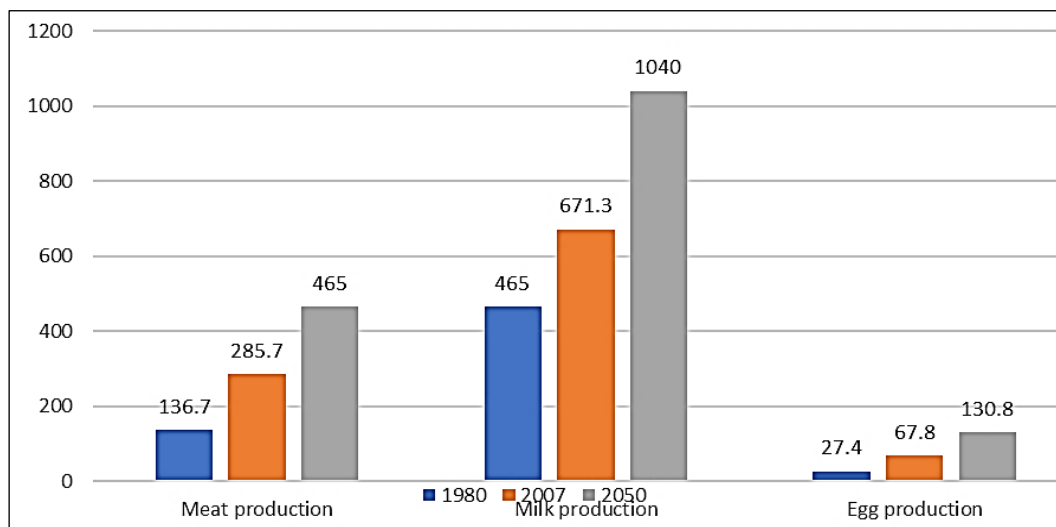


Fig 2: Global trends in the production of meat, milk, and egg (million tons)

In early 2010, an estimated 27 billion animals were bred as livestock worldwide and 66 billion were killed each year worldwide. Due to the increase in the population of the world. Between 1980 and 2007, worldwide meat production doubled, from 136.7 to 285.7 million tonnes, while egg production climbed by 150 percent, from 27.4 to 67.8 million tonnes, and milk production surged from 465 million to 671.3 million tonnes (FAO, 2015). If no provision is made to prevent further growth in the livestock industry, meat production is projected to increase to 465 million tons by 2050 and milk production to 1043 million tons (Steinfeld and Gerber, 2016), due to global population growth and the estimated increase in consumption of meat and milk per capita (Fig. 2). In addition, meat is an expensive food source because animals waste most of their energy and protein from digestion and body care. Extra food can be obtained through the soil to grow crops that will be eaten directly by humans. A meat-based diet requires a significantly greater amount of environmental resources per calorie compared to a more grain-based diet as it has been estimated on an average of 2 to 15 kg of plant foods are needed to produce 1 kg of meat (Aiking *et al.* 2011).

Environmental advantages of plant-based meat

Consumption of meat may be linked to external costs such as greenhouse emissions, degradation of natural resources,

adverse health effects and unsustainable agricultural and livestock techniques. Raising animals and producing meat, for example, may have had a detrimental influence on global GHG emissions, water pollution and resource scarcity. In certain studies, meat-eating has been linked to a variety of negative health effects, including cardiovascular disease and cancer. According to research Shifts in consumer behavior, and plant-based meat replacements for meat may decrease the health and the environmental consequences of meat production and consumption. (Grosso *et al.*, 2022; Van Vliet *et al.*, 2020) [11, 27].

Despite giving only 17 percent of humanity's food source, animal agriculture utilizes 77 percent of all agricultural land in the world. Agricultural production, which is the single largest driver of environmental pollution on land, is driven by this inefficiency. The single largest source of environmental degradation in the oceans is fishing, which can be substituted with plant-based products (Díaz *et al.*, 2019) [7].

Using all of the farmland to produce food for humans instead of animals, on the other hand, would allow western farmers to feed over twice as many others. As a result, the food distribution may be risen tremendously to account for all the food that expires or is thrown away before it is consumed. Plant-based meat is an efficient strategy to get the majority of this potency boost (Shepon *et al.*, 2018).

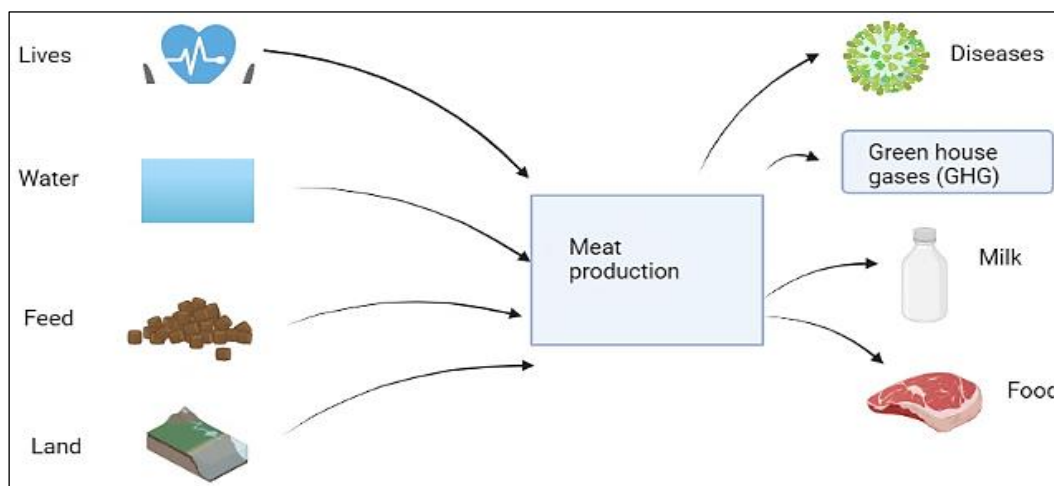


Fig 3: Pictorial representation of meat as an unsustainable source

Plant-based meat consists of 30%-90% less gas. The primary ingredients for plant-based meats, on the opposite hand, have low gas emissions, and extra process accounts for less than 13%-26% of plant-based meat's climate impact. The cropland not necessary for animal feed may even be accustomed to mitigating global climate change through rehabilitation, conservation or renewable energy production (Dettling, 2016) [6].

Plant-based meat uses 72-99% less water than typical meat (liter water/KG-Meat). Animal agriculture uses ninetieth of water for the cultivation of feed crops production. Even though the process needs 14-45% of plant-based meat total water use. Plant-based meat causes 51-90% less aquatic nutrient pollution than typical meat. Plant primarily based Meat needs No Antibiotics (Herrero *et al.*, 2015) [13].

Healthy animals are fed low doses of antibiotics to grow and forestall diseases, inflicting bacteria to adapt and become resistant. Several of those antibiotics measure employed in human medication, thus once bacterium becomes resistant, hospitals will not rely on them (Neill, 2016). If left untreated, by 2050 drug-resistant microbes may kill numerous folks annually and causes economic injury to the country additionally because of the impact on the world (Nadathur *et al.*, 2017) [20].

Plant-derived ingredients contain rough vegetable protein (TVP), fibers, starches, flours, and concentrates. Plant proteins square measure primarily derived from cereal and legume crops. Protein forms might include flows, and concentrates. As a result of numerous approaches in physical, chemical, and biological processes plant-based sources can gain more ability to fulfill key parameters in business adoption, like color, odor and taste (Heller, 2018) [12].

Challenges and opportunities

Assessments of strengths, weaknesses, opportunities, and threats (SWOT analysis) are used in marketing strategy to identify a company's internal strengths and weaknesses, as well as the possibilities and challenges offered by the external environment, which includes the market condition and trends. By developing a strategy on the basis of the prior description of worldwide drivers, global trends, and market data, as well as relevant consumer behavior elements, when using such tool to a business viewpoint on plant-based food and protein. One of the advantages is that consumers consider plant-based foods and proteins as healthier and more environmentally friendly. Furthermore, it is a popular current trend that is seen

as innovative and diverse. However, given that habits, familiarity, and beliefs about meat remain a barrier to adopting plant-based alternatives, there are still flaws in consumer perception and behaviour in the current situation (Aschemann *et al.*, 2020) [2]. Concerns about manufacturing and components in plant-based foods as a result of the clean-label food culture can lead to a bad perception. Consumer fear over potential health risks or health concerns highlighted regarding plant-based diets can lead to a reaction against plant-based meals.

Opportunities

Consumer awareness and need, as well as legislative support for reducing emissions in the food sector, are fueled by sustainability problems. A potential peak in meat demand in the BRICS countries, as well as the emergence of a global plant-based food movement, could boost export opportunities for know-how, ingredients, and meals. Plant-based foods are popular because they provide dietary variety and are new and trendy.

Conclusion

Plant-based substitutes and plant-based meats are gaining a foothold in global markets. With improved technology and resources, it will be possible to supply the growing demand for plant-based meat alternatives in the future years. Having an ethical, cost-effective, high nutritional value, and low environmental impact on the environment Extrusion of high moisture and shear flow Technology makes the manufacturing process simpler and more inexpensive. Proteins with a big scale and a texture similar to muscle proteins. The physical appearance the final product's eating pleasure and taste and texture experience would be comparable to cooked meat in terms of protein content providing dietary value Large-scale manufacturing, safe manufacturing methods Free scalability, shelf life, and safe handling processes pollution are just a few of the issues that must be addressed. Ensure that consumers' food is safe.

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