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Process Parameter Study on Microwave-assisted Foam-mat Drying Properties of Corn Soaking Water

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Abstract: In order to study the microwave-assisted foam-mat drying properties of corn soaking water and optimize process parameters, a quadratic regression orthogonal rotary method was used to analyze the influence of microwave power, material weight, material thickness and drying time on moisture content (dry basis), color value and protein content. Results showed that the primary and secondary sequence of parameters with regard to moisture content (*d. b.*) was drying time, microwave power, material weight and material thickness; the primary and secondary sequence of parameters with regard to color value was material weight, drying time, microwave power and material thickness; the primary and secondary sequence of parameters with regard to protein content was drying time, material weight, microwave power and material thickness. Optimum conditions were obtained as microwave power of 560 W, material weight of 46.88 g, material thickness of 6.20 mm and drying time of 8.01 min. The results might provide the theoretical basis and technical support for the microwave-assisted foam-mat drying of corn soaking water to produce yeast protein power.

Key words: corn, fermentation liquor, moisture content, color, protein, microwave foam-mat drying

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Introduction

Corn soaking water, as an organic byproduct from the wet processing of corn starch production, contains protein of 3%-4% (Gao and Yuan, 2010; Azoulay *et al.*, 1980). This protein of corn soaking water has high medicine and nutrition value (Wang and Xu, 2004; Li *et al.*, 2013). Yeast protein powder from corn soaking water is an available method for industrial production. Spray drying technology has been applied for drying concentration of fermentation broth from soaking liquid of corn kernel to produce yeast protein powder (Ratti and Kudra, 2006). However, dehydration quality and drying efficiency are hard to be controlled due to uniform size of starch kernel in soaking liquid of corn to block spray nozzle. A large amount of corn soaking water has been discharged directly to cause environment pollution due to deficiency of feasible drying method (Ratti and Kudra, 2006). Microwave-assisted foam-mat drying (MFD) is a novel drying technology, which combines advantages of foam-drying and microwave-drying to improve energy utilization rate, increase heating area of material, and more uniform of heating (Zheng *et al.*, 2009). MFD technology has been applied for drying process of berry fruit to produce berry powder with fine quality and high efficiency (Zheng *et al.*, 2013).

Objectives of this work were to study the microwave-assisted foam-mat drying properties of corn soaking water, analyze effects of drying parameters on drying quality of yeast protein power, and to optimize technological parameters.

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Materials and Methods

Experimental material

Experimental corn kernel was provided by Agricultural College Experimental Station of Northeast Agricultural University (Harbin, China). According to AOAC (1992) standard method, component contents of corn kernel were measured as protein contents of 9.55%, fat contents of 4.08% and starch contents of 74.16%.

Experimental equipments

In MFD experiment, equipment was employed as a food blender (HR1727, Philips) to grind corn sample, an electronic analytical balance (AB204-S, accuracy of 0.0001 g, Mettler-Toledo Instruments) to weight sample, a thermal oven (DHG-9053, Yiheng, Shanghai, China) to measure moisture content of sample, an oscillation water-bath pot (HZS-H, Donglian, Harbin, China) to heat sample, an oscillation incubator (HZQ-X100, Donglian, Harbin, China) to incubate fermentation broth of corn, an automatic color difference meter (DC-P3, Beijing, Xingguang, China) to measure color value of corn yeast powder.

Experimental measurement

Moisture content (*d. b.*) was measured by direct drying method, and measurement results were calculated by the formula which was shown in Eqn. (1) (Guo *et al.*, 2008; Zheng *et al.*, 2011; Sun *et al.*, 2012):

$$M_g=\frac{W}{G_g} \quad (1)$$

Where, M_g was moisture content (*d. b.*), W was water quality in sample (g) and G_g-dry matter quality (g).

Color value was measured based on uniform color space theory proposed by CIE (Coherent Infrared Energy) in 1976 (Bórquez *et al.*, 2010; Ratiya *et al.*, 2012; Zheng *et al.*, 2013).

Protein content was measured by using Kjeldahl instrument and measurement results were calculated by formula which was shown as Eqn. (2) (Zheng *et al.*, 2013):

$$X=\frac{(v_2-v_1)\times c\times 0.014}{m}\times 6.25\times 100 \quad (2)$$

Where, X was protein content in sample, v_1 was fraction of hydrochloric acid standard solution consumed in blank titration, v_2 was fraction of hydrochloric acid standard solution consumed in sample titration, c was concentration of hydrochloric acid standard solution and 6.25 was factor of nitrogen conversion into protein.

Experimental methods

According to results analysis of drying characteristic tests, microwave power (X_1), material weight (X_2), material thickness (X_3) and drying time (X_4) were selected as influence factors, and moisture content (*d. b.*) (Y_1), color value (Y_2) and protein content (Y_3) were selected as response values. Response surface method with center combination test was employed to design experimental procedure with four-factor and five-level by using the software of Design Expert (Ver7.1). Coding levels of parameters are shown in Table 1.

Results and Discussion

According to experimental design program, all MFD experiments of corn soaking water were operated, and the results are shown in Table 2.

Table 1 Independent variables and levels

Code value	Microwave power X_1 (W)	Material weight X_2 (g)	Material thickness X_3 (mm)	Drying time X_4 (min)
–2	140	20	2	3
–1	280	30	4	5
1	420	40	6	7
1	560	50	8	9
2	700	60	10	11