Research and Application Progress of Techniques for Improving Water-retaining Property of Meat Products

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Abstract Water retention techniques have attracted much attention because of its important role in improving the edible quality and increasing the yield of meat products. At present, water retention techniques mainly involve following aspects: raw materials and their treatment, such as water retention treatment before pig slaughtering and animal welfare water retention, processing techniques, such as vacuum rolling, pH adjustment, optimization of cooking methods, high pressure and ultrasound, and addition of water retention substances, such as water-retaining agents, natural water-retaining substances, and biological enzymes. In this paper, the research progress on the possible effects of various water retention techniques on the characteristics of meat products was reviewed.

Key words Meat product; Moisture; Water-retaining technique

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Meat products are an indispensable kind of nutritious food in life, and there are often some problems in production and processing, such as low yield, poor water retention, poor taste and poor texture quality (products with a too-low moisture content are dry, not meaty)[1]. Water-retaining property is an important factor affecting the quality of meat products[2], which not only directly affects the edible quality of meat, such as taste, aroma, juiciness, nutritional components and tenderness[3], but also relates to the product yield, which is the key determining product yield and economic benefits. Therefore, water-retaining property is usually regarded as one of the most important indexes for evaluating the quality of meat products.

The water-retaining property of meat refers to the ability of meat products to keep added water and their own water during production and processing, which is usually realized by electrostatic interaction and the gel-like structure of protein[4]. In order to ensure the economic benefits of meat products, many water-retaining methods have been developed. At present, existing water-retaining methods can be mainly divided into five categories: ① raw materials and their processing and water retention of meat (water retention treatment before slaughter, animal welfare water retention), ② processing technology and water retention of meat (vacuum tumbling, pH adjustment, optimization of cooking methods, high-pressure treatment, ultrasonic treatment), ③ food additives (phosphate, sodium bicarbonate, sodium citrate), ④ natural ingredients (carrageenan, dietary fiber, codlan gum, trehalose), and ⑤ biological enzymes and others (enzyme tenderization, glutamine aminotransferase, papain). This paper summarized the research progress, principle and application prospects of main commonly-used and effective water-retaining techniques at present.

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Raw Materials and Their Treatment and Water-retaining Property of Meat

Water-retaining treatment before pig slaughtering

Pretreatment before slaughtering and slaughtering methods are one of the factors that affect the water-retaining property of meat products. Before pig slaughtering, the vertical hanging basket circulation principle is used to stun pigs with carbon dioxide before slaughtering, which means that pigs enter stun baskets and sink to the bottom with carbon dioxide, causing them to suffocate[5]. Berg *et al.*[6] fed animals with creatine monohydrate (CMH) at the last stage of growth and determined its effect on the quality of fresh pork. The results showed that CMH supplementation could slow down the early and final pH decrease of animals after slaughtering, thus reducing the water loss of animals within 48 h after slaughtering. Clariget *et al.*[7] studied the effects of fasting time before slaughtering on the physiology, carcass and meat quality of beef cattle in pastures or feeding farms. The results showed that fasting time before slaughtering would affect blood parameters related to metabolism, reduce the carcass weight of live cattle and affect beef quality. Shortening fasting time can improve the water replenishment level of beef cattle during slaughtering. Acevedo-Giraldo *et al.*[8] studied the effects of fasting time before slaughtering on animal welfare and meat quality of commercial pigs. The results showed that fasting time had a significant effect on pH value, color and water-holding capacity of meat, and complete fasting for more than 12 h was beneficial to obtain better meat quality.

Animal welfare water retention

Animal welfare refers to the free and comfortable living of

animals in the environment, including following eight animal behaviors: reaction, feeding, adaptation, exploration, self-defense, territory, coordination and rest[9]. In China, at present, it is mainly to stop feeding and allow pigs to rest for half a day to one day before slaughtering, so that pigs can have a full rest in the waiting circle, thereby reducing the stress degree of pigs before slaughtering and improving the quality of meat[10]. Damian Konkol *et al.*[11] studied the application of selenium yeast and plant probiotics in improving the quality of broilers. After receiving plant selenium and organic selenium supplements, the pH value of breast and thigh muscles of broilers was the lowest. Selenium yeast is helpful to reduce the oxidative stress intensity of broiler muscles, especially for thigh muscles. In addition, plant probiotics are more conducive to the absorption of organic selenium and increase the content of selenium in chicken.

Processing Techniques and Water-retaining Property of Meat

Vacuum tumbling

Vacuum tumbling is to impact and beat meat products through machine rotation in vacuum environment, so as to improve the curing speed and the color, reduce the squeezing loss and cooking loss of meat products, and finally improve the water-retaining property and tenderness of meat products and thus the quality and structure of meat products[12]. Yang *et al.*[13] studied the effects of vacuum tumbling technique on the quality of prepared beef. The optimum vacuum tumbling parameters of prepared beef included vacuum degree 0.06 MPa, tumbling time 3 h and liquid-material ratio 32%. With these parameters, the shearing force, chewiness, hardness, resilience, free water relaxation time and immobilized water of prepared beef in the tumbling group were significantly lower than those in static marinating group. Therefore, vacuum tumbling can improve water-retaining property and tenderness, and obviously improve the texture of beef.

Adjusting pH

Adjusting pH value is also one of the commonly used physical water-retaining methods. Generally, the water-retaining property increases with the increase of pH, and reaches the best when pH is 6.5[14]. Goli *et al.*[15] studied the effects of sodium chloride and pH value on water-retaining property and mechanical properties of turkey meat under acidic conditions. The results showed that when the treatment time was short (5 – 20 min), the water loss was serious, and after being marinated by an acid solution, the pH value decreased from 6.1 to 5.1 within the first 5 min, and the cooking loss increased. Starting from 20 min, when the curing time was longer, with the increase of ionic strength and the decrease of pH value (pH value decreased from 6.1 to 4.6), the denaturation of protein could reduce cooking loss. When the curing time was as long as 360 min, the pH value decreased from 6.1 to 4.0, and the cooking loss increased. Swan *et al.*[16] studied the quality characteristics of the barbecue made from semimembranosus and adductor of bulls with high pH value and normal pH value, and the results showed that the cooking loss of the barbecue made from meat with high pH value was significantly reduced.

Optimizing cooking methods

Different cooking methods will also affect the water-retaining effect. For example, Sumer *et al.*[17] studied the effects of direct or indirect grilling of beef on the formation of polycyclic aromatic hydrocarbons and beef quality. Through the detection of water content, cooking loss, pH, lipid oxidation and other indicators, it was found that different cooking methods had no significant effect on the cooking loss of beef, but the cooking degree of beef affected the water content (the water content of direct grilling was 62.26, and that of indirect grilling was 61.80%), and had a very significant impact on the cooking loss (the cooking loss was 36.39% for direct grilling, and 35.91% for indirect grilling). Li *et al.*[18] studied the effects of different baking temperatures on the physical and chemical properties, sensory quality and digestive characteristics of eel hamburgers. The results showed that the water content of eel hamburgers decreased gradually with the increase of baking temperature, but the water-holding capacity remained unchanged. Bainy *et al.*[19] studied the effects of baking and grilling on the physical and chemical properties and texture of tilapia hamburgers. The results showed that there was no significant difference in fat content, moisture content and texture between grilled tilapia burgers and baked tilapia burgers, but baking led to better cooking characteristics.

High-pressure treatment

Proper high-pressure pretreatment can reduce the storage modulus of minced meat, improve the thermal stability of protein of meat products, and fix free water. It can also promote the formation of dense and uniform gel microstructure, and improve the water-retaining property of the gel[20]. Li *et al.*[21] studied the effect of soy protein isolate on the gel properties and water-holding capacity of low-salt pork myofibrillar protein under high pressure, and the results showed that under high pressure (200 MPa, 10 min), treating different concentrations of pork myofibrillar protein with soy protein isolate could significant affect its water-holding capacity. Mootian *et al.*[22] studied the effects of high-pressure pretreatment on the physical and chemical properties of hard clam meat. The results showed that after the clam meat with shell was treated at 552 MPa for 3 min, its volume became larger, its quality did not change significantly, and its drip loss decreased. It was found through comparison that the hardness of clam meat processed at 552 MPa was lower than that processed at 276 MPa.

Ultrasonic treatment

At present, ultrasound is regarded as a new physical non-thermal processing method using sound waves. In food processing, the frequency range is between 20 kHz and 1 MHz. When the ultrasonic intensity is high enough to exceed the intermolecular attraction in the medium, aerated bubbles will be produced[23]. This method has a good effect on water retention, and can provide high water content and yield[24]. This technique is regarded as a green

and promising new technique. In meat processing, it has been applied to the processes of meat tenderization, microbial inactivation, curing, freezing, homogenization, crystallization and drying[25]. Pinton *et al.* [26] studied a new method of producing phosphate-free meat emulsion by using high-power ultrasound and bamboo fiber (BF). The results showed that adding 2.5% bamboo fiber could effectively improve the texture change caused by no phosphate. High-power ultrasound improved the effect of bamboo fiber on the texture of meat emulsion by improving cohesion. This technique can realize phosphorus-free water retention.

Food Additives

Water retention by phosphates

Phosphates are mainly divided into orthophosphates and polyphosphates, while condensed phosphates include polyphosphates, metaphosphates and pyrophosphates, which are widely used in food industry. Fewer kinds of metaphosphates are applied in food industry, including polymetaphosphate and hexametaphosphate, of which hexametaphosphate is the one with strong water absorption and more application in compound production[27]. Under the condition of acidity or temperature rise, condensed phosphates will be hydrolyzed to form polyphosphates or orthophosphates with short chain length capable of complexing with cations in solutions, which can enhance the ionic strength of the solutions and greatly improve the hydrolysis speed[28].

Mechanism of water retention by phosphates: ① Phosphate buffer will change the pH value of meat products, and actin and myosin in muscles will shift from their isoelectric points to dissolve. And whether pH is lowered or raised, the water-retaining property of protein will be improved. However, phosphates can increase the pH value of meat, enhance the interaction between water molecules and protein, and improve the water-retaining property of protein[29]. ② Phosphates can bind calcium ions and magnesium ions in muscles, and there is a strong electrostatic repulsion between carboxyl groups and myofibrillar protein released from muscle protein, which makes the protein structure loose and have a large spatial structure that can absorb water[30]. ③ Phosphorylated protein disulfide bonds and sulfhydryl groups have strong effects. Negative charges in phosphates will draw hidden hydrophobic groups out and expose them on the surface of protein, which increases the hydrophobicity of the surface. Strong ionic strength can promote the dissolution of protein and improve water retention[31]. ④ The tenderness of meat is usually improved by improving the water-retaining property of meat, and myosin is the main component which improves the water-retaining property of meat. Actin and myosin can be dissociated from actin by adding pyrophosphates, tripolyphosphates and phosphates[32].

Ren *et al.* [33] found that the order of water-retaining effect of compound phosphates on chicken breast meat was: sodium pyrophosphate > sodium tripolyphosphate > sodium hexametaphosphate. Li *et al.* [34] studied the effects of different kinds of phosphates on the moisture content of refrigerated yak meat products. They found that with the increase of phosphate mass fraction, the water-retaining effect of yak meat was strengthened at first, and the best water-retaining effect was achieved until a certain critical point (0.36% – 0.41% sodium pyrophosphate, 0.30% – 0.45% sodium tripolyphosphate and 0.35% sodium hexametaphosphate). When the mass fraction continued to increase, its water-retaining effect was weakened. Li *et al.* [35] found that the yield and moisture content of sauce beef were the highest, and the hardness and chewiness were the lowest when adding proper amount of compound phosphate (0.4%).

Water retention by sodium bicarbonate

Sodium bicarbonate is a common and safe food material in life[36]. The water retention mechanism of sodium bicarbonate is attributed to adjusting pH value, releasing CO_2 enhancing the thermal denaturation of connective tissue when heated, weakening the cross-linking between myosin and actin, and improving the solubility of myofibrillar protein[37]. Li *et al.* [38] studied the effects of sodium bicarbonate on the water-retaining property of chicken breast meat. The results showed that the loss of squeezed juice in the control group and the experimental group was 24.73% and 18.92%, respectively. The drip loss was 1.69% and 1.42%, respectively. The cooking loss was 17.66% and 13.66%, respectively. The loss of thawed juice was 5.73% and 2.49%, respectively. According to the data, sodium bicarbonate could significantly improve the water-retaining property of chicken breast meat.

Water retention by sodium citrate

Zhao *et al.* [39] studied the effects of sodium citrate with the concentrations of 0.1%, 0.15%, 0.2%, 0.25% and 0.3% (*w/w*) in the experimental groups and sodium bicarbonate with the concentration of 0.2% (*w/w*) in the control group on the water-retaining property of frankfurters. When the concentration of sodium bicarbonate was 0.2% and the concentration of sodium citrate was 0.15%, the water-retaining effect was equivalent to that of the control group. Therefore, the combination of sodium citrate and sodium bicarbonate can replace phosphates and meet the requirements of green production. Ruusunen *et al.* [40] studied the effects of the contents of sodium citrate, carboxymethyl cellulose and carrageenan on the quality characteristics of low-salt and low-fat Bologna sausages. The results showed that sodium citrate and carrageenan could increase the flavor of low-salt and low-fat sausages, while sodium citrate alone would reduce the juice loss. Adding compound additives was better than adding single additives, and the best combination was sodium citrate and carrageenan. Muench *et al.* [41] studied the influence of potential additives on frankfurters with natural casing, and the results showed that the quality of frankfurters with natural casing could be improved by using sodium citrate alone or the mixture of sodium citrate and sodium diacetate. Song *et al.* [42] studied a new compound water-retaining agent and its application in chicken skewers. The new compound result was 0.4% soybean dietary fiber, 0.15% carrageenan, 0.1% acetate corn starch and 0.07% sodium citrate, which could obviously

improve the product quality.

Natural Ingredients

Water retention by carrageenan

Carrageenan is an important food additive with good solubility, viscosity, gelation and synergistic effect with other polysaccharides or protein[43]. Carrageenan forms a double helix structure, and then micelles are formed by molecular extension and a part of molecules arranging in a straight line. A large number of polysaccharides are bonded at different sites to form different three-dimensional network structures filled with water molecules. If the network is closely arranged, the ability to wrap water will be poor and it will be easy for it to secrete water; and if the reticular space is large, it will have a strong ability to wrap water and water secretion will not be easy[44]. Moreover, the molecular structure of carrageenan contains many hydrophilic groups, such as hydroxyl groups, which can also improve water-retaining property[45]. Wu *et al.*[46] studied the effects of carrageenan oligosaccharide on water retention of prawns. The results showed that the soaking treatment using carrageenan oligosaccharide could effectively reduce the thawing juice loss of frozen prawn meat (the thawing loss was 12.8%, 7.6% – 9.1% and 4.4% – 9.9% after being treated with distilled water, carrageenan oligosaccharide and pyrophosphate, respectively, and frozen for 6 weeks), and it had good effects in keeping the texture and color of prawns, delaying the decrease of myofibrillar protein content and protecting Ca^{2+}-ATPase activity. In addition, carrageenan oligosaccharide treatment had a good effect in maintaining the microstructure of frozen prawn meat, and the treatment effect with carrageenan oligosaccharide at the concentration of 3 g/100 ml was the best. Chen *et al.*[47] studied the effects of κ-carrageenan on the water retention and texture of low-fat pork gel. The results showed that κ-carrageenan had a significant effect on the water retention and texture of minced pork, and the addition of 0.5% κ-carrageenan could significantly reduce the cooking loss of pork gel and improve the total water-holding capacity and gel hardness.

Water retention by dietary fiber

Dietary fiber is the residue of plant food that resists the hydrolysis of human digestive enzymes, and it is composed of cellulose, hemicellulose and lignin[48]. Ma[49] studied the effects of soybean dietary fiber on sausage quality. The results showed that when adding the same amount of soybean fiber, soybean dietary fiber added with water resulted in lower hardness, lower water-retaining property and higher yield than dietary fiber without the addition of water. When no water was added, the optimum amount of soybean dietary fiber protein was 4%; and when water was added, the optimum amount of soybean dietary fiber protein was 8%. Zlatanoviĉ *et al.*[50] found that rough apple pomace had advantages in sensory characteristics, content and retention of dietary compounds and antioxidant (AO) activity. Wu *et al.*[51] investigated the effects of seaweed dietary fiber on the quality of low-fat and low-salt chicken frankfurters. The results showed that seaweed dietary fiber could improve the water-holding capacity and gel properties of low-fat and low-salt meat paste system, and then improve the edible quality of the product. Zhang *et al.*[52] studied the effect of water-insoluble seaweed dietary fiber on the physicochemical parameters of ham products. The results showed that the nitrite content decreased with the increase of seaweed dietary fiber content. However, less than 10% gave better flavor, taste and texture characteristics. Therefore, 10% addition was the best. Zhang *et al.*[53] studied the effects of different citrus fibers and their addition on the yield and quality of sauced beef. The results showed that adding citrus fibers could improve the yield of sauced beef. When adding citrus fiber of model CF100H60 with a concentration of 0.5%, the yield and sensory score of sauce beef were the highest.

Water retention by curdlan gum

Curdlan gum, also known as hot gel, gel polysaccharide and coagulated polysaccharide, is a water-insoluble glucan formed by β-1,3-glycosidic bonds, with triple helix conformation[54]. Curdlan gum has the characteristics of gelation, emulsibility, film-forming property and oxidation resistance.

Gelation: Its aqueous suspension can form two kinds of gels with different structures at low temperature and high temperature, which are called low-solidification thermally-reversible gel and high-solidification thermally-irreversible gel, respectively[55]. The gel used in food industry is generally high-solidification thermally-reversible gel, the strength of which is better than that of low-solidification thermally-reversible gel[56]. It is generally believed that the gelation mechanism of curdlan gum for heat-induced gel is related to its triple helix structure. Its triple helix structure turns into a single helix structure after heating, and single helices dominate after annealing. Part of the single helix structure re-spins into triple helices, and micelles are connected by hydrogen bonds, finally forming a low-coagulation reversible gel. When a triple helix structure is unwound at high temperature into a single chain, which then re-spins into a large number of triple helices, the network structure formed by the hydrophobic interaction between hydrogen bonds and micelles is very tight, and the gel strength is also higher than that of low-solidification thermally-reversible gel[57].

Emulsibility: Curdlan gum plays an important role in stabilizing oil-water interfaces, so it can be used as a good stabilizer and emulsifier. Mechanism: Curdlan gum combines with grease to form an elastic layer on the surface of oil droplets, which prevents the oil droplets from gathering by forming electrostatic effect and effective steric hindrance[58].

Film-forming property: At present, there are few studies on the mechanism of polymeric polysaccharide film formation, and the formation of polymer film includes three stages, solvent evaporation, elastic solid and complete film[59].

Oxidation resistance: Curdlan gum has the ability of inhibiting lipid oxidation and scavenging free radicals in food[60]. Li *et al.*[61] found that curdlan gum could increase the content of

non-flowing water in braised beef and reduce the content of free water when studying the effects of curdlan gum on braised beef. When 2% curdlan gum was added, the cooking yield increased by 33.43%. However, when curdlan gum was further added, the braised beef was in a gelatinous state and its sensory quality decreased. Chen *et al.* [62] found that the water-retaining property of quick-frozen beef patties with the addition of curdlan gum subjected to acid-base neutralization pretreatment was significantly improved, higher than that of quick-frozen beef patties with the addition of curdlan gum powder without pretreatment. The quality of quick-frozen beef patties was the best when adding 0.5% of natural gum with acid-base neutralization pretreatment. Zhao *et al.* [63] studied the regulation of curdlan gum on the water-retaining rate and texture characteristics of low-salt emulsified pork sausages. The results showed that adding 0.3% -0.9% curdlan gum could obviously improve the texture characteristics of emulsified sausage, such as resilience, chewiness and hardness, and increase the water-retaining rate. The addition of curdlan gum at 0.3% -0.6% could produce emulsified sausage with low sodium salt content and good texture characteristics. Cui *et al.* [64] studied the effects of curdlan gum-konjac gum complex on the gel characteristics of surimi sterilized at high temperature. The results showed that curdlan gum-konjac gum complex was not conducive to the gel formation of surimi, and it decreased with the increase of konjac gum ratio; and the water-holding capacity and whiteness decreased. Li *et al.* [65] studied the effects of curdlan gum and modified starch on the gel properties of catfish surimi. The results showed that the quality of fish balls could be improved when CDG was compounded with starch acetate of cassava, and when the addition amounts were 6% and 0.9% respectively, the resilience, whiteness and water-holding capacity of fish balls were the highest.

Water retention by trehalose

Trehalose, also known as yeast sugar, has many advantages and great development prospects. It is widely exists in nature and has good stability, so it has the characteristics of large output, low price and good frost resistance and water-retaining effect[66]. Alginate is a salt substance of alginic acid extracted from brown alga (kelp, kelp, *etc.*). It not only has good water-holding capacity, stability, gelation, thickening property and film forming property, but also is safe, non-toxic, non-irritating, tasteless, biocompatible and biodegradable. The long-chain molecular structure of alginate can penetrate into muscles, forming a coating on the surface of the muscles to prevent water loss and improve the quality of meat products. Meanwhile, it can enhance the mechanism of muscles, make the meat more fibrous, and improve the taste of meat products. Therefore, it has high application value in the processing and production of meat products[67]. Dai *et al.* [68] studied the effects of sodium alginate on fish sausages when added at the concentrations of 0%, 0.1%, 0.2%, 0.3%, 0.4% and 0.5%, respectively. The results showed that 0.3% sodium alginate had the best water-retaining effect.

Biological Enzymes and Others

Water retention by enzyme tenderization

Enzymatic tenderization can be divided into endogenous enzyme tenderization and exogenous enzyme tenderization. The endogenous enzyme system is mainly composed of calpain activator, proteasome and cathepsin (lysosomal protease). It is generally believed that the improvement of muscle tenderness after slaughtering is mainly due to the degradation of myofibrillar protein by endogenous enzymes. At present, it is widely believed that the proteolysis of muscles after slaughtering is the synergistic effect of the endogenous enzyme system, and the endogenous enzyme tenderization method has a better tenderization effect, but it mostly relies on physical methods to activate endogenous enzyme activity and exert tenderization[69-70]. Exogenous enzyme tenderization is to artificially add protease preparations to improve muscle tenderness. Exogenous enzymes used for muscle tenderization are mainly divided into plant protease (papain, bromelain, *etc.*) and bacterial protease (neutral protease, *etc.*)[71]. Chemical enzymatic processing techniques refers to the use of enzymes to catalyze the polymerization and covalent cross-linking reaction between myofibrillar protein of meat and the optimal substrate of enzymes, such as casein, soy protein isolate (SPI) and other homologous or heterologous protein groups[72]. Chemical methods involve the use of additives or chemicals for improving the water-retaining property of food. These methods usually affect the composition and structure of food, so as to reduce water loss and improve quality.

Water retention of transglutaminase

Transglutaminase (TG) is an enzyme that can catalyze the transacylation reaction and result in cross-linking between protein molecules[73]. The addition of TG enzyme can reduce the α-helix content of frozen-damaged myofibrillar protein (MP), but significantly enhance the cross-linking and heat-induced gelation behavior of frozen-damaged myofibrillar protein (MP), so its cooking loss is slightly reduced. Although the existence of L-arginine (Arg) significantly inhibited the development of heat-induced storage modulus (G') and reduced the hardness of frozen myofibrillar protein (MP) gel, the combination (Arg + TG) showed lower cooking loss and improved texture characteristics, and the gel showed the most exquisite and compact microstructure. The results showed that the combination of transglutaminase and L-arginine may be a potential strategy to improve the gelation properties of frozen-damaged meat protein[74]. Zhao *et al.* [75] studied the effects of different concentrations of TG enzyme on the water-retaining property of minced beef. It was found that with the increase of TG enzyme, the water-holding effect became better, the resilience and cohesion continued to increase, and the hardness and chewiness did not change significantly. However, after the concentration was 0.6%, there was no significant difference in water-retaining effect, and the hardness and chewiness decreased. When adding 0.6% TG enzyme, the total juice loss decreased by 4.75% compared with the control group, so when adding TG enzyme alone, the water-retaining effect was the best when its

concentration was 0.6%.

Papain

Chen *et al.* [76] found that adding 1% calcium chloride, 0.4% papain and 0.2% compound phosphate was the best tenderizer formula when studying the effect of compound tenderizers on goose jerky. Shi *et al.* [77] studied the effects of calcium chloride and papain on the sensory quality of air-dried meat. They found that the optimal tenderizing concentration of calcium chloride was 0.3 mol/L and that of papain was 0.04%, and the sensory evaluation of air-dried meat tenderized by papain was better than that of air-dried meat tenderized by calcium chloride.

Water retention by soybean protein isolate

Soybean protein isolate, also known as isoelectric point protein powder, is a high-purity plant protein product[78]. Soybean protein isolate mainly has water absorption and water retention, emulsification, gelation, oil absorption, foaming and other properties[79]. Among them, the water-retaining property is mainly due to the fact that when soybean protein isolate is added to minced meat and heated, water molecules fully contact with the minced meat, and a large number of water molecules wrap protein, resulting in hydration, which makes protein have water-retaining property[80]. Nie *et al.* [3] studied the effects of soy protein isolate on the water-retaining property of new duck ham. The results showed that when 4% soy protein isolate was added, the new duck ham could achieve better sensory quality and lower cooking loss, and its cooking loss was 25%. Coconut meat protein is an extract of fresh coconut meat, which has rich nutritional and functional characteristics[81]. Zhang *et al.* [82] investigated the effects of coconut protein on the water-retaining property of Wenchang chicken myofibrillar protein gel, and found that with the amount of coconut protein increasing, the water-retaining property of myofibrillar protein gel decreased, and the gelation became worse, and the water separation phenomenon of gel was serious.

Water retention by arginine and lysine

L-arginine and L-lysine, as natural spices, are included in GB 2760-2014 *National Food Safety Standard: Standard for the Use of Food Additives*. Guo *et al.* [83] and Li *et al.* [84] confirmed in their studies that arginine and lysine could significantly reduce the α -helix structure content of myosin and increase the content of surface hydrophobic groups and active sulfhydryl groups, indicating that arginine and lysine can induce the partial unfolding of myosin molecules, thus inhibiting myosin aggregation and enhancing the interaction between myosin and water. Lei Zhen *et al.* [85] studied the effects of different concentrations of L-arginine (Arg) on chicken actin. The experimental results showed that adding 0.3% L-arginine (Arg) had the best water-retaining effect on chicken actin, and its WHC value was 85%.

Conclusions

At present, there are more and more methods about water retention of meat, including the combination of physical methods and additives, such as the addition of sodium bicarbonate during rolling, and the effects of high static pressure and carrageenan on water retention and texture of low-fat pork gel. The combination of chemicals is also adopted, such as the effects of calcium chloride and papain on the sensory quality of air-dried meat and the effects of TG enzyme, compound phosphate and sodium bicarbonate on the water-retaining of minced beef. However, there are still bottlenecks in water conservation. For example, it is difficult to achieve phosphorus-free water conservation in actual production, and the problems in cost and sense of phosphorus-free water conservation need to be improved.

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