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Research progress on drying pretreatment technology of agricultural products

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Abstract

This paper mainly introduced the mechanism of agricultural products pretreatment technology and its application in the field of drying, pointed out that drying pretreatment has the characteristics of improving drying rate, maintaining the color of agricultural products, energy saving and environmental protection, and analyzed the current research status of agricultural products drying pretreatment technology at home and abroad, and finally summarized some problems existing in the current drying pretreatment technology of agricultural products. And the prospect of its next development is also given.

Keywords

Pretreatment, Dry, Agricultural products.

1. Introduction

At present, the main problems facing the drying technology of agricultural products are low drying efficiency, high energy consumption, quality deterioration, high pollution and high cost. Cracking these problems mainly starts from the following aspects: First, the research and development of drying equipment. The research and development of new equipment can reduce energy consumption and improve quality, but the complete replacement of equipment will increase the cost; The second is the optimization of drying process. The process was optimized by adjusting drying temperature and drying humidity of agricultural products. This method is low cost and easy to control, but the improvement effect on drying efficiency, quality and energy consumption is limited. The third is the use of dry pretreatment technology, mainly including chemical and physical treatment from two perspectives. In recent years, the drying methods of agricultural products combined with different pretreatment have been widely studied by domestic and foreign scholars, and it is found that pretreatment technology has the advantages of low cost, easy control, green safety, stable product quality, etc. In addition, it can reduce energy consumption and shorten drying time [1].

At present, the commonly used pretreatment methods include penetration, blanching, freezing, microwave treatment, peeling, ultrasonic, freeze-thawing and addition of chemical reagents. YongshengPei et al. found that ultrasonic pretreatment combined with far-infrared drying technology shortened the drying time of saffron. At the same time, flavonoids, antioxidant activity and main volatile components were well retained. LihuiZhang et al.found that ultrasonic and ultra-high pressure pretreatment combined with freeze-drying could increase the concentration of volatile compounds in strawberry. Drying pretreatment technology is gradually becoming the research focus of drying technology [2].

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2. Drying pretreatment method

2.1. Osmotic dehydration pretreatment

2.1.1. Osmosis of sugar solution

When agricultural products are placed in a sugar solution with a certain concentration, water will diffuse to the sugar solution with high osmotic pressure, thus reducing the moisture content of agricultural products, shortening the drying time, and alleviating the Browning after drying [3]. Ansar et al. used different concentrations of maltodextrin to pretreat passion fruit and then dry it, and measured the particle size and water content after drying. The results show that the particle size is positively correlated with the concentration of maltodextrin, while the water content is negatively correlated with the concentration of maltodextrin. The concentration of maltodextrin determines the osmotic pressure, and the higher the osmotic pressure, the faster the water diffusion rate. Andriana et al. used isomaltose, stevia glycoside and fructooligosaccharide for osmotic pretreatment of tomatoes, and then reduced the water activity in tomatoes by drying. Studies have shown that different concentrations and types of sugar penetration have a great impact on the nutrient composition and drying rate of dried products .

2.1.2. Enzyme permeation

Since the main component of agricultural products cells is cellulose, the agricultural products cell wall can be hydrolyzed to form microporous channels through enzyme pretreatment to accelerate water diffusion and shorten drying time. Compared with other pretreatment methods, enzyme pretreatment has less impact on product taste. Kucner et al[4]. pretreated blueberries with enzyme infiltration, using a pectinase to permeate and dehydrate them under vacuum. The other does not add enzyme preparations and can be dehydrated directly under vacuum conditions. The results showed that the wet substance content of blueberries pretreated with enzyme decreased significantly, and the cell wall permeability and drying efficiency were enhanced by the hydrolysis of pectin by pectinase.

2.1.3. NaCl solution infiltration

Osmotic pressure inside and outside cells of agricultural products in NaCl solution will accelerate water diffusion. Since the saturation concentration of NaCl solution is 36%, NaCl solution is suitable for agricultural products with high water content. Studies have shown that the osmotic dehydration efficiency of NaCl solution is not proportional to the concentration of osmotic solution, and the higher dehydration efficiency can only be achieved at the appropriate concentration of osmotic solution. Stefan et al. analyzed the effects of NaCl solution with different concentrations on the nutrient retention rate, water activity and rehydration of red beetroot through different infiltration times. Studies have shown that low concentration of NaCl solution can improve the betaine retention rate in beetroot, and the longer the permeation time, the lower the rehydration rate; however, too long the permeation time will cause NaCl to adhere to the surface of agricultural products, thus blocking micropores and preventing water from entering agricultural products, resulting in lower rehydration rate. The high concentration of NaCl solution will affect the quality of agricultural products after drying. Therefore, the best effect can be achieved only by using NaCl solution at the appropriate concentration and time, and the concentration and time of NaCl solution penetration are different for different agricultural products.

2.2. Blanching pretreatment.

Blanching is also known as killing green, hot water and steam are the main commonly used media, blanching treatment of agricultural products can passivate the internal enzymes of Browning, while killing the surface microorganisms of agricultural products, can well protect

the color of agricultural products, is a more common pretreatment method in the processing of agricultural products. Its advantages are firstly that it can soften the organizational state of agricultural products, accelerate the heat and mass transfer rate, and solve the problem of slow drying rate. Secondly, it can passivate the activity of oxidase in agricultural products and inhibit the Browning of agricultural products. The most important point is that the blanching medium is usually water or steam, and there is no chemical residue problem. Suitable for industrial production requirements. Blanching pretreatment can also reduce pesticide residues of agricultural products, improve the permeability of cell membranes and cell walls, thereby speeding up the subsequent dehydration process, reducing drying time and reducing energy consumption. The addition of natural plant extracts in the blanching pretreatment process can reduce the shrinkage degree of agricultural products after drying, and effectively improve the retention rate of nutrients [5]. Blanching pretreatment can also reduce the activities of peroxidase and polyphenol oxidase in agricultural products, increase the retention rate of polyphenol compounds, and improve the antioxidant capacity.

Common blanching methods include hot water blanching, steam blanching, etc., and some emerging blanching methods: such as ohmic blanching, microwave blanching, radio frequency blanching, infrared blanching, etc. TatsuyaOshima et al. conducted a study on hot air drying of persimmon and found that blanching pretreatment before drying could affect the degradation of carotenoids, thereby reducing the Maillard reaction in subsequent drying, increasing the drying rate and improving the hardness of the product. Chen Jing et al. showed that the carrot slices obtained by infrared ironing combined with hot air drying had bright color, brittle texture, lower POD activity and higher ascorbic acid content. However, there are some disadvantages of hot stamping pretreatment: for example, higher processing temperature will destroy the material structure; The water-soluble substances inside the material will flow out with the hot water medium, resulting in nutrient loss; And the water after hot treatment can not be reused, which will cause waste of water resources. Adugna et al. dried root crops after blanching and drying, and found that the amylose retained in the products was higher, and amylose could help prevent obesity and reduce the risk of type 2 diabetes. Gao Yang et al. studied the influence of different hot time on saccharic acid components of jujube Nansuanensis. Tang Sanjiang et al[6]. optimized the blanching process of quick-frozen apple, and studied the effects of blanching time, temperature and solid-liquid ratio on the relative activity of peroxidase. Ando et al. conducted a study on hot scalding treatment of carrot and found that it could inhibit water migration. After hot scalding, the volume shrank sharply, increasing the resistance to water, and thus reducing the water diffusion rate.

2.3. Freeze-thaw pretreatment.

With the rapid development of science and technology, cryogenic freezing technology is more and more applied to the pretreatment of agricultural products. Freeze-thaw pretreatment includes two processes: freezing and melting. Usually, the internal temperature of the material is below the freezing point to form an ice core and gradually form an ice crystal, so that the free water inside the tissue is frozen, and then the ice crystal is melted at a certain temperature to achieve thawing. After freeze-thaw pretreatment of materials, cell walls and cell membranes will be punctured by the influence of ice crystals. When the temperature rises, free water between tissues after melting will escape through the damaged cell membranes, thus realizing pre-dehydration of agricultural products. In addition, damaged cell membranes and cell walls will greatly change the permeability of plant tissues, which is conducive to the transfer of water during the drying process, thus shortening the drying time. Increase drying rate. Xu Xin et al. found that different freeze-thaw pretreatment methods before freeze-drying okra could reduce the drying time by 25.0%-62.50% and the total energy consumption by 24.28%-62.35%. Fen et al[8]. found in vacuum freeze-drying of garlic slices that freeze-thaw cycle pretreatment can

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shorten drying time, reduce energy consumption and improve product quality, while improving the thermal stability and antioxidant activity of polysaccharides, and improving the flavor and chemical composition of dry products. At present, freeze-thaw pretreatment technology has been studied and applied to agricultural products such as okra, carrot and garlic, but its internal mechanism and applicability remain to be further studied.

2.4. Pulsed electric field pretreatment.

Pulsed electric field pretreatment refers to the generation of high frequency pulses under strong electric field, which acts on the different charges on both sides of the cell membrane and attracts the different charges accumulated on both sides of the cell membrane. In the environment of strong electric field and high pulse, the density of the different charges inside and outside the cell membrane gradually increases, and the attraction is enhanced, and finally leads to the extrusion and rupture of the cell membrane. The permeability of the cell membrane was increased after the cell membrane was broken, and the water in the cell was diffused outside the cell. Zongo et al. pretreated mango with pulsed electric field and concluded through microstructure analysis that the cell wall and membrane basically maintained their original structure after pulsed electric field pretreatment. Pulsed electric field pretreatment produced tiny electroporation on the cell membrane, and water diffused outside the cell through the micropores. Wiktor et al. dried apples after pretreatment by pulsed electric field, which improved the rehydration rate of dried apples. In addition, pulse pretreatment can also eliminate microorganisms in agricultural products, which can play a good anti-corrosion effect.

2.5. Ultrasonic pretreatment.

Ultrasonic pre-treatment will compress and decompress the internal tissues of agricultural products, and micro-bubbles will be produced on the surface of agricultural products under the impact of ultrasonic waves. Under the action of ultrasonic waves at a certain frequency, gas micro-bubbles will circulate and oscillate around agricultural products, and the movement of micro-bubbles will also accelerate the flow of water in agricultural products. When the number of micro-bubbles is large enough, it will cause cell rupture and water in the cell will flow outside the cell. This reduces the water content of the produce. Ultrasonic pretreatment combined with solution penetration can accelerate water discharge and shorten drying time. Suwalee et al. used ultrasonic pretreatment to reduce the water content of litchi, but also reduced the survival rate of aerobic microorganisms, which also had the effect of inactivation and sterilization. Shi et al. conducted ultrasonic osmotic pretreatment and cellulase pretreatment on shiitake mushroom slices, and analyzed cellulase treated shiitake mushroom slices by low-field nuclear magnetic resonance spectroscopy, and found that the water fluidity was higher, the diffusion rate was faster, and the product tissue after enzyme treatment was more loose. In addition, the enzyme can hydrolyze the cell wall of plant tissue and increase the permeability of the cell wall, thereby increasing the water diffusion rate and shortening the drying time.

2.6. Ultrahigh pressure pretreatment.

In the process of ultra-high pressure pretreatment, the fluid flows to agricultural products through the micron-level high-pressure valve after being pressed by high pressure. The turbulence generated near the valve will impact the agricultural products, and the cells will break under the impact, thus increasing the porosity of tissues. During drying, the sublimation rate of water will be accelerated, thus shortening the drying time. Wang et al. used UHP to pretreat strawberry slices and dry them, which significantly increased the relative contents of glucose, fructose and esters in strawberry slices, thus enhancing the sweetness of strawberry slices while decreasing the acidity. It was also found that the pressure in the pretreatment process was positively correlated with the drying rate. In addition, ultrahigh pressure pretreatment can also inhibit the allergenicity of proteins, so that allergic proteins can be

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dissolved and released into the cell. Lin et al[7]. dried agricultural products after ultra-high pressure pretreatment, and found that the retention rate of volatile components in the dried agricultural products after treatment was higher, and the chemical bond of enzymes would be changed, resulting in the change of the structure of the aromatic compound zymogen, thus reducing the volatility. Drying after ultra-high pressure pretreatment will increase the porosity of tissues, accelerate the sublimation rate of water, and shorten the drying time. In addition, ultra-high pressure pretreatment is a non-heat treatment method, which can avoid problems such as tissue collapse of agricultural products caused by steam blanching pretreatment, and also has the effect of sterilization, thus extending the shelf life of dried products.

3. Comparison and analysis of pretreatment methods

Pretreatment of agricultural products before drying can effectively improve the drying rate, and effective pretreatment can not only inhibit the activity of polyphenol oxidase, but also effectively maintain the color and nutrients, and change the skin structure of agricultural products. This paper comprehensively analyzed the mechanism of the pretreatment methods such as hot blanching, freezing, impregnation and cellulase to accelerate the water loss of agricultural products. The study showed that effective pretreatment could change the epidermal cell structure of agricultural products, and enhance the tension of the internal structure of agricultural products during the drying process, so as to accelerate the water loss and improve the drying rate of agricultural products. However, due to the different mechanisms of different pretreatment methods, the degree of influence on the drying rate of agricultural products will be different. The agricultural products treated with cellulase had porous structure inside, and the agricultural products treated with cellulase had loose porous structure. Ethyl oleate combined with freezing pretreatment reduced the hardness of agricultural products, because the low temperature treatment produced ice crystals inside the agricultural products and maintained the fiber structure inside the agricultural products, thus reducing the hardness. Studies have shown that hot scalding pretreatment can significantly improve the hardness, because hot scalding pretreatment can passivate the activity of pectin methyl esterase in the cells of agricultural products, thus inhibiting the decomposition of pectin and maintaining the organizational structure of agricultural products. With the in-depth study of drying pretreatment by researchers, the drying rate will be greatly promoted, and the trend of combining various pretreatment methods is also developing.

4. Conclusion

At present, in addition to blanching and freezing pretreatment applications are relatively mature, other agricultural products drying pretreatment technologies mostly stay in the experimental and exploration stage. In practical application, there are the following problems: (1) It can only meet the drying pretreatment of small batches of agricultural products, lack of large equipment. (2) Partial drying pretreatment needs to switch processes, and the production continuity of multiple processes is low at the same time. (3) Different drying pretreatment stages need to change parameters, more processes, low degree of automation.

To solve the above problems, first, we should carry out more academic exchange activities and science and technology activities to the countryside, combined with the actual situation of agricultural products drying pretreatment industry to carry out specific research; Second, strengthen the cooperation between schools and enterprises, carry out technical training, and realize the efficient and sustainable development of agricultural products drying industry; Third, under the guidance of environmental friendliness advocated by the sustainable development strategy, the new concept of green development is implemented, and new energy is applied to the dry pretreatment industry of agricultural products.

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