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Far-infrared and microwave drying of peach

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Abstract

Little detailed information is available for the far-infrared and microwave drying characteristics on peach and far-infrared combined with microwave drying on other food products. Experiments were conducted to study microwave and far-infrared dehydration characteristics and two-stage drying process involving far-infrared following microwave drying on peach. As microwave drying power and infrared drying power increased, dehydration rate of peach increased and whole drying energy consumption decreased. Peach experienced two falling rate periods when dried with microwave drying or far-infrared drying, and the first falling rate period under moisture content of peach more than 1.7 (dry basic, d. b.), the second falling rate period under less than moisture content 1.7 (d. b.). The same water loss will consume more energy and the steeper curve of energy versus moisture content were obtained when the moisture content is less than 1.7 (d. b.). However, differed from microwave drying, an accelerating dehydration rate period existed in the initial period of far-infrared drying. The effects of infrared drying power, microwave drying power and exchanging moisture content at former far-infrared drying converting into latter microwave drying (three factors) on energy consumption rate and sensory quality (two indices) are significant. The interaction effect of infrared drying power and exchanging moisture content on two indices is significant. The effects of second-order of microwave drying power and of interaction between infrared drying power and microwave drying power on energy consumption rate were not significant. The effects of second-order of exchanging moisture content and of interaction between exchanging moisture content and microwave drying power on sensory quality were not significant.

Keywords: Microwave; Drying; Peach; Infrared; Quality; Characteristic

1. Introduction

Major disadvantages of hot air drying of foods are low energy efficiency, quality loss and lengthy drying time during the falling rate period (Boudhrioua, Giampaoli, & Bonazzi, 2003). Because of the low thermal conductivity of food materials, heat transfer to the inner sections of food during conventional heating is limited. The desire to eliminate this problem, prevent significant quality loss, and achieve fast and effective thermal processing has resulted in the increasing use of infrared and microwaves for food drying.

Infrared radiation has significant advantages over conventional drying. These advantages are higher drying rate, energy saving, and uniform temperature distribution giving a better quality product. Therefore, Infrared drying can be used as an energy saving drying method. At present, many driers use infrared radiator to improve drying efficiency, save space and provide clean working environment, etc. (Ratti & Mujumdar, 1995; Yamazaki, Hashimoto, Honda, & Shimizu, 1992).

Attempts have been reported on application of infrared drying of agricultural materials. With intermittent infrared and continuous convection heating of a thick porous material, the drying time can be reduced to 2−2.5 times less compared to convection alone while keeping good food quality and high energy effciency (Dostie, Seguin, Maure, Ton-That, & Chatingy, 1989).

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Far infrared drying of potato achieved high drying rate with infrared heater of high emissive power (Masamura et al., 1988). The drying rate was also reported to increase when the electric power supplied to the far infrared heater was increased and, consequently, the temperature of the sample was also observed to be high. Far infrared and near infrared drying using three types of granular bed and their quantitative comparison to hot air drying from the viewpoint of the heat transfer has been reported by Hashimoto, Hirota, Honda, Shimizu, and Watanabe (1991).

Infrared is important in drying technology, but it is not a panacea for all drying processes. It penetrates and produces heating inside the material being dried, but its penetrating power is limited (Wang & Sheng, 2004).

Microwave drying is more rapid, more uniform and more highly energy efficient compared to conventional hot air drying and infrared drying. In this case, the removal of moisture is accelerated and, furthermore, heat transfer to the solid is slowed down significantly due to the absence of convection. And also because of the concentrated energy of a microwave system, only 20–35% of the floor space is required, as compared to conventional heating and drying equipment. However, microwave drying is known to result in poor quality product if not properly applied (Yongsawatdigul & Gunasekaran, 1996a; Drouzasm & Dchubert, 1996).

For microwave applications, a two-stage drying process involving an initial forced-air convective drying, following by a microwave finish drying, has been reported to give better product quality with considerable saving in energy and time (Feng & Tang, 1998). Water accounts for the bulk of the dielectric component of most food systems especially the high moisture fruit and vegetable. Hence, these products are very responsive to microwave applications and will absorb the microwave energy quickly and efficiently as long as there is residual moisture (Feng, Tang, & Cavalieri, 2002). The microwave application for drying, therefore, offers a distinct advantage, i.e. high-energy absorption proportional to moisture content. Proteins, lipids and components can also absorb microwave energy, but are relatively less responsive (Mudgett & Westphal, 1989). A second advantage of microwave application for drying of vegetables is the internal heat generation (Wang, Zhang, Wang, & Xu, 1999). In a microwave drying system, the microwave can easily penetrate the inert dry layer to be absorbed directly by moisture in food parts. The quick energy absorption causes rapid evaporation (boiling) of water, creating an outward flux of rapidly escaping vapor (Feng, Tang, Cavalieri, & Plumb, 2001). In addition to improving the rate of drying, this outward flux may help to prevent the collapse (shrinkage) of tissue structure, which prevails in most conventional air drying techniques. Hence better rehydration characteristics may be expected in microwave-dried products (Al-Duri & McIntyre, 1992; Wang, Xiong, & Yu, 2004; Wang & Xi, 2005).

In recent years, microwave drying has gained popularity as an alternative drying method for a variety of food products such as fruit, vegetable, snack food and dairy product. Several food products have been successfully dried by the microwave-vacuum application and/or by a combined microwave assisted-convection process. The researchers included Kim and Bhowmik (1995) for plain yogurt, Yongsawatdigul and Gunasekaran (1996b) for cranberries, Lin, Durance, and Scaman (1998) for carrot slices, Drouzas and Saravacos (1999) for model fruit gels, Al-Duri and McIntyre (1992) for skimmed milk, whole milk, casein powders, butter and fresh pasta, Bouraout, Richard, and Durance (1994) for potato slices, Tulasidas, Raghavan, and Norris (1996) for grapes, Funebo and Ohlsson (1998) for apple and mushroom, and Ren and Chen (1998) for American ginseng roots, Prothon et al. (2001) for apple and Feng et al. (2000) for blueberries.

It has also been suggested that microwave energy should be applied in the falling rate period or at a low moisture content for finish drying (Kostaropoulos & Saravacos, 1995; Funebo & Ohlsson, 1998). Microwave may be advantageous in the last stages of air drying. Because low efficient portion of a conventional drying system is near the end, two-thirds of the time may be spent, the last one-third of the moisture content (Al-Duri & McIntyre, 1992).

However, the far-infrared and microwave drying characteristics on peach and far-infrared combined with microwave drying for food were little reported, i.e. little detailed information is available on the alternative microwave power drying on food products, such as a two-stage drying process involving far-infrared following microwave drying.

The objectives of this study were: (1) to study far-infrared and microwave dehydration characteristic of peach and discuss the influence of drying power on dehydration characteristic and energy consumption; (2) to determine the effect of exchanging moisture content (the moisture content of breaking point that former far-infrared drying convert into latter microwave drying), infrared drying power and microwave drying power on sensory quality, rehydration ratio and energy consumption rate; (3) to obtain optimizing combination of drying parameter for sensory quality and energy consumption rate.

2. Materials and methods

2.1. Material

Ripe peach (a firm yellow Chinese peach, Zhe-Agriculture No. 2, was usually used to process into