Effect of Different Pretreatments on Explosion Puffing Drying of Hami Melon at Modified Temperature and Pressure in Xinjiang

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Abstract This paper studies the influence of three different pretreatments (blanching, citric acid soaking, and NaCl soaking) on the moisture content, degree of puffing, color, hardness and crispness of Hami melon under explosion puffing drying at modified temperature and pressure in Xinjiang. The results show that using 60s blanching pretreatment can help to reduce the moisture content of puffed product while maintaining product color; 2.5% citric acid pretreatment can make products maintain high degree of puffing and crispness, but reduce product color; 2% NaCl penetrating fluid plays a significant role in maintaining product color, while maintaining crispness.

Key words Pretreatment, Xinjiang, Hami melon, Modified temperature and pressure

1 Introduction

The Hami melon is a type of muskmelon, and its outer color is generally white through pink or yellow through green. The inside flesh is sweet and crisp. It contains rich vitamins, glucose, fructose and trace elements[1]. Hami melon is a fruit unique to China, and also a fruit product with obvious advantages in Xinjiang. The explosion puffing drying technology at modified temperature and pressure is an emerging environmentally friendly, energy-saving puffing drying technology exclusively for producing non-fried fruit and vegetable chips in recent years, with broad application prospects in fruit and vegetable processing[2-4]. Currently, there are some problems in the process of explosion puffing drying at modified temperature and pressure. First, during the processing, the material is prone to browning; second, the high moisture content will reduce product crispness, thereby losing commercial traits. In order to develop Xinjiang's fruit and vegetable specialties puffed at modified temperature and pressure, our institute cooperates with relevant scientific research institutes to make a series of related studies, and has made stage progress in technological research on explosion puffing drying of a variety of fruits and vegetables at modified temperature and pressure. However, there are many factors affecting explosion puffing drying of fruits and variables at modified temperature and pressure, and especially the interaction between some important parameters, such as slicing manner of raw materials before puffing and pretreatment mode, has not yet been fully understood. This test is designed to investigate the influence of three pretreatment modes (blanching, citric acid soaking and NaCl soaking) on the quality of Hami melon products under explosion puffing drying at modified temperature and pressure, and improve processing technology of the related products.

2 Research at home and abroad

Domestic and foreign scholars have done a lot of researches on the pretreatment of fruit and vegetable drying processing. Cai Yadong *et al.*[5] study the pretreatment of fried and puffed Hami melon products, and find that before the frying of raw material, using calcium salt hardening treatment, NaCl soaking treatment and dextrin infiltrating and filling treatment can help to make the processed puffed products have good color and intact shape. Mujica-Paz *et al.*[6] study the vacuum infiltration pretreatment of Hami melon and other fruits, and use response surface methodology to optimize the infiltrating and soaking process of Hami melon. Moreover, Varnalis AI *et al.*[7-8] study the influence of blanching and sulfur bleaching pretreatment on the hot air drying and puffing effect of potato, and find that sulfur bleaching treatment has no significant influence on puffing of potato, and hot air drying after blanching will increase degree of puffing. Bi Jinfeng *et al.*[9] study the influence of three different pretreatment methods (blanching, freezing and soaking) on the quality of Hami melon products under explosion puffing drying at modified temperature and pressure, and results show that moderate blanching pretreatment helps to reduce puffed product moisture content, and improve the degree of puffing and product color.

3 Materials and methods

3.1 Materials Hami melon (purchased from Shihezi fruit wholesale market); citric acid, NaCl (Beijing Chemical Reagent Company).

3.2 Instruments and equipments Puffed fruit and variable dryer at modified temperature and pressure (QDPH10-1, Tianjin Qinde New Materials Technology Co., Ltd.); electric constant temperature blast box (DHG-9123A, Shanghai Jinghong Experi-

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mental Equipment Co., Ltd.); properties analyzer (Ta. XT 2i/50, UK Stable Micro Systems Company); color difference meter (CR-400, Japan Minolta Company); refrigerator (BCD-219D, Qingdao Haier Co., Ltd.). The experimental apparatus is shown in Fig. 1.

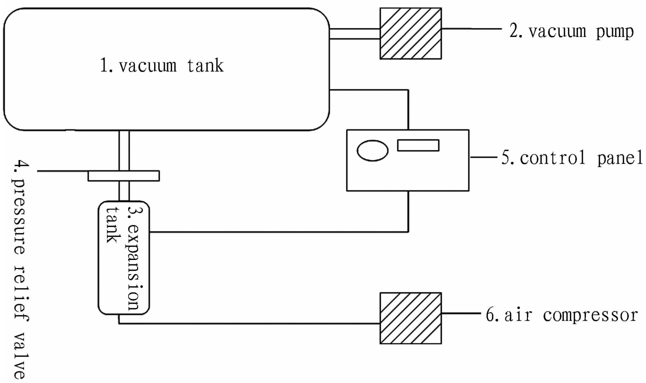

Fig. 1 Puffed fruit and vegetable dryer at modified temperature and pressure

3.3 Methods

3.3.1 Process. Raw materials→cleaning→removing inedible part→segmentation→ pre-drying→softening→puffing drying→cooling→packaging→product. By the experimental study, the explosion puffing drying conditions at modified temperature and pressure were determined as follows: puffing temperature of 85℃; puffing pressure of 0.2 MPa; puffing time of 30 min; vacuum temperature of 70℃; evacuation time of 90 min.

3.3.2 Indicator measuring method. (i) Moisture content determination: according to Rodrigues direct drying method[10]. (ii) Color measuring: with whiteboard color as standard for correction, using colorimeter to measure lightness index of Hami melon (L). The larger the L value of product, the better the color of product[11]. (iii) Determination of degree of puffing: specific volume method. Ultra-fine quartz sand filling method was used o measure the volume of puffed products. The measuring instrument was made by ourselves, and the volume was averaged. The degree of puffing was calculated according to Equation (1):

$$\text{Degree of puffing} = V - V_0 \quad (1)$$

where V is the volume after puffing, mL; V_0 is the volume before puffing, mL. (iii) Crispness and hardness determination. Texture analyzer was used for determination, and the measurement conditions were as follows: measuring force in the process of lower pressure; test speed of 2.0 mm/s before test; test speed of 1.0 mm/s; test speed of 2.0 mm/s after test; test distance of 5.0 mm; data acquisition rate of 500 times/s; threshold of 5 g; probe P/100. Referring to the method of Hawlader *et al.*[12], crispness can be denoted by the number of peaks in the stress curve. The crispness in this test was denoted by the number of peaks generated during test. The larger the number of peaks, the better the product crispness. The hardness value was equal to the force peak in the curve, namely the greatest force needed to break samples, with the unit of "g". The greater the value, the harder the product.

3.3.3 Experimental design. (i) Blanching treatment. The Hami melon was cut into 1 cm slices, and they were divided into five treatment groups. They were put into the boiling water to be blanched for 0, 60, 120, 180 and 240s, respectively, and then placed into 60℃ electric blast oven for 8 h of drying. In the same conditions, the explosion puffing drying was conducted at modified temperature and pressure, and the moisture content, degree of puffing, color, hardness and crispness of puffed products were measured. (ii) Citric acid soaking treatment. After the Hami melon was cut into 1 cm slices, they were divided into five treatment groups. They were soaked in 0, 1.5, 2.5, 3.5 and 4.5% citric acid solution for 4 h, respectively, and then put into 60℃ electrothermal blast oven for 8 h of drying. In the same conditions, the explosion puffing drying was conducted at modified temperature and pressure, and the moisture content, degree of puffing, color, hardness and crispness of puffed products were measured. (iii) NaCl treatment. After the Hami melon was cut into 1 cm slices, they were divided into five treatment groups. They were soaked in 0, 2, 4, 6 and 8% NaCl solution for 3 h, respectively, and then put into 60℃ electrothermal blast oven for 8 h of drying. In the same conditions, the explosion puffing drying was conducted at modified temperature and pressure, and the moisture content, degree of puffing, color, hardness and crispness of puffed products were measured.

3.3.4 Data analysis. SPSS 18.0 was used for data difference analysis.

4 Results and analysis

4.1 Effect of blanching treatment on the dried puffed product quality As shown in Table 1, with increasing blanching time, the moisture content of puffed product first increased and then decreased, and at 60s, it was significantly different from other groups ($P \leqslant 0.05$). After 120s, the moisture content gradually decreased, and at 240s, the moisture content was lowest, indicating that proper blanching treatment could accelerate material dehydration, possibly because the high temperature blanching could increase the deformation ability of materials during puffing, and speed up water loss. With increasing blanching time, the degree of puffing first increased and then decreased, and the puffed product under 120 s blanching treatment had the degree of puffing significantly higher than under other treatments. With increasing blanching time, the product color decreased, at 60s and 180s, the differences between treatments were not significant ($P \geqslant 0.05$), and at 240s, L decreased, indicating that excessive blanching was detrimental to product color, because with the destruction of material cell surface, cell lysates flowed out, and the material's ability to maintain color decreased. With increasing blanching time, the product hardness showed a downward trend, but rose suddenly from 240s, indicating that proper blanching could help to reduce puffed product hardness, but excessive blanching would increase product hardness. The puffed product crispness first increased and then decreased, and it was highest at 60s. Considering the above factors, the puffed product quality was good under 60s blanching treatment.

Table 1 Effect of blanching on the dried puffed product quality

Treatment time//s	Moisture content//%	Degree of puffing//mL/g^{-1}	*L*	Hardness//g	Crispness
0	9.43^{b} ± 0.37	3.32^{d} ±0.18	68.47^{a} ±1.35	4875.34^{a} ±185.41	18.74^{b} ±3.03
60	9.73^{c} ±0.61	3.98^{c} ±0.26	60.33^{b} ±0.14	1734.87^{b} ±117.03	20.21^{a} ±6.33
120	10.78^{a} ±0.52	4.55^{a} ±0.14	56.47^{c} ±0.48	1052.45^{c} ±88.13	12.56^{c} ±3.45
180	10.53^{a} ±0.28	4.22^{b} ±0.46	60.88^{b} ±0.78	756.66^{d} ±118.25	5.13^{d} ±3.46
240	9.44^{b} ±0.34	4.12^{b} ±0.48	56.04^{c} ±0.51	1521.33^{b} ±132.69	4.04^{d} ±1.88

Note: Different letters in the same column represent significant differences, $P \leqslant 0.05$, the same in Table 2 and Table 3.

4.2 Effect of citric acid treatment on the dried puffed product quality As shown in Table 2, with the increasing concentration of citric acid, the moisture content of puffed product showed a rising trend. When the citric acid concentration was 2.5% to 3.5%, the moisture content difference between products was not significant ($P \geqslant 0.05$), and when the citric acid concentration was 4.5%, the moisture content declined sharply, possibly because the high concentration acid could soften the material and exacerbate dehydration when products were puffed. With the increasing concentration of citric acid, the degree of puffing first increased and then decreased, and when the concentration was 2.5%, the degree of puffing was best. With the increasing concentration of citric acid, the product color showed a decreasing trend, and there was no significant difference in L between the concentration of 1.5% and 2.5% ($P \geqslant 0.05$), but the difference between the level of 2.5% and 4.5% was significant ($P \leqslant 0.05$), indicating that too high citric acid concentration was not conducive to maintaining product color, possibly because too high concentration acid treatment destroyed the cell structure and led to content loss, resulting in decreased product color. With the increasing concentration of citric acid, the hardness of puffed product showed an overall downward trend, but it rose when the concentration was 4.5%, indicating that proper citric acid treatment could reduce the hardness of the product and increase the degree of puffing. When the citric acid concentration was 2.5%, the crispness of puffed product was best. Therefore, by the 2.5% citric acid pretreatment, good product quality could be obtained.

Table 2 Effect of citric acid treatment on the dried puffed product quality

Citric acid concentration//%	Moisture content//%	Degree of puffing//mL/g^{-1}	*L*	Hardness//g	Crispness
0	9.43^{c} ± 0.37	3.32c ±0.18	68.47^{a} ±1.35	4875.34^{a} ±185.41	18.74^{b} ±3.03
1.5	9.73^{b} ±0.61	3.98^{b} ±0.26	60.33^{b} ±0.14	1734.87^{b} ±117.03	12.56^{c} ±3.45
2.5	10.78^{a} ±0.52	4.55^{a} ±0.14	60.88^{b} ±0.78	1052.45^{c} ±88.13	20.21^{a} ±6.33
3.5	10.93^{a} ±0.28	4.22^{b} ±0.46	56.47^{c} ±0.48	756.66^{d} ±118.25	5.13^{e} ±3.46
4.5	9.44^{c} ±0.34	4.12^{b} ±0.48	56.04^{c} ±0.51	1521.33^{b} ±132.69	7.04^{d} ±1.88

4.3 Effect of NaCl treatment on the dried puffed product quality The effect of NaCl treatment on puffed product quality can be shown in Table 3. With increasing NaCl concentration, the moisture content showed an overall downward trend, possibly because NaCl had high penetration capacity, and could accelerate dehydration of material, thereby reducing the moisture content during puffing. The degree of puffing was best when the NaCl concentration was 2%, and with the increasing NaCl concentration, *L* continued to increase, indicating that high concentration NaCl treatment could improve puffed product color. The hardness of puffed product decreased with the increasing NaCl concentration, but suddenly increased when the concentration was 8%, indicating that high concentration NaCl treatment would increase the hardness of puffed product, detrimental to product quality. The crispness was best when the concentration was 2%. In summary, the effect was best under 2% NaCl treatment.

Table 3 Effect of NaCl treatment on the dried puffed product quality

NaCl concentration//%	Moisture content//%	Degree of puffing//mL/g^{-1}	*L*	Hardness//g	Crispness
0	9.78^{a} ± 0.17	3.89^{c} ±0.18	51.02^{d} ±1.35	4875.34^{a} ±185.41	18.74^{b} ±3.03
2	9.96^{a} ±0.31	4.98^{a} ±0.26	63.33^{c} ±1.14	1734.87^{b} ±117.03	20.21^{a} ±6.33
4	9.58^{b} ±0.52	3.78^{c} ±0.33	68.47^{b} ±0.89	1052.45^{d} ±88.13	12.56^{c} ±3.45
6	8.93^{c} ±0.28	4.22^{b} ±0.46	69.88^{b} ±0.78	756.66^{e} ±118.25	5.13^{e} ±3.46
8	7.83^{d} ±0.12	4.02^{b} ±0.19	71.04^{a} ±1.08	1521.33^{c} ±132.69	7.04^{d} ±1.88

5 Conclusions

Proper blanching pretreatment could help to reduce the moisture content of puffed product, but excessive blanching would cause a decline in product color, and 60s blanching had good effect; the citric acid pretreatment helped to increase the degree of puffing

(To page 70)

the humic acid urea topdressing increased the yield and economic coefficient by 2% and 5.2%, respectively. Obviously, the topdressing of urea supplemented with humic acid played a more prominent role in increasing yield than base fertilizer, and 300 kg of topdressing was better than 180 kg of topdressing. In 8 experimental treatments, the yield and economic coefficient were highest under the basal application of 375 kg/ha ordinary DAP + 150 kg/ha ordinary urea, and 300 kg/ ha humic acid urea topdressing.

Table 5 Comparison of wheat aboveground dry matter weight under different treatments at different growth stages

Treatment	Aboveground dry matter weight		
	Overwintering stage	Jointing stage	Filling stage
A_1B_1	9.85 c	83.65 b	123.01 f
A_1B_2	11.76 b	89.74 a	133.35 e
A_1B_3	10.92 bc	55.04 e	180.13 b
A_1B_4	10.80 bc	65.94 c	186.38 a
A_2B_1	11.93 b	58.57 d	114.51 g
A_2B_2	9.81 c	83.14 b	166.87 c
A_2B_3	11.43 b	56.68 de	139.96 d
A_2B_4	13.83 a	55.45 e	134.51 de

Note: Different lowercase letters in the same row indicate significant differences at 0.05 level.

References

[1] DU W, ZHAO BQ, LIN ZA, *et al*. Effect and mechanism of organic-inorganic compound fertilization on chemical fertilizer utilization I ~ Effect of urea compounded with organic material on maize yield and fertilizer utilization[J]. Plant Nutrition and Fertilizer Science, 2012,18(3):579 – 586. (in Chinese).

[2] CHEN ZD, HE JM, LI XY, *et al*. Studies on increasing N utilizing efficiency in maize by applying humic acid[J]. Chinese Journal of Eco-Agriculture, 2007,15(1):52 – 54. (in Chinese).

[3] WANG YJ, ZHU K, WANG JX, *et al*. Study on the humic acid adsorption of chromium in sandy soil[J]. Journal of Safety and Environment, 2007, 7(5): 42 – 47. (in Chinese).

[4] HE J, YAN L, YANG K, *et al*. Study on component and character of humic acids from different sources[J]. Chinese Journal of Soil Science, 2003, 34(4): 343 – 345. (in Chinese).

[5] LIU YL, DING FJ, GU DY, *et al*. Characteristics of wheat-maize yield and soil organic carbon/ nitrogen mineralization in cinnamon soil with application of different activation humic acid-urea[J]. Soils, 2015,41(7): 42 – 48. (in Chinese).

[6] LIANG ZC, CHENG SX. The research progress of the function mechanism of humic acid and urea[J]. Humic Acid, 1997(2):1 – 4. (in Chinese).

[7] YAN SD, LIU LJ, HONG JP. Effect of humic acid-urea complex on urea transformation and nitrogen release[J]. Chinese Journal of Eco-Agriculture, 2008, 16(1): 109 – 112. (in Chinese).

[8] JUAN YH, CHEN LJ, WU ZJ, *et al*. Response of urea-N transformation to humic acid[J]. Chinese Journal of Soil Science,2011,42(1):112 – 116. (in Chinese).

(From page 66)

and crispness for the dried puffed products, but the moisture content was high, and 2.5% citric acid treatment was appropriate; NaCl solution soaking treatment could effectively promote material dehydration, and high concentration NaCl penetrating fluid played a significant role in maintaining material color, but it would increase product hardness and reduce product quality, and 2% NaCl treatment had the best effect.

References

[1] YABUMOTO K, JENNINGS WG. Constituents of cantaloupe, cucumismelon and their biogenesis[J]. Journal of Food Science,1977(42):32 – 37.

[2] ZMAMER CM. Gun-puffed vegetable snacks: A new way to eat your veggies[J]. Food Technology, 1995, 49(10):64 – 65.

[3] SULLIVAN JF, CRAIG JC. The development of explosion puffing[J]. Food Technology, 1984,38(2):52 – 55.

[4] SULLIVAN JF, EGOVILLE MJ, KONSTANCE RP, *et al*. Storage stability of continuous explosion puffed potatoes[J]. Food Science and Technology, 1983, 16(2):76.

[5] CAI YD, ZHAO CJ. On the technology of vacuum fried crisp melon [J]. Science and Technology of Food Industry, 1998(6):59 – 60. (in Chinese).

[6] MUJICA-PAZ H, VALDEZ-FRAGOSO A, LOPEZ-MALO A, *et al*. Impregnation properties of some fruits at vacuum pressure[J]. Journal of Food Engineering, 2003(56): 307 – 314.

[7] VARNLIS AI, BRENNAN JG, MACDOUGALL DB. A proposed mechanism of high-temperature puffing of puffing. Part. The influence of blanching and drying condition on the volume of puffed cubes[J]. Journal of Food Engineering, 2001(48): 361 – 367.

[8] VARNLIS AI, BRENNAN JG, MACDOUGALL DB. A proposed mechanism of high-temperature puffing of puffing. Part Ⅱ. The influence of blanching and initial drying on the permeability of the partially dried layer to water vapour[J]. Journal of Food Engineering, 2001(48): 369 – 378.

[9] BI JF, FANG F, DING YY, *et al*. Effect of different pretreatments on the product quality of explosion puffing drying for hami-melon[J]. Food and Machinery, 2010(2): 15 – 18.

[10] RODRIGUES S, FERNANDES FAN. Dehydration of melons in a ternary system followed by air-drying[J]. Journal of Food Engineering, 2007(80): 678 – 687.

[11] NATH A, CHATTOPADHYAY PK. Optimization of oven toasting for improving crispness and other quality attributes of ready to eat potato-soy snack using response surface methodology[J]. Journal of Food Engineering, 2007(80): 1282 – 1292.

[12] HAWLADER MNA, PERERA CO, TIAN M. Properties of modified atmosphere heat pump dried foods[J]. Journal of Food Engineering, 2006(74): 392 – 401.