Advances in the study of chromogenic agents in meat products

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Abstract. In order to improve the organoleptic properties, edible quality and flavor of meat products, and extend its shelf life, some additives are commonly used to guarantee the color retention of meat products. Nitrate and sodium nitrite are frequently-used chromogenic reagents, but it has been proven that their usage has potential safety risks. Excessive consumption of them can cause carcinogenesis, teratogenesis, and mutation. Therefore, the search for other effective alternatives is imminent, which has become a research hotspot at home and abroad. This paper expounds the problems in the processing of meat products and the mechanism of chromogenic reagents. The effect of chromogenic reagents on the preservation of meat products is also discussed, which provides a reference for further research on meat chromogenic reagents.

1. The quality change of meat products and the mechanism of nitrate

1.1 Changes in the color of meat products

The quality of meat and meat products was evaluated by its color, flavor, tenderness, water retention and juiciness. The color of meat is the first impression consumers have on the quality of meat. The meat color is of varying shades of red, which mainly depends on the pigment substance in the muscle and residual blood, namely, myoglobin and hemoglobin, respectively. The REDOX of the heme center iron ion of myoglobin and the binding status of oxygen are the direct causes of the change of flesh color (Fig.1). Generally, the changes in meat color go through two processes. Firstly, the myoglobin in fresh meat reflects dark purple, very unstable, and if not taken care of, it will be oxidized to show bright red in the air in less than 3 h. Secondly, bright red will turn to brown, the slowing of which is the key to color retention.

Fig.1 Transformation of various chemical states of myoglobin
1.2 Nitrates and nitrites

1.2.1 Mechanism of color-protective effects of nitrates and nitrites and their risks
Nitrates have been added to meat products for thousands of years, from which nitrites are produced. In weak acid condition, nitrous acid is formed by nitrites, which is very unstable. As a result, the formation of nitric oxide (NO) by hemoglobin is accelerated, and nitroso myoglobin is also generated. When heated, nitroso myoglobin will release thiol and stable nitroso with bright red color is formed, rendering special salted color to meat, which is the chromogenic mechanism of the meat.

Although nitrates is chromogenic, antibacterial, antioxidative and flavor-enhancing, researchers come to discover that nitrites can react with secondary amine in meat products to form nitrosamine, which is a strong carcinogen[1]. Animal experiments showed that the carcinogenic effect can be found in not only long-term low-dose consumption but also a sufficient amount of one-time consumption.

1.2.2 Research progress of substitutes for nitrate and nitrite
Since 1950, when someone found out that dimethylnitrosamine can trigger cancer, scholars around the world have set off a search for alternatives to nitrite in meat products[2]. Unfortunately, no substitute has been found to completely replace nitrite.

At present, looking for effective substitutes for nitrate and nitrite is prone to the following aspects: Limit the use of nitrite in the processing of meat products so as to lower the residue of nitrite;(2) Inhibit the formation of RNNOs to avoid its harmful effect on the human body;(3) Use mixed additives such as chromogenic reagents, chelating agents, antioxidants, antibacterial agent and other components instead of nitrite additives[3]. In view of this, considering the role played by nitrite, the research was mainly carried out from the aspects of chromogenic, antibacterial, and antioxidant substitutes. In recent years, the research on color fixatives compound has become increasingly mature.

2. Other color fixatives

2.1 Natural chromogenic substitutes
Monascus red is a kind of natural pigment produced and secreted by mycelia of Monascus during the process of growth and metabolism. Monascus is the secondary metabolite of Monascus, derived from microorganism[4]. After years of exploration and experiments, researchers have concluded that Monascus red has coloring, anticorrosion, health care and medicinal value[5]. Because of its coloring and preservative effect, Monascus red is widely used in meat and salted products, which can enhance the flavor of food, render food special color, prolong its shelf life and reduce the dosage of nitrite. In recent years, due to the continuous development of the food industry and the improvement of living standards, people are more prone to green food, Monascus red is more and more popular and favored by people, which has been widely used in the processing of bacon, ham sausage, sausage and other meat products. Zou Yu[6] found that the addition of Monascus red can increase the amino acid content in meat products and give the food a good flavor. The results[7] showed that when the dosage of Monascus red in low-salt petre was 0.14 g/kg (the amount of sodium nitrite was 0.04 g/kg), it could meet the sensory requirements of consumers, and the stability was also greatly improved. Li Yanping and other[8] found that adding Monascus red could increase the content of amino acids in meat products and give food a good flavor. Investigator[9] found that Monascus red could effectively inhibit the changes of protein MP molecular structure of pig muscle and maintain the stability of its secondary structure. The analysis MP solubility, emulsification and rheological properties of pork showed that Monascus red could effectively improve the hydrophilic, surface and gel properties of MP. Too high or too low concentration of Monascus red could affect the processing performance of low nitrate meat products. The optimum addition amount of Monascus red was 0.15%. The functional properties of protein in pig muscle were better than that in high sodium nitrite (0.01%) experimental group. The easy oxidation and light instability of Monascus red were studied[9]. The object of the experiment was beef sauce, and three color fixatives (sodium ascorbic acid, tea polyphenols, glucose)
were used. The chromogenic subgroups of pigment were protected, and the color reduction was inhibited with the purpose of function complementation and synergistic effect achieved. It has been proved that the color fixative has a good color protection effect and products still possessed a considerable red color after stored for 28 days. Therefore, *Monascus red* can be used as chromogenic reagents in meat products processing to partly replace sodium nitrite, so as to achieve low nitrate in meat products, with broad application prospect.

2.2 Antibacterial substitutes

Nisin is a polypeptide substance, which is a non-toxic, highly effective and natural preservative produced by *Streptococcus lactis* during metabolism, which has a significant inhibitory effect on gram-positive bacteria such as *Clostridium botulinum* and *Listeria* \[10\]. It can be broken down into small molecules of amino acids during human metabolism. Some people had studied the preservation effect of 0.5% nisin on frozen grass carp slices, by determining of total microbial population, volatile base nitrogen (total volatile base nitrogen; and TVB-N) value, volatile odor, pH value and K value, to evaluate the quality change of grass carp slices \[11\]. It turns out that, during storage, the colony total, TVB-N value and K value of 0.5% Nisin treated grass carp were lower than that of control group; pH values decreased and then rised. The electronic nose test showed that, Nisin could effectively slow down the deterioriation of fish flavor. The result showed that 0.5% Nisin preservative had better preservation effect on grass carp slices under cold storage and could extend the shelf life of grass carp slices. According to the study of Xu Haixiang \[12\], there is no significant difference in the quality of Chinese sausage treated with 600 mg/kg Nisin and 40 mg/kg nitrite and that of Chinese sausage treated with 90 mg/kg nitrite. To sum up, not only can Nisin partly replace the use of nitrite, but also it can inhibit the growth of harmful bacteria, extend the shelf life of products, prevent corrosion and prevent poisoning, thus greatly enhancing the safety of food. Moreover, study \[13\] showed that fermented celery powder can inhibit the growth of *Listeria monocytogenes* without negatively affecting the quality and sensory properties of the product. Chitosan has been widely used in food due to its edible, non-toxic, antioxidant and bacteriostatic properties \[14\]. And when chitosan reacts with glucose and other monosaccharides in maillard reaction, the antibacterial and antioxidant abilities were significantly enhanced \[15\].

2.3 Antioxidant substitutes

Antioxidants such as vitamin C and Vitamin E can prevent the oxidation of myoglobin to ferrimyoglobin and promote the transformation of ferrimyoglobin and oxygenated myoglobin, effectively extending the preserving time of meat (Fig 2).

![Fig.2 Effects of Vitamin E and Vitamin C Immersion on Changes](image)

Tea polyphenols, a kind of natural food antioxidant, mainly exists in tea, have antioxidant effect and strong antibacterial effect. Du Wei added a certain amount of tea polyphenols to sausage, results showed that not only it can reduce the residual amount of sodium nitrite in the product (up to 57.54%
at least\cite{16}, but also it can effectively prevent lipid oxidation. Spices also have a strong antioxidant effect owing to its rich content in VC, flavonoids and other reducing substances, which has a strong blocking effect on nitrification reaction. Experimental studies have shown that ginger, garlic and turmeric also have antibacterial and antibacterial effects\cite{17}. Terpenoids such as carnosic acid, carnosic phenol, rosmarinol and rosmarinic acid in rosemary are the main active components that play an antioxidant role\cite{18}. In addition, clove and cinnamon have good antioxidant properties because they contain eugenol and cinnamonaldehyde. Chen Lu found that adding 0.04% rosemary, 0.04% clove and 0.04% cinnamon can delay the lipid oxidation of quick-frozen meatballs and inhibit the growth of microorganisms\cite{19}.

3. Conclusion
To sum up, over the years, although researchers have found a variety of color fixatives, their effects are not strong when used individually, which cannot completely replace the role of nitrite. Nitrite plays an indispensable role in some food processing, but its disadvantages should not be ignored. It will still be the first choice of meat processing enterprises at present owning to the lack of substitute and low costs. How to reduce the usage of nitrite in meat products and find its substitute is still an important research direction in the future academic circles, driving a group of researchers to strive for it.

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