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Research Article

The Microwave Concentrator Design and Study on Concentrating Apple Juice

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Abstract: Microwave concentrating device on fresh apple juice is designed in order to increase concentrating fresh apple juice efficiency and microwave concentrating process on fresh apple juice were studied. The designed microwave concentrator contains microwave generator, dehumidification system, electrical cabinet, parabolic waveguide, control system, microwave leakage inhibited mechanism and other components. The concentrating experiment is carried by the designed concentrator, from the setting-to-work test, the design was success.

Keywords: Microwave concentrating, microwave concentrator, microwave control system, microwave power generator

INTRODUCTION

Apple is one of traditional Chinese main fruit and commonly used in China (Zhou and Hu, 2013); the origin of apple is relative scatter and mostly located in mountainous areas, traffic is inconvenience, the period is shorter and which brought great suffering to transport. Apple processed into apple juice is one way to solve this problem in apple harvest season. Moisture content of fresh apples is high, moisture content of processed fruit juice is high, so there need to be concentrated. In concentrated apple juice study (Candrawinata *et al*., 2013), Guo *et al*. (2013) concentrated apple juice using headspace Solid Phase Micro-Extraction (HS-SPME) and optimized the extraction parameters by fuzzy evaluation method, the process is also different because of different parameters; Brugnoni *et al*. (2013) studied the nutrients in concentrating apple juice process, analyzed the influence of storage conditions on its nutrients. Martin *et al*. (2013) discussed sterilization in concentrating apple juice process. But for concentrating apple juice the conventional techniques were used, microwave was not employed in juice concentrating. A number of studies are conducted on application of microwave and are used in sterilizing and drying field (Geng and Ge 2013; Geng *et al*., 2013). Microwave concentrating apparatus used in concentrating fresh apple juice process is not reported because of the high cost of microwave apparatus. Microwave concentrating apparatus is designed based on microwave concentrating experimental results; and find the microwave concentrating conditions and the best process route on fresh apple juice in this study.

THE WHOLE STRUCTURE AND PRINCIPLE OF MICROWAVE CONCENTRATOR

The whole structure of microwave dryer: The microwave concentrator is assembled mainly by the microwave generator, dehumidification system, electrical cabinet, control system, transmission system, microwave leakage control mechanism, energy transportation mechanism and framework. The microwave concentrator structure is shown in Fig. 1.

The components design:

The microwave generator: The microwave generator consists of a magnetron (2M210-M1 Panasonic), high-voltage transformer (700E-1 (AL)), high-voltage diodes (HVH-12) high-voltage capacitor (CH85 1.0 μF±3% 2100VAC 50/60HZ-10/85 internal discharge resistor, fuse (8A250V SICHERUNG FUSE). The microwave generator function is to generate microwave, fresh apple juice is in high temperature under the microwave affecting and then play the effect of concentrating.

The energy transport apparatus: The energy transport mechanism is to ensure the transmission of microwave energy. According to the distribution characteristics of microwave energy (Chen, 2013), the apparatus is designed similar car headlights (Fig. 2); the role of the headlamp reflector is that gathered radiation from a point in a limited taper angle and produce a high luminous intensity. The design can make the microwave distribute uniformly and the concentrating effect is better.

The design of microwave concentrating chamber: Since microwave energy are more concentrated in the

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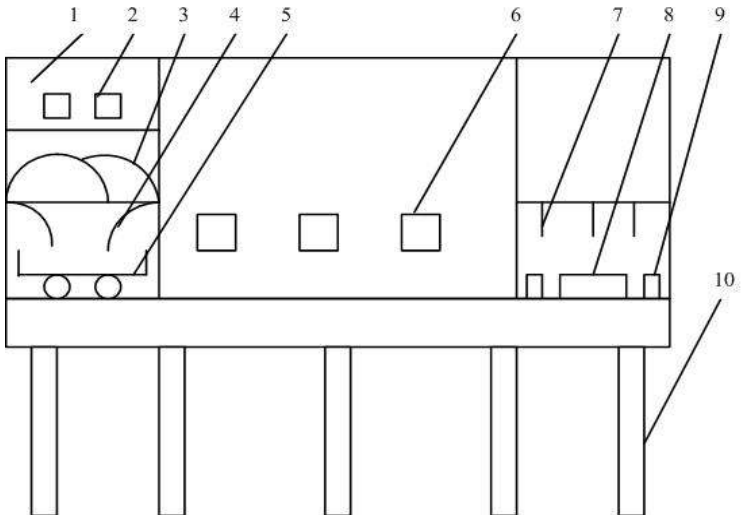

Fig. 1: The whole structure figure of annulus microwave concentrator; 1-Electrical cabinet; 2-Microwave generator; 3-Parabolic waveguide; 4-The left microwave leakage control mechanism; 5-The apple juice transporting apparatus; 6-Dehumidifying systems; 7-The right microwave leakage control; 8-Linear motor; 9-Guide rail; 10-Framework

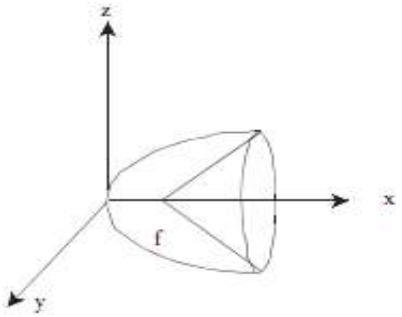

Fig. 2: Shape of the energy transport mechanism

concentrating chamber, materials heating is rapid, especially for sheet materials heating, therefore waveguide type drying chamber is selected. Designed ring-shaped tunnel microwave concentrator made from galvanized tin, the upper wall opened a coupling port for inputting microwave; both sides of the upper wall has two rows of apertures for discharging moisture; in the middle sidewall provided with an observation window for observing the internal running (Wang, 2004). The microwave concentrator size is designed according to size of the apple juice transporting apparatus and how to make the electric field evenly distributed and drying efficiency. The concentrating efficiency determines the maximum size, the size of the apple juice transporting apparatus determine the minimum size under normal circumstances.

Juice transport system: Fresh apple juice transport apparatus is set in the bottom of the microwave concentrating chamber, guide rail is set in the bottom of transport apparatus, the transport apparatus is driven by linear motor.

Dehumidiyying system: Air humidity inside the drying chamber is an important factor affecting concentrating efficiency. Vapor from apple juice is discharged continuously in concentrating process, if not discharged promptly the vapor from the chamber, it will reduce the concentrating efficiency and the discharged humidity is to be set thus can improve concentrating efficiency. Holes are opened the inner wall with 10 rows, 3 mm diameter and center distance of 8 mm. ventilation is installed outside the concentrating chamber and prevent condensation of water back, both preventing microwave leakage and ensuring the vapor discharged smoothly.

The microwave leakage control mechanism: The microwave leakage control mechanism is disposed at both ends of the microwave dryer, the microwave leakage control mechanism installed in order to avoid harm to the human. The home heating microwave oven and industrial microwave drying apparatus leakage is stipulated as follows: at 50 mm distance from the apparatus, the microwave power cannot exceed 500 mW/mm^2 (2450 MHz) (Wang, 2004). The microwave leakage control mechanism of microwave drying apparatus is used hybrid-type mechanism (Zhang and Hong, 1999); suppressor is composed by comb-type attenuator and added absorbed material in the end.

The principle of microwave concentrator: Fresh apple juice contains a lot of water; the water molecules rub strongly in a very short time at sufficiently high frequency under the microwave effect, make the molecular motion increase, the temperature rise and while water in fresh apple juice evaporated in form of vapor. With the temperature rising, the vapor is formed continuously. Water in fresh apple juice is discharged in high temperature, which is microwave concentrating principle (Hatibaruah *et al*., 2013).

Table 1: The influence of different concentrating mode to concentrated juice quality

Sample No.	Concentrating mode	Concentrated ratio %	The sensory index
1	1.8KW×120s	76	The juice color is dark and flavored with paste
2	1.08KW×120s	73	The juice color is lighter, viscous and evenly
3	1.08KW×90s	54	The juice color as fresh and diluted

Microwave concentrator performance analysis: Firstly take fresh apple juice and concentrating respectively in different power and same concentrating time, observe color and taste of the concentrated juice, calculate concentrated ratio; then concentrating, respectively in same power and different concentrating time, observe color and taste of the concentrated juice, calculate concentrated ratio. The concentrating results are shown in Table 1.

It can be seen from Table 1 that in same concentrating time, the microwave power is greater, the concentrated ratio is greater and the concentrated efficiency is higher; in same microwave power, concentrating time is longer, the concentrated ratio is greater and the concentrated efficiency is higher. Microwave power is great, the concentrated ratio and efficiency are high, but the concentrated fruit juice quality is bad, because the microwave power is great, temperature rising sharply and there appeared charred for local overheating.

CONCLUSION

The microwave concentrator can be used for concentrating fresh apple juice and can realize continuous production, improved production efficiency and clean. A parabolic waveguide is used in microwave concenrtrator, microwave distribution is more uniform in microwave concentrator.

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