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Research Article

An Experimental Study on Shanghai Green Vegetable Drying by Microwave

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Abstract: In order to identify the relationship between the microwave and the drying effect and apply microwave to dry the Shanghai Green Vegetable, studied the Shanghai Green Vegetable drying process by microwave. The results show, microwave can effectively remove the moisture in Shanghai Green Vegetable and the drying quality and drying effect would not be affected. Compared with the traditional drying technology, the microwave drying characteristics are short time, fast speed and high efficiency. The craft provides the basis that the microwave is used in Shanghai Green's Vegetable drying.

Keywords: Craft, drying, microwave, shanghai green vegetable

INTRODUCTION

Shanghai Green Vegetable, also known as Shanghai Cabbage, is one of the most common cabbage varieties in east of China, oval leaves, petioles hypertrophy, green, waist, beautiful and neat, thin fibers, good taste, rich nutrition, it is a huge potential for development (Song and Liu, 2012; Xie *et al*., 2013). But Shanghai Green Vegetable is high water content, easy to rot, improper post-harvest handling and processing methods caused that Shanghai Green Vegetable losing is quite high. The Shanghai Green Vegetable has considerable economic value, but now, Shanghai Green Vegetable processing does not arouse enough attention in the country. There is a great demand for processed vegetables on market and there is more after having vegetables pack in instant noodles, the annual consumption of instant noodles is up to 50 billion packets in China, dried Shanghai Green Vegetable is needed prodigiously, drying Shanghai Green Vegetable has great potential to meet this demand. Drying is the most widely used method in food preservation, coal, wood and so on are as energy in traditional drying, caused air pollution and there is defect in the dried Shanghai Green Vegetable on nutrition, color, taste, health and etc. There is less report about Shanghai Green Vegetable drying at home and abroad, so researching drying methods and drying characteristics are particularly important. Microwave is electromagnetic waves with strong penetration; microwave drying process is the water diffusion from inside to outside and speed up the drying process. Compared traditional drying method, microwave drying has short time, high efficiency, healthy and easy to control, reliable and feasible in technology. Currently, microwave drying technology has been applied in many areas of food drying (Figiel, 2009; Bondaruk *et al*., 2007; Sunjka *et al*., 2008; Maskan, 2001) and there is no report on drying Shanghai Green Vegetable by microwave. Microwave drying characteristics Shanghai Green Vegetable is studied and developed Shanghai Green Vegetable processing technology.

MATERIALS AND METHODS

Materials and main equipment: The fresh Shanghai Green Vegetable, The microwave drying equipment in experimenting (operating frequency: 2450×10^6 Hz), Electronic balance, Infrared Thermometer.

Experimental method:

Pretreatment before drying: Choose Shanghai Green Vegetable of fresh, good color and no mechanical damage and fully rinse to remove sand and other impurities, drain water to avoid influence of external moisture on experiment and then taken the whole leaves as test materials. The surface temperature of Shanghai Green Vegetable is tested after drying period by infrared thermometer, 10 points is taken to test temperature on entire drying chamber and averaged. The drying table is rotatable in the drying process, in order to measure the mass after drying, part is taken.

Drying experimental design: Loading density of 1 kg/m^2 and drying Shanghai Green Vegetable under 400, 500 and 600 W microwave power, respectively; setting microwave power 500 W, drying Shanghai Green Vegetable with material density of 1, 2 and 3 kg/m^2, respectively. In each experiment, recorded the sample mass every 1.5 min and total drying time is 25 min, water content were determined according to GB/T5009.3-2003 "Determination methods of moisture in foods". Each experiment was repeated three times and averaged.

Determination of drying rate: Drying rate:

$$\eta = \triangle m/\triangle t$$

where,

Δm = The mass of water loss in two consecutive measurements, g

Δt = The interval time between two consecutive measurements, min

RESULT ANALYSIS

The influence on the shanghai green vegetable quality of microwave power: Figure 1 is Shanghai Green Vegetable microwave drying curves in different power.

It can be seen from Fig. 1, drying time is shorting with microwave power increasing when the material density is constant. Shortened amplitude of drying time is not increased with microwave power increasing in conditions of 500 and 600 W, respectively this may be because evaporation rate of surface is faster than migration rate of water within Shanghai Green Vegetable in higher power and resulting energy efficiency reduced after microwave energy absorbed. It can also be seen from Fig. 2, curve interval is big and indicating that influence on the Shanghai Green Vegetable drying rate of microwave power is great.

Figure 2 is Shanghai Green Vegetable drying rate curves in different power.

It can be seen from Fig. 2, Shanghai Green Vegetable microwave drying process can be divided into three stages, namely acceleration, constant speed and deceleration phases. In initial drying, microwaves make water molecules in Shanghai Green Vegetable vibrated, frictional heat is generated and the temperature of inside and surface is rising at the same time, water of the surface is evaporating, temperature is decreasing, therefore temperature gradient is generated and pushes water migration out. On constant speed drying stage, the surface water loss rate is equal to the internal water migration out rate, so the drying rate remains unchanged over a period of time. The bound water is removed on final stage, due to Shanghai Green Vegetable surface is no longer wet, The surface water loss rate is faster than the internal water migration out rate, so the drying rate decreases gradually, (Geng and Ge, 2014; Ge, 2014) also comes to similar conclusions. Microwave power is greater, the drying rate is greater and the time required drying Shanghai Green Vegetable to safe water content is shorter.

The influence on the shanghai green vegetable quality of density: Figure 3 is Shanghai Green Vegetable microwave drying curves in different density.

It can be seen from Figure 3, with increasing of Shanghai Green Vegetable density, the drying time is extended. This is mainly because the greater density, the total water content is greater; microwave energy absorbed by per mass water is reducing when microwave power is constant, therefore, the drying time will be extended when other conditions remain unchanged.

Figure 4 is Shanghai Green Vegetable drying rate curves in different density.

It can be seen from Fig. 4 the drying rate is different with different Shanghai Green Vegetable densities. The drying rate is increasing with different Shanghai Green Vegetable density increasing at the same water content. Because the density is greater, the surface area which evaporates water is greater too, so the drying rate is also increased. It can also be seen from Fig. 4, density influence on Shanghai Green Vegetable drying rate is greater.

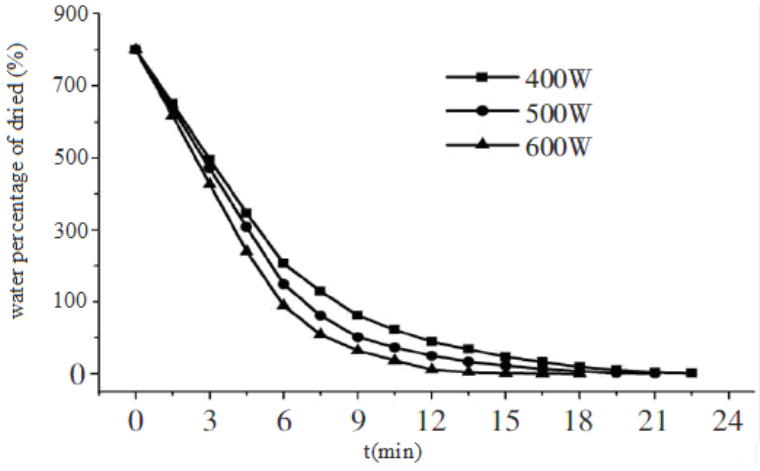

Fig. 1: Drying curves of different microwave power

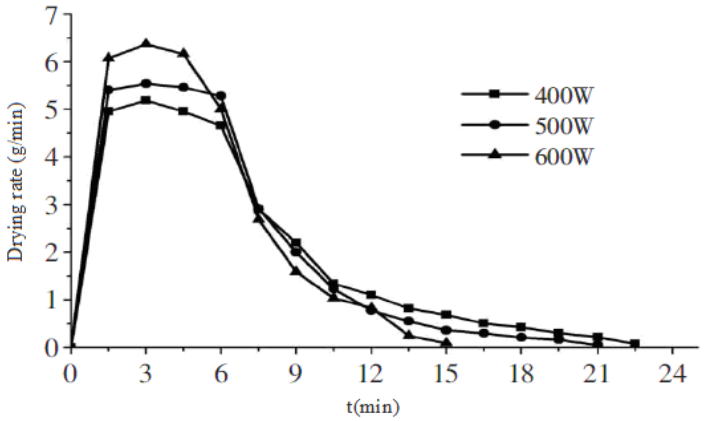

Fig. 2: Drying rate curves of different microwave power

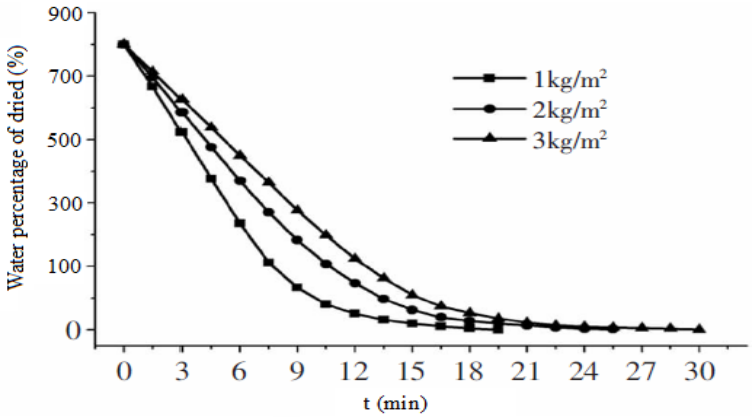

Fig. 3: Drying curves of different density

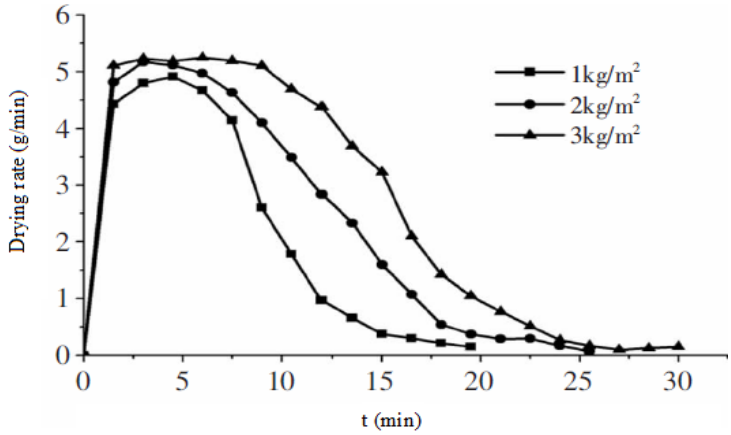

Fig. 4: Drying rate curves of different density

Table 1: Temperature measuring results

	Number of times					
Measuring point	1	2	3	4	5	6
The temperature on the 1st point	31.8	28.6	30.3	29.7	31.9	35.0
The temperature on the 2nd point	29.3	30.7	30.2	34.6	28.9	29.5
The temperature on the 3rd point	30.8	29.6	24.8	29.2	30.0	31.6
The temperature on the 4th point	29.9	30.9	26.2	30.0	29.1	28.5
The temperature on the 5th point	32.7	29.8	25.5	29.8	32.3	33.9

Temperature distribution during microwave drying shanghai green vegetable: The dried Shanghai Green Vegetable temperature were measured in different power (400, 500 and 600 W, respectively) and same density distribution; the dried Shanghai Green Vegetable temperature were measured in same power and different densities (1, 2 and 3 kg/m^2, respectively) distribution, the number of measurement points is 10, the specific temperature is shown in Table 1.

CONCLUSION

- Shanghai Green Vegetable microwave drying process can be divided three stages: acceleration, constant speed and deceleration according to drying rate; microwave power and Shanghai Green Vegetable density influence on Shanghai Green Vegetable microwave drying rate is greater.
- The greater of the microwave power, the shorter of the time that Shanghai Green Vegetable is dried to the security water content in the drying process, but when the power reaches a certain value, power increased has little effect on drying rate; the greater the Shanghai Green Vegetable density, the longer of the drying time.
- Temperature distributions are uniform and not very high, this is conducive to maintain nutrients of Shanghai Green Vegetable and keep fresh color.

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