International Journal of Biology and Life Sciences
ISSN: 2957-9511 | Vol. 3, No. 3, 2023

Plant-based Meat Products and Their Research and Development Progress

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Abstract: With the aggravation of environmental problems in livestock and poultry raising and the improvement of consumers' health awareness level, people keep looking for food products that can partially or completely replace animal-based meat products. Plant-based meat products are meat imitation products with similar texture, taste and flavor as traditional animal meat products, which are obtained by spinning, extruding and other key processing technologies using suitable plant proteins as raw materials. In this paper, we introduce the characteristics of common processing materials and types of plant-based meat products, elaborate on the nutritional and safety aspects of today's plant-based meat products, and discuss the challenges and opportunities facing the domestic plant-based meat products market. It aims to provide theoretical reference for the research and development of plant-based meat products in China.

Keywords: Plant-based Meat Products; Plant Proteins; Key Technologies; Research and Development.

1. Introduction

In recent years more and more consumers have been aware of the environmental problems caused by long-term large-scale livestock and poultry raising, but there is little mention of such situations in our consumer groups, mainly because with the economic development and the improvement of people's living standards, food is no longer just to satisfy the sense of satiety, but rather to the pursuit of nutrition, safety, and health(GEERTS M E J), and it is difficult to change the long-term dietary habits of people. The unique flavors in traditional specialty meat products, such as the sauce flavor and fermentation flavor (KAMANI M H), are difficult to be completely replaced by the plant-based meat products currently produced in China. However, plant-based meat products have shown great advantages in some aspects, such as reducing obesity, enriching vitamins, trace elements and controlling blood pressure and cholesterol, and other positive effects. Therefore, the research on plant-based meat products is carried out, on the one hand, to deal with the possible future food security crisis and to achieve energy saving and emission reduction, safety and efficiency in processing (KYRIAKOPOULOU K); on the other hand, it can regulate the nutrients required by the human body, such as proteins and amino acids, through functional plant-based meat products (BLEAKLEY S). In this paper, we have reviewed the common raw materials and types of plant-based meat products, as well as the nutritional and safety aspects nowadays.

2. Ingredients for Plant-based Meat Products

2.1. Soybeans

Soybean is one of the most widely used plant-based meat product ingredients today. A wide variety of legume products can be found in all regions of the world, making soy very affordable as an ingredient, and its concentrates, which typically contain 70% protein (CHRONAKIS I S), are often used as a substitute for meat ingredients, and the protein concentrate is very similar to the fiber found in chicken (ISMAIL I). Soybeans are also rich in fat and carbohydrates, nutrients and vitamins. According to the protein content in soy protein it can be categorized as soy protein powder, soy protein concentrate, and soy isolate. Soybean isolate protein has better solubility, water retention, oil retention and viscoelasticity, and the application of soybean isolate protein to the field of tofu can not only improve the hardness and water retention of tofu, remove the soy flavor, but also increase the palatability of tofu, increase the way of tofu consumption in food, provide essential proteins, and make up for the deficiency of the protein content of the vegetarian products is low (SOUZA FILHO P F).

2.2. Cereals

The common cereals are wheat, rice, barley and oats, and the desired cereal proteins can be extracted from such plants. Among them, wheat gluten is commonly used in the production of imitation meat products due to its own good viscoelasticity and good value for money economy (CORNET S H V). Through the study of the microstructure of wheat starch produced by extrusion method, it was found that the addition of different ratios of water can affect the hardness and protein solubility of meat imitation products (G. YAO K S L), and the microstructure of cereal proteins is changed after extrusion modification, and their functional properties will be greatly improved compared with the natural cereal proteins (GUZMAN-ORTIZ F A).

2.3. Grease

Fats and oils have a lubricating effect as binders in the preparation of products. Traditional meat products basically remain simple cured, sauced, brined, steamed and smoked (BARZEGAR F), but vegetable oils can be added to plant-based meat products to make the meat juicy, tender and have a unique flavor. Various oils and fats extracted from various plants such as rapeseed, sunflower, corn, peanut, soybean, etc. are used to enhance the texture and flavor of the products by maintaining the integrity of their flavor substances. The most used vegetable protein vegetarian meat products in the main

series of products of Beyond Meat and Impossible Food are coconut and olive oils, and fatty acids of different plant fats and oils may vary due to the plant species and the processing method of the products. The fatty acids of different vegetable fats and oils vary depending on the type of plant and how the product is processed.

2.4. Algae

Algae are rich in proteins, and experiments have been conducted to mix and process several microalgae with grains, rice, and edible oils to produce high-quality products that can be easily digested (XIONG Y L). Meanwhile, combining microalgae with soybean isolate and soybean protein concentrates can be used as a well-performing gel and foaming agent (BOHRER B M). Compared to conventional crops, microalgae require fewer site facilities and pollute nature less. Under suitable conditions, the cultivation of microalgae can be accomplished in a short period of time and without producing greenhouse gases, and the dry weight of the treated microalgae can still be maintained at more than 50% of the original protein (Zhang, H). Xanthophylls, a type of microalgae, have been shown to enhance vitamin levels (Zhang, J), and when combined with legume plants, significantly increase the vitamin content of soybeans.2021 In April 2021, Sophie's Bionutrients introduced the world's first 100% microalgae-based hamburger patty, which was described as containing 24 grams of protein per patty (60 grams), which is about twice the protein content of the same amount of beef or fish. Each patty (60 grams) is said to contain 24 grams of protein, which is about twice the amount of protein found in the same amount of beef or fish, and the patty contains nine essential amino acids that aid in protein synthesis.

2.5. New Resources

Some fungus plants possess high protein content, but because they are not easily digested by the human body, they are rarely used to extract fungus protein and as raw materials for plant-based meat products. In some regions of China, fermented products such as soybean paste and soy sauce are often added to plant-based meat products by utilizing their characteristics of long preservation time, nutritional richness, and taste enhancement, so mushroom foods and fermented foods have been taken as one of the candidates for the next generation of ideal plant-based proteins. The benefits offered by plant-based foods are increasingly understood and people are turning to vegan foods for long-lasting healthy living. Plant-based proteins are rich in dietary fiber, antioxidants, vitamins and various micronutrients (Zhang, Q), and according to SOUZA et al (Zhu, Y., Wang), fungal proteins have been shown to have a positive impact on cholesterol, sugar and insulin blood levels, and have been welcomed by a wide range of consumers and have a promising future in the meat substitution market.

3. Types and Characteristics of Plant-based Meat Products

3.1. Ground Meat Products

Ground meat products have a rich variety of common burgers, chicken nuggets, meat patties, etc., which are generally required to have good chewiness, juiciness, firmness and bite. Traditional animal-based minced meat products are mainly composed of proteins, fats, and a small amount of seasoning, salt, and binders, a small amount of salt can change the protein structure and enhance the flexibility of the product (Song, Q), while binders reduce the changes in moisture and fat to achieve the purpose of improving the texture and appearance of the product. The composition of plant-based minced meat products is very similar to traditional products, most of the plant proteins are converted into a fibrous structure similar to minced meat, which is called "textured vegetable protein", and finally mixed with other ingredients to obtain the target product. At present, China's research on plant-based minced meat products is not deep enough, and the products on the market are still mainly plant-based vegetarian meat instead of meat sauce, for example, the brand "Butcher's Meat" launched a new plant-based beef sauce in April 2022, in which the content of plant meat is ≥30%.

3.2. Pieces of Meat Products

The purpose of block meat products is mainly to partially replace sliced meat products such as chicken, pork and steak. These products are long-fibered or layered, and are usually made by extruding plant-based raw materials, then freezing, marinating, cooking, and other processes to achieve a structure, color, tenderness, flavor, and other aspects that are basically the same as those of animal-based meat products. Most of the current technologies for block meat products still use extrusion, but another shear cell technology also has great potential and is expected to be able to manufacture large plant-based meat products (Wang, X). In developed countries, block meat products are the main form of plant-based product sales.In 2020, Nestlé officially released the Jia Zhi Cuisine brand, and by the end of that year, the products had been formally put on the shelves of Box Ma Fresh and other offline stores, including vegetarian crispy chicken nuggets, vegetarian braised pork and other products.

3.3. Emulsified Products

Similar to traditional animal meat products, plant-based emulsified products contain a large amount of water, protein, fat, carbohydrates, salt and spices. When adding spices, attention should be paid to the control of the amount; the southwest region prefers spicy, the north is heavy on salt, and the coastal region of Guangdong prefers light (Xiao, Y), and the different ratios will affect the consumer's sensory evaluation of the product. Many of the processes for making plant-based emulsified products are inspired by the use of additives in traditional meat products and utilize large amounts of protein to partially or completely replace animal meat (Yefang, Z). Mixing water, hydrocolloids, and plant proteins can form a stable emulsion in a colloidal solution, which is due to the addition of casein as well as divalent metal cations condensing to form a fibrous structure, making the product more similar to animal products in terms of texture, for example, in the development of plant-based sausages, emulsified products can be used as a replacement for fatty meats, and can achieve a high degree of similarity to traditional animal meats in terms of appearance and texture, and at present At present, Qishen Foods has developed a variety of vegetarian products such as low-fat sausage, Sichuan-style vegetarian sausage, and hahong sausage on the basis of emulsified products, which has broadened the way forward for China's plant-based meat market.

4. Nutritional and Safety Aspects of Plant-based Meat Products

The initial research and development of plant-based meat was aimed at health and environmental protection, to create meat substitute products suitable for large-scale production, with good economic efficiency, and in line with the needs of people's consumption. As an alternative to animal meat, plant-based products will also face the problem that the nutritional flavor of the product will change after cooking (Yuchen), and likewise, whether the safety of the food can be controlled in the process needs to be investigated.

4.1. Nutritional Properties

Conventional meat products are generally high in protein, vitamins and minerals (Yyh, A), but all have unequal amounts of cholesterol, zero hormones, trans fatty acids and antibiotics compared to plant-based meat products, and long-term consumption of animal meat products poses certain health risks.

In the production process of plant-based meat, some carbohydrates are added appropriately. This is due to the fact that it can increase the gloss and softness of the product when producing emulsified products such as ham, meatballs and sausages. The raw materials used in the production of plant meat are usually soybean, peanut and other substances (Z., P. P. N), ARACELI (Zhan, X. M) and other studies found that the main amino acid composition of plant proteins is based on glutamic acid, aspartic acid, proline and leucine, but the nutritional content of certain proteins is not up to the standard, such as soybean proteins lack of methionine and so on. In terms of vitamins and minerals, unlike traditional animal products, plant-based meat products are made by mixing a variety of plant raw materials, which can be matched with each other according to the different characteristics of various raw materials, so as to achieve the purpose of nutritional enrichment and balance.

4.2. Safety

In order to achieve a flavor and texture similar to that of traditional meat products, plant-based meat products often use certain processing techniques and additives in the production process. Because of the differences in raw materials, the same process may produce different harmful substances as well as loss of nutrients. Protein foods may produce toxicants and carcinogens, such as heterocyclic aromatic amines, under high-temperature processing. Currently, the phenomenon of toxic substances in meat processing is generally addressed by the addition of phenolic natural antioxidants as potential inhibitors of toxic substance formation.

The color of raw materials for plant-based meat products may differ from that of animal meat, which requires the addition of a certain amount of coloring agents. In order to obtain a long shelf life, manufacturers also add preservatives and stabilizers such as titanium dioxide, methyl cellulose, etc. BOHRER studied the formulations and nutritional composition of seven popular commercial alternatives (burgers, hams, and chicken nuggets), and from the list of ingredients, it was found that each of these products contained 20 to 30 additives. The high number of additives in these products, coupled with the saturated fat and high salt content of some of the products, warrants further study of their safety compared to traditional animal meat products.

There are specific groups of people who have allergic reactions to certain plant proteins, such as peanut protein allergy, and this situation also poses certain risks to the plant-based meat products market. In addition, plant-based meat products are usually high-moisture foods, both cooked (ready-to-eat) and raw, and the effects of specific storage conditions (packaging, temperature, etc.) on the microbiological safety and flavor changes (e.g., lipid oxidation) of the products should be strictly controlled.

5. Conclusion

With the continuous improvement of people's consumption level, meat products in some countries have been in short supply, and the emergence of plant-based meat products can to a certain extent solve the sustainable development of meat and environmental issues. In addition, plant-based meat products are rich in proteins and various types of trace elements, which have the effect of regulating the balance of human nutritional intake. Therefore, plant-based meat products will be one of the important choices for consumers in the future, but in the concept of domestic consumers, plant-based meat products are only a kind of vegetarian dish with the taste of animal meat, which leads to a large gap between the domestic plant-based meat market and foreign countries. Therefore, popularizing the benefits of plant-based meat products to consumers and searching for more suitable raw materials and improved processing technology for plant-based meat products is an important development direction. At present, the domestic market for plant-based meat products has great potential, and breaking the traditional concept of vegetarian consumption, improving the quality of products, and conducting in-depth research on current plant-based meat products is a way forward for us.

Declarations

Not applicable.

Conflicts of Interest

The authors declare that they have no conflict of interests.

Availability of Data and Material

The data used to support the findings of this study are available from the corresponding author upon request.

Code Availability

Not applicable.

Authors' Contributions

All authors read and approved the final manuscript.

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