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Research Article

An Experimental Study on Banana Slice 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 in banana slices production process, microwave drying process of banana slices was studied. The effects on drying rate were studied in different microwave power, slice thickness and initial moisture content and variety law of water content was studied during drying process. The experimental results showed that the microwave drying process was divided into three stages: the rising rate, the constant rate and the reducing rate. The most significant effect on drying rate of banana slice is microwave power, followed is initial water content and slices thickness. The bigger microwaves power, the lower initial moisture content, the faster drying rate, the shorter drying time.

Keywords: Banana slices, drying process, microwave drying

INTRODUCTION

After apple, citrus and pear, banana is the fourth most amount fruit in China, banana resources are rich in China and planting area is about 5.3 million acres, the total output is more 8.5 million tons (Li *et al*., 2015). Banana has obvious health care function, is rich in falconoid, polyphones, polysaccharides, anthocyanins and so on and has antioxidant, anticancer and antitumor (Amorim *et al*., 2009), improve immunity (Vijayakumar *et al*., 2008), protect red blood cells (Sundaram *et al*., 2011) and cardiovascular etc; and banana is rich in resistant starch, dietary fiber and oligosaccharide, has laxative, weight loss and prevention and control diabetes. Therefore, the banana is known as "king of new fruit" (Cheng *et al*., 2015). Banana belongs to respiratory climacteric fruit, is perishable and is prone to chilling injury under the low temperature condition and easy to be bacteria, microbial infection in storage and transportation (Mbéguié-A-Mbéguié *et al*., 2009). Therefore, it has become a hot research to develop banana products which are suitable for transportation and storage, banana slice, juice and sauce are the typical banana products. Especially in recent years, banana slices are favored by customers for natural, nutrient, crisp, convenient, easy storage etc, process of banana slices becomes hot research.

Currently the main production of banana slices is fried, the process of vacuum fried banana slices was studied (Zhang *et al*., 2010), the fried process of vacuum fried banana slices was studied (Yamsaengsung *et al*., 2011), how to keep crisp, control high oil in fried banana slices and the acid value, peroxide value variety in storage, improve the shelf life are need to solve for fried banana slices. So the dried banana slices are coming, the methods of dried banana slices are hot air drying under atmospheric pressure and vacuum freeze drying, the process of drying banana slices using hot air was studied (Yan *et al*., 2008), the process of freeze drying of banana slice was studied (Zhuang *et al*., 2011). Time long, high energy consumption, high cost are the common problem no matter the hot air drying and vacuum freeze drying, so microwave is used in drying banana slices, the effects of microwave power, thickness and initial moisture content on the drying characteristics of banana slices were studied in this study and theoretical basis for the industrialization of drying banana slice is provided.

Drying effect to which the microwave power, the thickness and initial moisture content of the banana slice are first introduced, then to identify the relationship among these factors and provides a theoretical basis for the application of microwave in banana slices production process.

MATERIALS AND METHODS

Material: Fresh banana, slightly blue, slices

Main instrument: Microwave drying apparatus (2450 MHz), optical balance (±0.0001 g), electronic balance, Changzhou Want balance instrument limited company, pharmaceutical scales.

Method:

Determination of initial moisture content: According to GB/T5009.3-2003 "determination method of water content in food".

Drying characteristics experiment: Microwave drying experiment are done in different microwave power, different thickness banana slices and different

initial moisture content and drying curves and dehydrating rate curve of banana slices are determined in different process parameters.

Dried banana slices moisture content and dehydrating rate:

Dried banana slices moisture content: $W = (m_0 - m_c)/m_c$:

Water loss rate: $V = \Delta m/\Delta t$

where,
m_0 = Mass of dried banana slices
m_c = Mass of initial banana slices
Δm = Dehydrating mass of two adjacent measuring
Δt = Time interval of two adjacent measuring

RESULTS AND ANALYSIS

Effects of microwave power on banana slices drying characteristics: Microwave drying experiment are done under the condition that microwave power is 80, 120, 160 W, respectively the slice thickness is 8 mm and the initial moisture content is 80%, drying curves of banana slice are drawn (Fig. 1 and 2), Fig. 1 is drying curves in different microwave power, Fig. 2 is variety of dehydrating rate in different microwave power.

It can be seen that from Fig. 1 banana slices drying time is decreasing with microwave power increasing in same slices thickness and initial moisture content, influence of microwave power on drying time is decreased gradually, this is because when microwave power is to a certain, banana slices absorb a lot of microwave energy rapidly and lead to water evaporating rapidly, a large amount of water is directly discharged in ways of internal evaporation and liquid water, at the same time, the internal water diffused and migrated fast and more than the surface water evaporated, so that the internal water content is much lower than the surface water content, water content reducing reduces microwave energy absorption.

It can be seen that from Fig. 2, dehydrating rate of banana slices is increasing correspondingly with microwave power increasing in same slices thickness and initial moisture content, Microwave power is more, unit water in banana slice absorption microwave energy is more, water temperature rising is faster and drying time is shorter and dehydrating rate is more. In the middle of drying, microwave energy absorbed is used for banana slices evaporation; the drying rate is relatively stable. In the later drying, microwave energy absorbed by banana slices is decreasing with water content decreasing, drying rate is decreasing gradually. Further analysis can be seen that banana slices

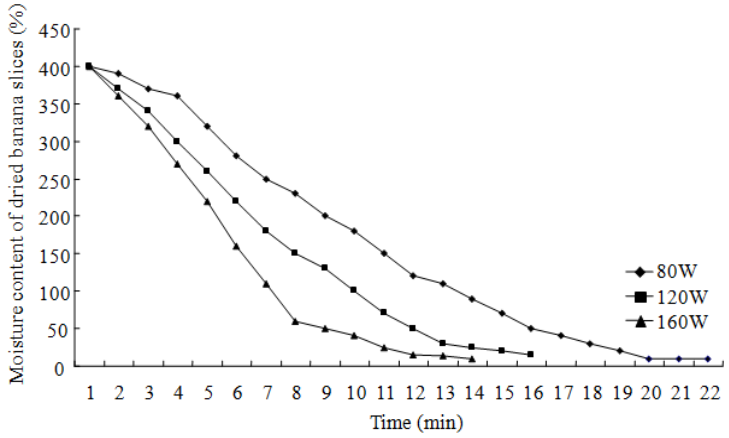

Fig. 1: Drying curves in different microwave power

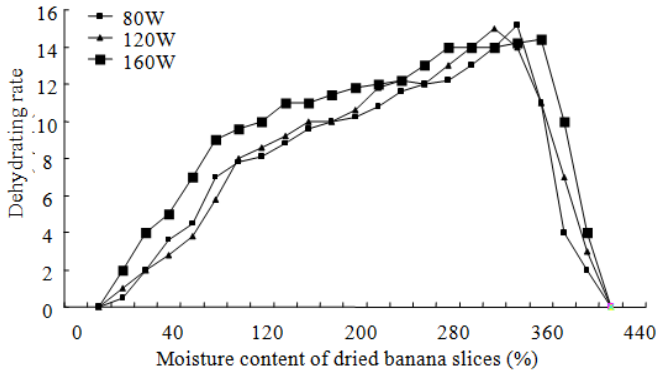

Fig. 2: Variety of dehydrating rate in different microwave power

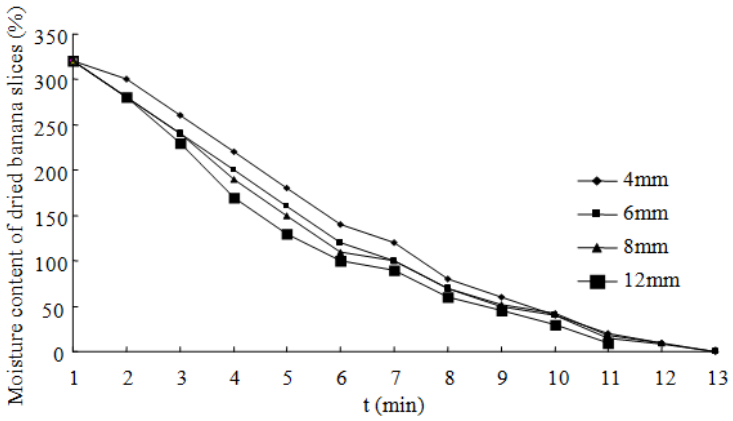

Fig. 3: Drying curves in different thickness

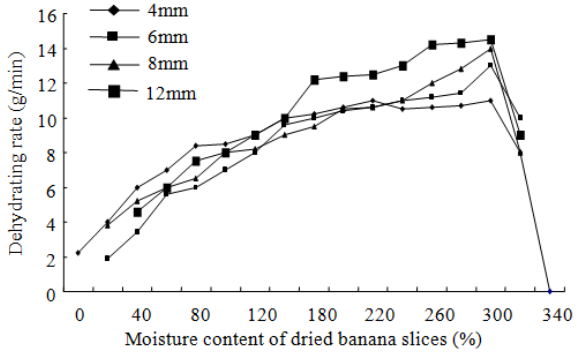

Fig. 4: Variety of dehydrating rate in different thickness

dehydration process can be divided into 3 stages, that is, accelerated drying stage, constant drying stage and reducing drying stage, banana slices dehydration process is mainly in constant drying stage.

Effects of banana slice thickness on drying characteristics: Microwave drying experiment are done under the condition that microwave power is 120 W, the slice thickness is 4, 6, 8, 12 mm and the initial moisture content is 80%, drying curves of banana slice are drawn (Fig. 3 and 4), Fig. 3 is drying curves in different thickness, Fig. 4 is variety of dehydrating rate in different thickness.

It can be seen that from Fig. 3 banana slices thickness is more, drying time is shorter. The drying time is longest when banana slice thickness is 4 mm, this is because the thickness of banana slice is too small, part of microwave penetrates banana slice and results energy losing, so banana slices thickness is smaller, drying time is longer. When the slice thickness is 6 mm and 8 mm, the two drying curves are very close, the variety is basically the same; the drying time is the same too. So it can be inferred that when the banana slices thickness increases, the microwave energy is required more, the drying time is increasing with the banana slices thickness increasing. It can be seen that from Fig. 4 there are 3 dehydration stages in banana slices drying process. In the microwave drying process, the dehydration rate is more with banana slice thickness increasing when the banana slices thickness is below 12 mm. This is because the banana slice thickness is in the range of microwave penetration, banana slices is heated in internal, the central temperature is rising fast, the temperature difference and pressure difference of internal and external are formed, the water evaporation rate is quicken, the drying rate increases fast, the drying rate is also higher.

Effects of initial moisture content on banana slices drying characteristics: Microwave drying experiment are done under the condition that microwave power is 140 W, the initial moisture content is 70, 50, 30%, respectively drying curves of banana slice are drawn (Fig. 5 and 6), Fig. 5 is drying curves in different initial moisture content, Fig. 6 is variety of dehydrating rate in different initial moisture content.

It can be seen that from Fig. 5 the initial moisture content is lower, drying time is shorter. The drying time is longest when the initial moisture content is 70%, the drying time is shortest when the initial moisture content is 30% and it can be known that the initial moisture content is higher, the evaporation is more, so the drying time is longer.

It can be seen that from Fig. 6 that the banana slices initial moisture content impact on microwave drying process significantly. The initial moisture content is smaller, the drying time of the constant and reduction drying stage is reducing obviously, the constant drying stage is less obvious and even no the constant drying stage. The reason is that water molecules are very easy to absorb microwave energy to produce heat, the initial moisture content is low and the banana slices absorb microwave energy small, there is not enough moisture to maintain constant drying stage, so the constant drying time is short, moisture content in reduction drying stage is lower, the drying time in reduction drying stage is shortened and the whole

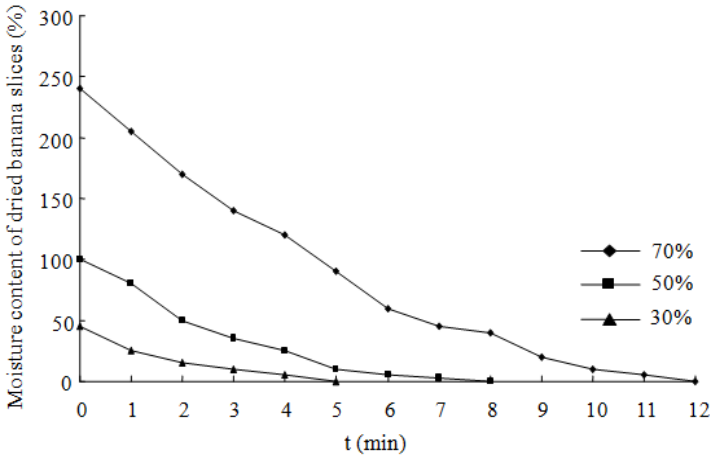

Fig. 5: Drying curves in different initial moisture content

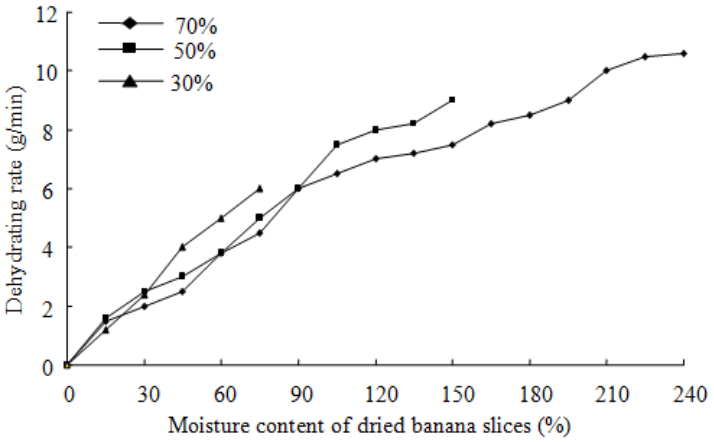

Fig. 6: Variety of dehydrating rate in different initial moisture content

drying time is shortened. Otherwise, the initial moisture content is higher, microwave energy absorbed by banana slice is more, dehydrating rate is accelerated and reached maximum and the next is constant drying stage. With the evaporation of water, microwave energy absorbed by banana slice is decreasing; the next is reduction drying stage, at present, the moisture content is high; therefore, the time of constant drying stage and reduction drying stage is longer.

CONCLUSION

There are 3 stages in microwave drying process of Banana slice: accelerating drying stage, constant drying stage and decreasing drying stage; the higher of microwave power, the faster dehydrating rate of banana slice, the shorter of drying time to reach safe water content; the more thickness of banana slice, the faster drying rate of banana slice that the thickness of banana slice is in range of 4 mm-12 mm and depth of microwave penetration, the shorter of drying time required to reach safe drying.

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