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THE RELEVANCE OF RESEARCH THE PROGRESS ON THE APPLICATION OF MUSHROOM IN MEAT PRODUCTS PROCESSING

In this article, the function of mushrooms and the progress of their application in meat processing were introduced. According to the last research, some types of meat products contain more saturated fatty acids, cholesterol, sodium salt, phosphate, nitrite and other components, and excessive intake of these components may lead to obesity, cardiovascular disease, cancer and a series of diseases. So, the food industry is redesigning existing products or developing new ones that are healthier and more sustainable, and shifting to focus on the application of plant ingredients. Attention is drawn to the fact that more and more studies have been conducted to improve the nutritional and functional properties of food by adding vegetables, beans, cereals, tubers, edible seeds, algae or insects as substitutes for fat, protein and salt. Mushrooms has attracted much attention because of its high nutritional value, wide variety of bioactive compounds, antioxidant effect and health function, and excellent flavor and taste, mushroom can provide exogenous active substances for meat products and improve the nutritional value and functional properties of meat products. The application progress and development prospect of mushroom as fat substitute, protein substitute, salt, phosphate and nitrite substitute, flavor additive and antioxidant in meat products were analyzed. There is a lack of research on the health function of mushroom in meat products, and the potential effects and mechanisms of mushroom applied to meat products on human health and health function need to be further explored in the future. The results showed that the application of mushrooms in meat processing meets people's requirements for green, healthy and functional food industry. Mushrooms are a promising functional additive in meat processing.

Keywords: mushrooms, application, meat products, processing, functional properties.

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АКТУАЛЬНІСТЬ ДОСЛІДЖЕНЬ ЩОДО ЗАСТОСУВАННЯ ГРИБІВ У ПРИ ВИРОБНИЦТВІ М'ЯСОПРОДУКТІВ

У статті було представлено функціональні властивості грибів і перспективу їх застосування в технології м'ясопродуктів. Згідно з останніми дослідженнями, деякі види м'ясних продуктів містять більше насичених жирних кислот, холестерину, солі натрію, фосфати, нітрити та інші компоненти, а надмірне споживання їх може призвести до ожиріння, серцево-судинних захворювань, раку та ряду інших захворювань. Таким чином, харчова промисловість переробляє існуючі продукти або розробляє нові, більш здорові, і зосереджується на застосуванні рослинних інгредієнтів. Звертається увага на той факт, що все більше і більше досліджень проводяться задля поліпшення поживних і функціональних властивостей їжі шляхом додавання овочів, бобів, злаків, водоростей як замінників жиру, білка і солі. Заслуговує уваги застосування грибів, що завдяки своїй високій поживній цінності, широкому спектру біологічно активних сполук, антиоксидантній дії та оздоровчій функції, а також чудовому аромату та смаку, можуть забезпечити екзогенні активні речовини для м'ясних продуктів і покращити їх харчову цінність і функціональні властивості. Проаналізовано особливості застосування грибів як замінника жиру, білка, замінника солі, фосфату та нітриту, смакової добавки та антиоксиданту в м'ясних продуктах. Останнім часом недостатньо досліджень щодо оздоровчої дії грибів у м'ясних продуктах, тому потенційний ефект на здоров'я людини та механізми застосування грибів у м'ясних продуктах потребують подальшого вивчення. Результати показали, що застосування грибів у технології м'ясопродуктів відповідає вимогам щодо екологічних, здорових та функціональних продуктів харчування. Таким чином, гриби є перспективною функціональною добавкою при переробці м'яса.

Ключові слова: гриби, застосування, м'ясні продукти, виробництво, функціональні властивості.

Formulation of the problem

Meat and meat products are important sources of nutrients such as protein, vitamins, fatty acids, minerals and some bioactive compounds, and play an important role in People's Daily diet [1]. However, some types of meat products contain more saturated fatty acids, cholesterol, sodium salt, phosphate, nitrite and other components, and excessive intake of these components may lead to obesity, cardiovascular disease, cancer and a series of diseases [2]. Therefore, reducing the use of these adverse ingredients, increasing healthy ingredients such as unsaturated fatty acids and natural antioxidants, and developing more nutritious and healthy meat products with functional properties have become a research hotspot in recent years [3].

Currently, the food industry is redesigning existing products or developing new ones that are healthier and more sustainable, and shifting to focus on the application of plant ingredients [4]. More and more studies have been conducted to improve the nutritional and functional properties of food by adding vegetables, beans, cereals, tubers, edible seeds, algae or insects as substitutes for fat, protein and salt [5]. Because of its high nutritional value, wide variety of bioactive compounds, antioxidant effect and health function, and excellent flavor and taste, mushroom can

provide exogenous active substances for meat products and improve the nutritional value and functional properties of meat products, so it has attracted much attention [2-3]. In recent years, mushroom have been widely used in the meat processing industry, including as a substitute for animal fat, protein, salt, flavor additives and antioxidants in meat products. Therefore, the nutritional value and health function of mushroom were briefly introduced in this paper, and the application progress of mushroom in meat products in recent years was reviewed, which provided a certain reference for the further study of healthy and nutritious meat products.

Analysis of recent sources

Mushroom are a kind of edible large fungi, with the characteristics of high dietary fiber, high protein, low fat, low calorie and many active substances. Therefore, many nutritionists believe that "one meat, one vegetable and one mushroom" can be promoted as a better dietary structure [6-7]. In recent years, with the understanding of the health effects of dietary fiber of mushroom and the in-depth study of its molecular properties, many researchers pay more attention to the relationship between the composition, functional properties and application prospects of dietary fiber.

Mushroom are a source of novel dietary fiber and are rich in carbohydrates with a total content of 35% to 70% of dry matter [8], including digestible carbohydrates such as trehalose, glycogen, mannitol and glucose, as well as non-digestible carbohydrates such as beta-glucan, chitin and mannan [9]. Studies have shown that β-glucan is a polymer composed of glucose units connected by α and β-glucoside bonds. It is the main polysaccharide of mushroom with a content of 0.21 ~ 0.53 g/100g (dry base) and exists in the cell wall of fungi. It is mainly composed of 54% ~ 82% insoluble and 16% ~ 46% soluble β-glucan [10]. It has the functions of immune regulation, antibacterial, antioxidant, antiviral, antifungal, anti-tumor, cholesterol-lowering and blood glucose regulation, and has become a new source of prebiotics [11-12]. For example, recent studies by Murphy et al. [13] have shown that β-glucan in shiitake mushrooms has antiviral activity and can play a preventive role in novel coronavirus pneumonia by enhancing immune system tolerance. In addition, some studies have shown that β-glucan has gelling and thickening properties, which has certain application potential in food [14-15]. Khan et al. [14] reported that β-glucan extracted from different mushroom (Agaricus bisporus, Oyster mushroom and Drumstick mushroom) had certain expansibility (3.45-4.49 g water /g sample), fat binding force (5.34-6.65 g oil /g sample), emulsification ability (about 65% oil /1% β-glucan) and thermal stability, and could be used as an effective functional ingredient in food or pharmaceutical industry processing. Abreu et al. [15] reported that β-D-glucan extracted from Silky mushroom exhibited shear thinning behavior. When the concentration of the solution increased, the apparent viscosity increased, showing gel behavior and thermal stability during simulated pasteurization.

Protein is the second largest component of mushroom, and its content generally accounts for 19% ~ 35% of dry matter [16-17]. It contains 9 kinds of essential amino acids for human body, especially rich in lysine and leucine, which are lacking in most cereal foods, and can meet human protein requirements [17]. In addition, mushroom do not contain cholesterol and have low lipid content, usually accounting for 0.1% ~ 16.3% of dry matter. The main components are unsaturated fatty acids such as linoleic acid, oleic acid and linolenic acid, among which linoleic acid is an essential fatty acid and cannot be directly synthesized in human body [18]. Mushroom are also a good source of vitamins, containing B vitamins, thiamine, pantothenic acid, niacinamide, folic acid and a small amount of VK, VE and VC [19]. In addition, UV-irradiated mushroom are an important source of ergocalciferol [20]. VD, a known prohormone, usually exists in two common forms, ergocalciferol and cholecalciferol, and is mainly associated with important physiological functions such as bone mineralization, immune regulation and calcium and phosphorus homeostasis [21].

Moreover, mushroom also contain more minerals that can play an important role in the normal operation of different metabolic pathways, such as calcium, potassium, magnesium, sodium, phosphorus, copper, iron, manganese and selenium [19]. Therefore, the nutritional value of mushroom is rich, can provide the human body with the required protein, essential amino acids, dietary fiber, vitamins and minerals and other nutrients, is an essential part of the human diet.

Mushroom not only have good nutritional value, but also have better health function. Beginning in the 1960s, scientists began to explore the potential of mushroom for health benefits and discovered a variety of unique bioactive compounds, including phenols, terpenoids, fungal lectins, polysaccharides (mainly beta-glucans), etc. [22]. Scientific evidence confirms that compounds or fungal chemicals derived from mushroom can be used to maintain health and regulate multiple functions of the body [23]. For example, phenolic compounds in mushroom, including flavonoids, hydroxybenzoic acid, hydroxycinnamic acid, lignans, phenolic acids, tannins and oxidized polyphenols, can act as free radical inhibitors, metal passivators, peroxide decomposition agents or oxygen scavengers, have anti-cancer, anti-bacterial and anti-inflammatory effects, and can prevent a variety of degenerative diseases. Including brain dysfunction, cardiovascular disease, and aging [8, 23]. Polyphenol derivatives in Sarcodontia albicolor can improve glucose and lipid metabolism by reducing glycosylated hemoglobin, insulin and blood sugar levels, and increase plasma superoxide dismutase levels by reducing liver total cholesterol, triglyceride and low density lipoprotein cholesterol levels, thereby reducing inflammation and fatty liver and changing intestinal microbiota [24]. In addition, vanillic acid and syringic acid (0.31 mg/g dry sample, 0.45mg/g dry sample, respectively) extracted from shiitake waste have potential benefits in the treatment of osteoporosis. The main mechanism of action is that vanillic acid and eugenic acid reduce the activity of tartrate-resistant acid phosphatase (TRAP) and the number of TRAP-positive polykaryotic cells in the osteoclasts induced by nuclear factor κB receptor activation factor ligand in RAW264.7 cells. Inhibiting the differentiation of pre-RAW264.7 osteoclasts into osteoclasts has the potential to prevent osteoporosis [25].

The aim of this work is to introduce the function of mushrooms and the progress of their application in meat processing.

Presenting of main material

According to the progress in the application of mushroom in meat processing, attention is drawn to the use mushrooms as a fat substitute. Animal fat is a triacylglyceryl ester formed by esterification of glycerol and fatty acids, which plays an important role in the taste, juiciness and water retention of food. However, excessive intake of fat seriously affects human health. According to the report on Nutrition and Chronic Diseases of Chinese Residents (2020), the ratio of dietary fat to energy supply of residents continues to rise, unhealthy lifestyles are still prevalent, and the problem of overweight and obesity among residents continues to become prominent. Therefore, the development of low-fat meat products has attracted increasing attention and attention, and the development of healthy and nutritious animal fat substitutes has become a current research hotspot. At present, the commonly used fat substitutes are lipid substitutes, protein substitutes and carbohydrate substitutes. Mushrooms have low fat content, high quality polyunsaturated fatty acids and high dietary fiber content, excellent ability to adsorb and bind water, which can improve the juiciness and taste of meat products, minimize the impact of fat on meat products, and is a potential alternative to fat [18].

In recent years, more and more mushroom have been applied to the production of low-fat meat products in order to achieve the purpose of not affecting the taste and quality of products on the basis of fat reduction. Ceron-Guevara et al. [26] studied the effects of bisporus mushroom powder and oyster mushroom powder on the quality characteristics of Frankfurt sausages during refrigeration after replacing 30% or 50% fat, respectively. The results showed that the fat content of the two kinds of prepared sausages decreased, the content of water and dietary fiber increased, the protein content and amino acid spectrum did not change, and the sensory score increased. Among them, the increase in water content is attributed to the addition of edible fungus powder, which is rich in dietary fiber, especially β-glucan, has the ability to retain fat and water, and plays a role in improving the texture and water retention of meat products. In addition, the study also noted that the bisporus mushroom powder caused the sausage to be too dark due to its dark color, while the addition of oyster mushroom powder caused the texture of the sausage to soften.

These results indicate that the color properties, dietary fiber and protein content of edible mushroom powder have certain effects on the color, water retention and texture of the product. Patinho et al. [27-28] added Agaricus bisporus pulp to fat-reducing beef burgers, and found that the high water content and water retention properties of Agaricus bisporus increased the moisture content of beef burgers, improved juiciness, did not affect elasticity and color but reduced hardness. This is mainly due to the addition of non-meat components of mushroom to reduce the protein content of meat, thus reducing the hardness of the product, but mushroom can retain more water in the protein matrix, improve the sense of "fat" in the senses, increase the "juicy" experience, so as to reduce the negative impact of fat reduction. In addition, through different treatment of mushroom, the effect of fat reduction can be better achieved. Using Pleurotus eryngii as raw material, Wang Liyan et al. [29] studied the substitution effect of four treatments (unheated, boiled, fried and fried) on all backfat in Pleurotus eryngii pork sausage from aspects of physical and chemical properties, process and sensory aspects. The results showed that different pre-treatment of mushroom had different effects on the nutritional composition and quality characteristics of low-fat meat products. Compared with the control group, the energy and fat contents of the four kinds of prepared Pleustreus eryngii pork sausage were significantly reduced, and the content of protein, water, total dietary fiber, cooking loss and retention water were increased.

However, the fried and oil-fried pleustrei pork sausage had better flavor and higher texture and overall acceptability scores. The above research shows that mushroom as a fat substitute is a good choice, which can not only maintain the sensory and physical and chemical properties of the product, but also achieve fat reduction, improve product yield, improve nutritional composition, increase flavor and other effects. However, in the future, it is necessary to consider the influence of the color of mushroom itself, the amount of fat replacement and the pre-treatment method of mushroom on meat products.

As about the use mushroom as a protein substitute, mushrooms contain a high proportion of easily digestible protein and dietary fiber, presenting the texture of meat and becoming a potential substitute for meat protein. In recent years, there have been many studies to partially replace meat protein in meat products with mushroom. Yahya et al. [30] studied the effects of different proportions of chicken and fresh oyster mushroom on chicken sausage, and found that the chicken sausage with fresh Oyster mushroom added had the highest acceptability, increased moisture and dietary fiber content, decreased hardness and increased elasticity, indicating that oyster mushroom is a potential substitute for chicken, suitable for the production of meat products with lower meat protein content and more healthy nutrition. The study suggests that dietary fiber in Oyster mushrooms can improve the water retention of meat products and retain the water released by the meat substrate. In addition, because Oyster mushroom contains more β-glucan and water, when oyster mushroom is ground in a blender, polysaccharide and water will interact to form a thick paste, and the interaction between water and polysaccharide in the paste will affect the action of protein, thus affecting the gelling properties of the gel [31], which is conducive to the elasticity of the gel but not conducive to the hardness of the gel. Al-Dalain [32] studied the application of Agaricus bisporus mushroom substitute meat in beef sausage processing, and found that the optimal replacement amount of Agaricus bisporus mushroom is 30%.

At this time, the total essential amino acid content of beef sausage is increased by 1.11 times, the antioxidant effect is better, and the sensory score is higher. The studies of Myrdal [33] and Wong [34] et al also

showed that Agaricus bisporus mushroom could be used as a potential meat substitute, with up to 80% added, without affecting the physical and chemical properties of the product, and the sensory properties of the product were better. Wang Liyan et al. [35] studied the effect of shiitake mushrooms replacing pork on sausage processing characteristics, and the results showed that shiitake mushrooms protein interfered with the formation of meat protein network and destroyed its continuity during heating, thus reducing the hardness of sausage. However, the addition of mushroom increased the content of water, total dietary fiber, total phenol and 1, 1-diphenyl-2-trinitrophenylhydrazide free radical clearance, reduced the level of protein and energy, and effectively increased the nutritional value of sausage.

In recent years, with the advent of artificial meat and plant-based meat, the application of mushroom in meat analogues has been further developed. Fungal proteins are low fat, high protein and high fiber (including nearly 2/3 β-glucan and 1/3 chitin poly (N-acetylglucosamine) compounds, and can be used as safe meat alternatives due to their tightly packed layered structure that produces more fiber and elastic eating qualities [36]. At present, studies [37] have reported that the mycelium of Agaricus bisporus cultured by deep fermentation has a fleshy fiber structure, which can be used to produce delicious, healthy and nutritious artificial meat food. In addition, there are many new processing technologies that can also be used in the production of edible mushroom meat analogues. Yuan et al. [38] used mushroom (Shiitake mushroom, Pleurotus mushroom, Drumstick mushroom) and soybean protein as raw materials to prepare three kinds of mushroom based plant meat with similar structure to real beef by hot extrusion method. Then, using the prepared plant meat as raw material, Yuan Xinyue et al. [38] successfully prepared three kinds of plant meat sausage with different formulas. Among them, the plant meat sausage prepared with drumstick mushroom and soybean protein as raw materials is the most similar to meat sausage texture. In addition, the improvement of physical and chemical properties, texture properties, taste and flavor of fermented sausages by fibrous extrudates of mushrooms and soy protein as meat substitutes was further studied.

The results showed that the physical and chemical properties and texture properties of meat substitutes were close to those of real meat products, and the fermented sausages prepared by them were close to the taste of traditional fermented sausages. At the same time, the unique aroma characteristics of drumstick mushroom were added [39]. The above research shows that mushroom and fungal proteins are potential meat protein substitutes that can improve the nutritional value of products and contribute to the production of healthy meat products with low animal protein content and high nutritional value. However, consumer acceptance is an important issue that must be considered.

If use the mushroom as a substitute for salt, phosphate and nitrite, it can be noted, that salt, phosphate and nitrite in meat products can not only taste and protect against corrosion, but also promote the hydrolysis of myofibrillate protein, improve product water and oil retention, improve product texture and improve product stability [40]. However, excessive intake of salt can cause high blood pressure, heart disease or kidney disease and adversely affect human health [41]. Mushroom are potential salt substitutes because they can provide saltiness to meat products, increase pH value, improve water retention, etc. [42]. Recently, some researchers have successfully used mushroom to replace sodium, phosphate and nitrite in meat products, thus achieving the effect of reducing the salt consumption of meat products [33, 41, 43].

Salt plays an important role in food processing, providing saltiness and promoting the dissolution of salt-soluble proteins. Mushrooms contain unique umami enhancing compounds (free amino acids such as glutamate, 5 '-nucleotides, L-glutamyl oligopeptides, tripeptides, etc.), which can provide a certain saltiness and umami taste, thereby improving the taste of meat products. Myrdal et al. [33] replaced part of sodium chloride and meat protein with bisporus mushrooms in beef tortillas, which could significantly reduce the salt content without affecting the overall taste of the product. The authors speculate that the main umami substances in the mushroom can synergistically act on the taste of meat, providing a balanced salty and rich taste, thus achieving salt reduction in meat products without loss of overall flavor intensity. Wong et al. [44] found that replacing 26.7% of sodium chloride with bisporus mushrooms in the preparation of beef patties reduced the sodium chloride content of beef patties, but did not affect their saltiness. In a recent study, Franca et al. [45] extracted umami components (mainly L-glutamic acid) from the by-products of mushroom and used them as flavor enhancers to produce low-salt beef burgers. The results showed that the salt content of hamburgers was reduced by 34.74% to 52.50%, and the texture did not change significantly.

Phosphates, especially alkaline phosphates such as sodium pyrophosphate and sodium tripolyphosphate, can improve the quality of products by increasing the pH of processed meats to increase water retention, improve texture, and inhibit lipid oxidation.

Mushrooms contain dietary fiber, have antioxidant effects and raise pH value, and exhibit functions similar to phosphate, which is a potential phosphate substitute [46]. Jo et al. [41] successfully applied Flammulina mushroom powder to the production of low-salt chicken sausage instead of phosphate. The results showed that the fat and water loss of chicken sausage were significantly reduced due to the ability of dietary fiber in Flammulina mushroom to combine water and oil. In addition, polyphenol substances inhibited lipid oxidation of chicken sausage by exerting antioxidant effects, with no negative effects on the color and sensory properties of the sausage.

The study of Choe et al. [47] showed that the pH value and malondialdehyde content of emulsified sausage with 1.0% Flammulina powder added was slightly higher than that of sausage with 0.3% phosphate added, and it was believed that Flammulina powder could replace phosphate in meat products. Jeong et al. [46] reported that when 1% freeze-dried Flammulina mushroom powder was used to replace 0.3% sodium pyrophosphate, the cooking

loss of beef patties was reduced, possibly due to the effect of dietary fiber, while 1% ovens dried Flammulina mushroom powder significantly improved the lipid oxidation of beef patties. In addition, the two Flammulina mushrooms powders had no significant effect on the texture of beef patties.

The main function of nitrite in meat processing is hair color and preservation. Edible mushrooms combined with the right processing techniques can also play a similar role to nitrite. Jo et al. [43] found that plasma treated Flammulina powder could synthesize nitrite, and the treated Flammulina powder could replace the nitrite of ham sausage. The results showed that the nitroso heme content and color of Flammulina powder sausage were close to those containing phosphate and nitrite when stored for 30 days under the condition of accelerated oxidation. There was no significant difference in thiobarbituric acid reactive substances (TBARs), which confirmed that Flammulina powder could effectively replace nitrite in ham intestines. However, there are few studies on the use of mushroom to replace nitrite. In the future, the effect and potential of different mushroom and their combined processing methods to replace salt, phosphate and nitrite in meat products can be explored, which has broad application prospects in the development of low-salt healthy food in the future.

As about the mushroom as flavor additives, various ingredients and additives are widely used to improve the flavor characteristics of meat products. With the improvement of living standards and health awareness, consumers are paying more and more attention to product flavor, food safety and the use of natural additives [48]. Because of its unique taste and aroma, mushroom can be used as flavoring substances in the food industry. For example, 1-octene-3-ol is one of the typical eight-carbon aromatic compounds of mushroom, which has a mushroom, musty or earthy taste, and also has a sweet taste, and has been included in the Food additives database of the United States Food and Drug Administration [41]. At present, mushroom as flavor additives to improve the flavor characteristics of meat products has gradually attracted the attention and attention of researchers.

Liu et al. [49] prepared meat-taste Maillard reaction products by thermal reaction using mushroom (Shiitake mushroom, Pleuropleube erineus, Pleuropleube disporangus) as raw materials. The results showed that mushroom were ideal raw materials for preparing meat-taste base precursors, and could produce a large number of free amino acids and polypeptides by decomgenerating proteins. Mushroom can not only provide meat flavor, but also promote the formation of flavor substances in meat products. Wang et al. [50] studied the effects of straw mushroom powder on the physicochemical, nutritional and sensory characteristics of Cantonese sausages. The results showed that the addition of straw mushroom powder could improve the physical properties of sausages, increase the contents of amino acids, fatty acids and volatile compounds, and enhance the flavor characteristics, among which phenylalanine may be a potential source of volatile compounds. It is biotransformed by enzyme action or microbial action to produce benzaldehyde.

The authors speculated that the changes of physical and chemical properties and flavor characteristics of sausage might be related to the interaction of endogenous enzymes and meat proteins during sausage processing. In order to further explore the effects of endogenous enzymes of straw mushroom on the flavor and flavor formation of Cantonese sausage. Wang et al. [51] studied the effects of different amounts of grass mushroom endogenous enzymes on the physicochemical and flavor characteristics of Cantonese sausages. The results showed that the endogenous enzymes of grass mushroom could improve the taste, taste and flavor characteristics of sausages by promoting moderate protein hydrolysis and lipid hydrolysis of sausages. Among them, the contents of umami, sweet, bitter and essential amino acids were significantly increased, the alcohol content was significantly decreased, and the ester content was significantly increased, forming the characteristic aroma of sausage, which could not only cover the putrid taste of the product, but also provide floral and fruity flavor for the product. These results indicate that mushroom can be used as a natural flavor additive, which can enrich the types of flavor substances in meat products and promote the formation of flavor substances, and contribute to the development of meat products with better flavor, but the specific mechanism of action is still unclear.

Mushrooms also can be used as antioxidants, when meat and meat products are prone to oxidation reactions during handling, processing, storage and cooking preparation before consumption [52]. Lipid oxidation and protein oxidation directly affect the flavor, color, texture and other quality characteristics of meat and meat products, and reduce the nutritional value and safety [53]. As a result, there is growing interest in products containing natural antioxidants to control lipid oxidation and food spoilage. Mushrooms contain a variety of natural antioxidant components such as polyphenols, flavonoids, dietary fiber, ascorbic acid, carotene, polysaccharide, ergothioneine and terpene, which have antioxidant and free radical scavenging effects and can be used as food antioxidants and supplements to reduce the risk of food oxidation [54].

In recent years, many scholars have studied the antioxidant effect of mushroom and their extracts on meat products, and believe that mushroom and their extracts have antioxidant activity, which can inhibit protein and lipid oxidation to a certain extent. For example, the study of Pahila et al. [55] found that the crude extract of ergothioneine can neutralize hydrophilic and lipophilic active free radicals, thereby controlling the oxidation of astaxanthin lipids and delaying its oxidation process. Ozunlu et al. [56] added oyster mushroom powder to salami to evaluate its effects on lipid and protein oxidation in salami during storage. The results showed that oyster mushroom powder could effectively delay the lipid oxidation and protein oxidation of sausage during storage. Pil-Nam et al. [57] studied the effect of mushroom powder on Frankfurter sausage during storage, and the results showed that mushroom powder could significantly inhibit the growth of TBARs value and the growth of aerobic mold of sausage during storage, without changing the color and texture of sausage during storage, and improve the oxidation stability of sausage. However, in recent studies, the antioxidant effect of mushroom has not been confirmed, on the contrary,

there are studies showing that mushroom can promote product oxidation. For example, Ceron-Guevara et al. [26] studied the effects of Agaricus bisporus and oyster mushroom on the oxidation stability of Frankfurt sausage during storage, and the results showed that Agaricus bisporus and oyster mushroom had higher TBARs value during storage. This may be due to the drying conditions during the drying process, which promote Browning of mushroom and the formation of protein degradation products, which react with thiobarbituric acid to form colored complexes.

In addition, Qing et al. [48] studied the effects of Grass mushroom, Crab mushroom, Oyster mushroom, and Agaricus biporus mushroom powder on the physicochemical properties of minced beef and found that mushroom can promote moderate oxidation of minced beef itself, and the oxidation process may be mainly related to the two effects of active enzymes of mushroom:

1) The endogenous enzymes of mushroom, such as protease and serine protease, can hydrolyze meat proteins, promote the release of peptide chains, and thus make proteins easier to oxidize;

2) The oxidase of mushroom induces protein oxidation and the formation of protein cross-linked structures. It can be seen that the antioxidant effect of mushroom in meat products has not been a consistent conclusion. In the future, it is necessary to further study the effect of mushroom and their extracts on the antioxidant effect of meat products and the internal mechanism, which has positive significance for the quality, function and human health of meat products.

Conclusion

Mushroom are important sources of nutrients and bioactive ingredients, which have high nutritional value, unique flavor and various health functions, and have attracted attention in the field of food processing. Mushroom can be used as animal fat, protein and salt substitutes and flavor additives to improve the nutritional composition and value of meat products, processing characteristics and health characteristics, in line with people's requirements for green, healthy and functional food industry. However, the antioxidant effect of mushroom in meat products is still controversial, and the mechanism of its action in meat products is not deeply studied.

At present, the relevant reports on the application of mushroom in meat products are relatively lacking, which can not meet the needs of current food processing applications. Therefore, in order to better develop new and healthy edible mushroom meat products, the following prospects were made:

1) Further study the effects of different types of mushroom, different addition ratios, and different edible mushroom components (dietary fiber, polysaccharide, protein, etc.) on the physical and chemical properties and nutritional properties of meat products;

2) Further study the potential mechanism of the effects of mushroom and their components on the quality characteristics of meat products, and establish a complete database of the quality changes of mushroom and meat products;

3) More in-depth studies are needed in the future to determine the antioxidant effect of mushroom on meat products and the underlying mechanism;

4) There is a lack of research on the health function of mushroom in meat products, and the potential effects and mechanisms of mushroom applied to meat products on human health and health function need to be further explored in the future.

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