Research progress on the effect of microwave sterilization on agricultural products quality

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Abstract: Different sterilization methods have different effects on the quality of agricultural products, microwave sterilization inhibited or eliminated microorganism by the use of microwave thermal effects and non-thermal. In this paper, the effects of microwave sterilization on the quality of fruits and vegetables, dairy, meat, grain, aquatic products and other agricultural products were introduced, and the possible development trends of microwave sterilization in agricultural products processing application were put forward.

1. Introduction
Traditional heat sterilization was mainly carried out by heating, with the characteristics of slow heat transfer and long sterilization time, which seriously affects the quality of agricultural products such as color, texture and flavor. Microwave sterilization is a new type of sterilization technology, with strong penetration, short heating time, uniform heating [1,2]. There is a trend that manufacturers of agricultural products choose microwave sterilization instead of heat sterilization [2]. But there was no systematic research report at present whether the quality of agricultural products have changed after microwave sterilization. In this paper, the effects of microwave sterilization on the quality of fruits and vegetables, dairy products, meat, grain and other agricultural products were analyzed, which aimed at providing a theoretical and application basis for microwave sterilization technology in the processing of agricultural products.

2. Research status of microwave sterilization on processing quality of agricultural products

2.1 Effect of microwave sterilization on fruit quality
In view of the problems of the traditional sterilization of juice on quality, Yu Xiu-li et al [3] optimized microwave sterilization conditions of mango puree by orthogonal experiment and compared with the quality of pasteurization process. The results showed that when the microwave sterilization conditions of power, treatment time and sample initial temperature were fixed at 550 W, 60 s and 35℃, it can inhibit the degree of browning with the mango puree, and it can protect the nutritional content and color. Compared with the pasteurization treatment, the use of microwave sterilization can achieve bactericidal effect increasingly and maintain original quality.

Microwave sterilization can effectively retain the functional substances in fruit juice [4]. Wang Jinjin[5] investigated the changes of activity index of loquat juice stored in 4℃ after microwave sterilization.
sterilization, the results shown total phenols, Vc and scavenging capacity of DPPH• were significantly increased, PPO and POD were completely inactivated, but the effect on pH and SSC were slight, indicating that microwave sterilization technology not only has a good bactericidal effect, but also maintains the quality of loquat juice.

2.2 Effect of microwave sterilization on fruit cake and vegetable noodle
Xiao Nan [6] studied the microwave sterilization process for the Sanhuali fruit cake. They used orthogonal experimental methods to study the impact of microwave sterilization power, microwave sterilization time and cake thickness on the quality of Sanhuali cake. The results showed that the best parameters were sterilized at microwave power of 480W and cake thickness of 0.4cm for 50s, In this condition, the cake could preserve the nutrition of Sanhuali fruit and the color reserved. Wu Zhen[7] investigated the shelf-life of microwave sterilization treatment of wetting noodle with pumpkin to improve preservation, indicated that the shelf-life of pumpkin noodle in 4℃was 65 days, carried out by microwave power 800W, treatment time 22s.

2.3 Effect of microwave sterilization on mushroom quality
The problems of high moisture content, surface without protection structure, susceptible to microbial infection in Fresh mushroom industry caused the difficulty of producing and saling widely. Xiao Fei [8] explored the quality of mushrooms on microbiology, color, texture, oxidase activity, total phenols and antioxidation after microwave sterilization in the storage process. The study found that microwave sterilization time affected on the color and texture of mushroom significantly. When the microwave treatment time lengthened, the mushroom browning serious. However, when the microwave power was 1000W for 1min, the brightness of mushrooms was stable and the browning decrease. PPO and POD of mushrooms treated by microwave sterilization were undetectable nearly, antioxidant activity increased slightly during the storage.

2.4 Effect of microwave sterilization on mashed potato
Kanishka Bhunia [9] shown that mashed potato sterilized by microwave-heat was a paste shape and the formation of oil on the surface, which due to the starch gelatinization and protein coagulation formed. Mashed potato color changed from light yellow to dark brown and browned significantly, at the same time, lipid oxidation and Maillard reaction in the storage process. The microwave-assisted heat sterilization of mashed potato provided a theoretical basis for the shelf-life of products. However, the limitation of this research was that high temperature reduced product quality. Therefore, further studies on how to reduce the sterilization temperature and ensure products quality.

3. Effect of microwave sterilization on dairy products
Most of the nutrients in milk were heat-sensitive substances. milk was treated by pasteurizing or high temperature instantaneous sterilization would cause loss of nutrients. Zhang Zhongxin [10,11] found that microwave-heating milk has a slighter impact on vitamin C than water bath heat sterilization. The milk layer thickness and microwave power had significant effects on milk fat, but not on the protein, as the thickness of the milk layer increased, the loss of milk fat increased, oppositely, milk fat loss decreases with increasing microwave power.

4. Effect of microwave sterilization on meat products
4.1 Effect of microwave sterilization on quality of stewed pork liver
Related research [12]shown when the surface temperature reached 70℃, similar sterilization efficiency to that obtained by high temperature treatment was obtained. Moreover, after microwave sterilization, the color of stewed pork liver became dark, water content reduced, tissue structure was dense and vitamin A content declined. But only minor quality change was observed when compared with high temperature sterilization.
4.2 Effect of microwave sterilization on quality of recombinant meat
Yang Jialei [13] studied the effect of microwave sterilization on texture characteristics of pork with sweet soybean paste was studied by texture profile analysis. Results showed that texture characteristics of products had little effect from microwave power (P > 0.05). However, different sterilization times revealed a significant effect on elasticity (P < 0.05) and no obvious effect on other texture characteristics (P > 0.05). Therefore, microwave sterilization was applicable method without effect on major texture characteristics and taste of pork with sweet soybean paste.

5. Effect of microwave sterilization on quality of cereals

5.1 Effect of microwave sterilization on rice
Rice was susceptible to mold contamination and mildew in the storage, which caused the loss of about 1 million tons of rice each year [14]. Some researches [15,16] used microwave sterilization technology to treat of rice, optimized of microwave sterilization for Aspergillus niger, Aspergillus flavus from rice, when microwave power set at 119W ~ 700W, Aspergillus flavus, Aspergillus niger spore number logarithmic cycles positively correlated with microwave power, compared with water-bath heating treatment, effect of microwave sterilization was 8.5 times as much.

5.2 Effect of microwave sterilization on rice noodles
Rice noodles is an embodiment of the added value of rice. In the south of China, rice noodles is a popular food, but most of the production of fresh rice noodles is not large. It mainly produced by small workshops, poor sanitation and short shelf-life. It can not form a certain scale, hindered development of rice noodles market [17,18]. Fresh wet rice noodles pickling-microwave sterilization process was studied by Yuan [19], resulting revealed in the conditions of pickling concentration 1.0%, pickling time 60s, microwave power 480W and microwave sterilization time 50s. In this condition, the rice noodles preservation period of was up to 2 months, hardness and the chew was reduced compared to non-sterilizing, but the change was not obvious.

6. Effect of microwave sterilization on aquatic products
Aquatic products were susceptible to microorganisms and Low degree of processing, which restricted industry development of aquatic product [20,21]. The research[22] revealed effect of microwave sterilization on preservation of sea cucumber, with the prolongation of microwave sterilization time. The total number of colonies showed a downward trend. When the time of microwave sterilization was from 15 min to 18 min, the total number of colonies dropped the fastest, and had little effect on the quality of sea cucumber. But the microwave time was too long, the tissue of sea cucumber was destroyed and affect the taste and flavor. Chu Xiaoyan [23] studied the microwave sterilization time and power on the quality of micropterus salmoides, the results showed that microwave sterilization time and power affected seriously on the moisture of fish. When microwave sterilization time 45s, power 280W, the loss of moisture in fish meat was minimized, the total number of colonies was <10 CFU/g, and the sensory quality also reached the ideal state.

7. Analysis of the effect of microwave sterilization on the processing quality of agricultural products
Microwave sterilization had no significant effect on the color of fruit and vegetable products, could retain the nutrients such as phenols, flavonoids and vitamin C, had a strong inhibitory effect on PPO and POD. But the impact on moisture transfer was obvious, high-power microwave would cause water loss seriously, thus damaging the organizational structure of fruits and vegetables.

Microwave sterilization was no damage for the protein, vitamin C and other nutrients in dairy products, but milk fat was easily destroyed and the milk fat layer became thinner in the process of microwave sterilization, which would have a certain impact on the quality of dairy products. meat products treated by microwave sterilization would become dim, loss water, dense tissue and a slight
decline in taste. But the elasticity, cohesion, recovery of meat maintained better. High microwave sterilization power has a great influence on the color of cereal, was easy to cause puffing, which led to the increase of the viscosity and the decrease of the chewiness, hardness, adhesive degree, chewing degree and moisture of aquatic products were dealt with of microwave sterilization changing obviously, which was mainly the loss of water seriously, making the hardness and chewiness of aquatic products increased, thus affecting the taste of aquatic products.

In summary, the main factors on quality of agricultural products are the sterilization power and time of microwave sterilization, the high power or long time of sterilization have a great impact on the color, texture, flavor, nutrients and moisture, While sterilization power and time would be strictly control, materials reached the bactericidal effect and retain nutrients in agricultural products.

8. Outlook

Microwave sterilization is a newly developed technology, and it is popular with researcher. Through the analysis above, we can see that microwave sterilization in the processing of agricultural products need further exploration. in term of research content analysis, The research of effect of microwave sterilization on agricultural products mainly focused on the sterilization process and the impact on the quality of agricultural products. But which is still shallow, We would strengthen the microwave sterilization on theoretical research on the quality of agricultural products, but also according to different characteristics of agricultural products, select the appropriate microwave condition. On the basis of experimental data, the mathematical model of microwave sterilization was set up to choose the best bactericidal process parameters for the production of agricultural products, improved the product quality and provide a theoretical basis for the selection of processing equipment. From the research material, The main research object of microwave sterilization was fruits and vegetables and meat products, but few reports on plants, shrimp and shellfish, and the application of microwave sterilization in raw material of agricultural products needs to be expanded.

From the bactericidal technology perspective, the research that microwave sterilization combined with other technologies can be expanded, to strengthen bactericidal effect, which was conducive to reducing the microwave on agricultural products quality impact. As to sterilization equipment, The equipment features, such as automation level, complete sets and functional combinations can not keep up with the production and research needs, which cause microwave sterilization had not been universal yet in the processing of agricultural products. It might be our future important research direction: whether the substance in agricultural products turned into toxic and hazardous substances or there are any harmful substances melt from packaging materials after treatment with microwave sterilization. Strengthening the microwave sterilization technology and the theory of the impact on the quality of agricultural products to promote the broad application of microwave sterilization in the food industry.

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