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Mini Review

Research Progress on Antimicrobial Peptides within the Food Industry

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Introduction

Antibacterial peptides, also known as antimicrobial peptides or natural antibiotics, are encoded by specific genes in a variety of biological cells, and are broad-spectrum polypeptides with applications including anti-bacterial, anti-fungal, anti-virus, tumor cells, etc [1]. They area class of small molecular peptides with 10-50 amino acids, most of which are cationic, and are widely found in organisms, including bacteria, fungi, plants, insects, fishes, birds, crustaceans, amphibians and mammals. In addition to their broad-spectrum antimicrobial activity, antibacterial peptides also have good resistance of high temperatures, good thermal stability and are highly safe. Surprisingly, the action mechanism of antibacterial peptides is unique and cells don't evolve and acquire "multidrug resistance" (MDR) [2]. Consequently, there are potential application values in the food industry, agriculture, animal husbandry, pharmaceutical industry, health care products, and cosmetics processing industries. At present, Nisin, the first and only antibacterial peptide approved for food preservation, has been used in more than 50 countries and regions worldwide [3].

Application in Food Preservation

We all know that food preservation involves legacy technologies with use of large amounts of chemical preservatives or physical means such as pickling (involving sugar, vinegar, salt, etc.), smoking or drying, with little focus on food safety, quality, and flavor. Natural preservatives have the advantages of low toxicity and few side effects, as well as degradability, and safety. Therefore, there has been a growing interest in natural preservatives [4]. Among the natural preservatives, antibacterial peptide preservatives have attracted thorough attention and are increasingly becoming a popular research topic in food preservation because of their safety, non-toxicity, and beneficial health effects. Hisako [5] reported that only adding a small dose (nmol/g grade) of insect antibacterial peptides during the processing of meat products could control the growth of bacteria and maintain the flavor and color of foods. At the same time, it could also reduce the content of nitrite and nitrosamines that can endanger people's health. Fang et al. [6] studied that a novel zinc chelate peptide was prepared with protein hydrolysate in octopus scrap and had excellent antibacterial activity against Staphylococcus aureus. The study indicated that zinc peptide chelate, as a natural bacteriostatic agent, has potential application prospects in the food industry. Hajer et al. [7] investigated two biologically active peptides (PHAB-s and PHAB-p) with antioxidative and antibacterial activities which were prepared and separated by using byproducts of European prion as raw material. Both of these peptides could prevent fat oxidation of meat products during storage and inhibit the growth of yeast, mold and coliforms. Thus, they could replace traditional preservatives and are widely used in the storage of meat.

Application in Fruit and Vegetable Preservation

There are many kinds of rot pathogenic bacteria in fruits and vegetables, and there are many traditional sterilization methods, such as application of high temperature and extra high voltage, which can damage tissues and cause the loss of nutrients, thereby affecting the corresponding quality of the produce. Interestingly, bio-derived antibacterial peptides have a broad antibacterial spectrum, they can maintain the product flavor at room temperature, extend the shelf life of fruits and vegetables, and ensure food safety. Therefore, they has the potential to replace chemical preservatives in preservation of fruits and vegetables. Patil et al. [8] separated an antibacterial peptide RPT-0001 that can inhibit the activity of Gram-negative and Gram-positive bacteria, and silver nanoparticles were synthesized with RPT-0001.Compared with the citrate-coated silver nanoparticles, RPT-0001 and SNPs had good antibacterial synergistic effects, and therefore could be widely used in food preservation, packaging materials and treatment of food-borne infections. Zhang Suqin et al. [9] found that Nisin significantly reduced the decay rate of white jade at 4 °C. Mythili et al. [10] found that Nisin not only extended the shelf life of Carrots for 15 to 25d, also reduced the discharge of freon, thereby protecting the environment. Tao Weiyu [11] added antibacterial peptide from Potassium Bacillus subtilis R21-4 to 1% pullulan and coated broccoli with this mixture at 10 °C, finding that the peptide could effectively delay the decay of broccoli. Li Meng et al. [12] studied the effects of different concentrations of gluconolactone, chitosan and antimicrobial peptides (produced by Bacillus licheniformis ES-2-4) on the preservation of cherry tomatoes at 8 ± 1 °C. They obtained the optimal combination that was 0.5% gluconolactone + 4% chitosan + antibacterial peptide stock solution [12].

Application in Active Packaging

Antibacterial packaging, the most important one in active packaging, can be accomplished using high-molecular polymers and antibacterial agent. The antibacterial agent can slowly and continuously penetrate into the surface and inside of food from the packaging material, finally killing bacteria by destroying the osmotic pressure of bacterial cells [13]. Cui Shanshan et al. [14] added Nisin to the carrier material and applied it to the PE film, forming a 0.07 mm coating film. Nisin would diffuse out and achieve the antibacterial effect when contacting with the solution, and as the temperature increased, the diffusion coefficient increased. Ercolini et al. [15] added Nisin to plastics to make an antibacterial packaging for refrigeration of beef at 1°C. It was found that the packaging not only reduced the amount of G+, but also did not affect the original microbial population in the beef for maintaining meat nutrition. Alrabadi et al. [16] stored cheese with low density polyethylene film (LDPE) containing 2,000 IU/mL Nisin at room temperature and found that Nisin antibacterial packaging had a food preservation effect by effectively inhibiting microbial growth and reducing release of some volatile metabolites [17]. Ferrocino et al. [18] found that the number of microorganisms could be effectively controlled when they preserved beef with a Nisin antibacterial package under vacuum at 1°C.

Conclusion and Perspective

Antibacterial peptides, as natural antibacterial agents with safe, non-toxic side effects, broad antibacterial spectra and high efficiency sterilization, have excellent potential application value, but still face many challenges in the corresponding industrialization and marketization. The primary problem of large-scale production is the high production cost; the levels of antimicrobial peptides are extremely small in living bodies and difficult to separate and purify, so that chemical synthesis is the main means of synthesis of small molecule peptides. In addition, the antibacterial activity of many natural antibacterial peptides is relatively low. For example, Nisin has an inhibitory effect on most Gram-positive bacteria, but has no effect on Gram-negative bacteria. Thus, how to maintain the structural advantages and simultaneously design new antimicrobial peptides that have high antibacterial activity, high stability, low hemolytic activity and low cytotoxicity through methods containing the replacement of amino acids, the construction of hybrid peptides, chemical library combination, and so on, are important and difficult points for the development of antimicrobial peptides at present. In addition, when the antimicrobial peptide is made into a packaging material, there are further areas to be explored including stability, controlled release, release amount, and the effect of external conditions.

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