Contents lists available at ScienceDirect

Food and Bioproducts Processing

journal homepage: www.elsevier.com/locate/fbp

Effects of germination time and drying temperature on drying characteristics and quality of germinated paddy

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ABSTRACT

Germination time and drying temperature are very important parameters affecting the quality of the germinated paddy (GP) since the microstructure of starch granules is modified during germination. The experimental results showed that the germination time increasing from 60 to 68 h provided more loosely-packed starch granules, lower hardness of cooked GP, higher γ-aminobutyric acid content (GABA) and larger number of fissured GP after drying. However, the modified microstructure did not cause a difference between drying curves at each germination time. Prediction results of the moisture content from the two-layer model were in good agreement with the experimental results and also showed that the effective moisture diffusion coefficient values of husk were significantly lower than those of germinated brown rice. Drying at a higher drying temperature could reduce the number of fissured GP more significantly. The hardness of cooked GP samples and their GABA contents obtained from drying temperatures changed insignificantly from that of the shade-dried GP. The sensory analysis results revealed that the texture of GP was better than that of the rice without germination and the longer germination time provided the adverse effect on the fermentation odour and texture.

Keywords: Germinated paddy; Drying characteristics; Fluidized bed; Texture; Moisture diffusivity; Modeling

1. Introduction

Brown rice consists of bran layers, embryo and endosperm. Milling to remove the bran layers and germ provides white rice, which is mostly consumed by people. As compared to white rice, brown rice is richer in nutritional components such as vitamins, minerals and protein and also richer in bio-functional components (Heinemann et al., 2005). However, brown rice is not favoured by consumers because of hard texture. The improvement of cooked brown rice texture is important and may bring people to consume more brown rice.

Germination is an efficient method that provides a soft brown rice texture after cooking. During germination, hydrolytic enzymes are produced and activated (Banchuen et al., 2009). These enzymes destroy hydrogen bonds at random points in the high molecular weight polymers,

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Received 21 January 2014; Received in revised form 10 September 2014; Accepted 29 September 2014
Available online 17 October 2014
http://dx.doi.org/10.1016/j.fbp.2014.09.013

particularly starch, to lower molecular weight polymers, i.e., glucose and maltose. The decay of starch enables the change of textural properties (Induck et al., 2006). Moreover, the germination also enhances the nutritional functions and health benefits of brown rice. The biochemical activities occurring during germination generate bioactive components especially γ-aminobutyric acid (GABA) (Moongngarm and Saetung, 2010). GABA has beneficial effects on human health such as decreasing stresses in brain, helping the anti-hypertensive effect and limiting cancer cell proliferation (Hyun-Jung et al., 2009; Dinesh-Babu et al., 2009).

A good quality of finished germinated rice depends on germination time and drying temperature. Germination time involves directly the decomposition of starch. Prolonging germination time provides more decomposition of starch and higher level of bioactive components. Thus, it is necessary to compare the quality at different germination times. In addition, the decay of starch during germination may affect the product quality during drying because of the weaker strength of kernels which will produce a large number of fissured kernels. Drying temperature also causes a change of microstructure of starch granules. At high drying temperature (above 100 °C), some starch granules lose their shape and some have a less defined shape with less space among starch granules due to the starch gelatinization (Jaisut et al., 2008). This provides the increase of strength of kernel structure and subsequently withstands the stresses taking place during drying (Srisang et al., 2011). Hence, drying at high temperature may decrease a number of fissured kernels in dried germinated rice. However, it may provide the adverse effect on the textural properties of dried germinated rice. The hardness of cooked dried germinated rice may increase as compared to that of the cooked shade-dried germinated rice due to the occurrence of gelatinization (Rattanamechaiskul et al., 2013).

Therefore, the objective of this work was to investigate the effect of germination time and drying temperature on the quality and drying characteristics of GP. Also, the moisture diffusion coefficient of GP was determined. The assessment of the dried GP quality was considered in terms of textural properties after cooking, GABA content, cracked kernels and thermal properties as well as the sensory evaluation of the cooked product.

2. Materials and methods

2.1. Paddy sample

Chai Nat 1 rice variety obtained from the Rice Department, Chai Nat province, Thailand, was used. The storage time was approximately three months prior to experiment. A moisture content of rice obtained from the Rice Department was about 15% (d.b.).

2.2. Preparation of brown rice sample

Paddy sample was dehusked in a hulling machine (Ngeksenghuat, model P-1, Bangkok, Thailand) and then graded using an indent cylindrical separator (Ngeksenghuat, model I-1, Bangkok, Thailand).

2.3. Preparation of GP

For the determination of drying characteristics, Chai Nat 1 paddy was soaked in water at the controlled temperature of 35 °C for 60, 64, 68 and 84 h. The samples with germination time over 84 h were not used because the germinated rice spoiled. For the determination of GP quality, the samples with germination time over 72 h were not examined in this study since GP had a strong fermented odour. During germination, the water was changed every 4 h. After germination, the germinated samples were dried in a batch fluidized bed dryer.

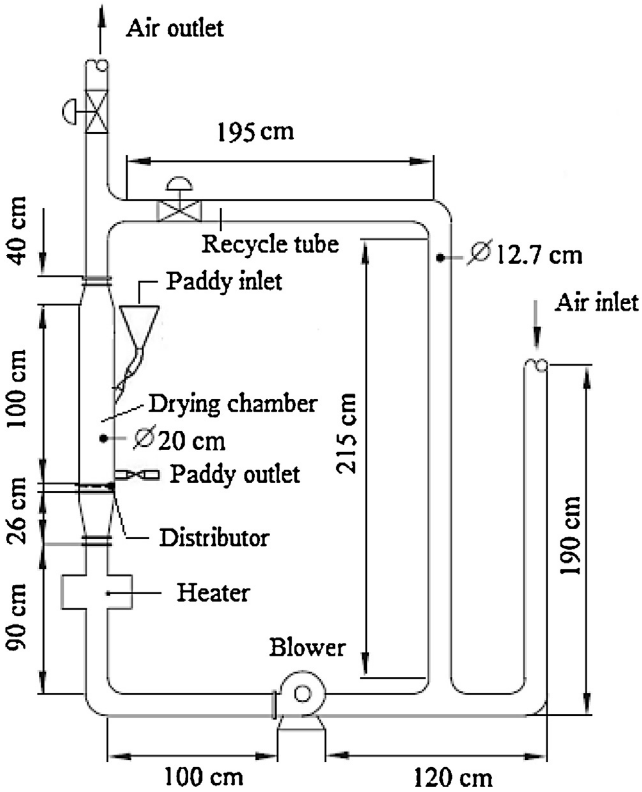

Fig. 1 – Schematic diagram of hot air fluidized bed dryer.

2.4. Preparation of germinated brown rice (GBR)

Brown rice was soaked in water at the same conditions as performed in the preparation of GP. The determination of drying characteristics of GBR in this study was used for calculating the moisture diffusion coefficient of GBR. This value will be used for determining the moisture diffusion coefficient of husk in the ellipsoid model with two layers.

2.5. Preparation of dried sample

GP or GBR was dried in a hot air fluidized-bed dryer schematically shown in Fig. 1. The drying system comprised a stainless steel cylindrical drying chamber with 20 cm diameter and 140 cm height, a backward-curved blade centrifugal fan driven by a 1.5 kW motor, and a 12 kW heater controlled by a PID controller with an accuracy of ±1 °C. The drying conditions were set at inlet drying temperatures of 90–150 °C and a superficial air velocity of 3.5 m/s. The exhaust air was partially recycled with a fraction of 0.8 and the remaining proportion was expelled to the surrounding.

For the drying curve determination, a sample of GP or GBR (0.2 kg) with an initial moisture content of about 54% (d.b.), corresponding to the bed height of 1 cm, was dried for 2, 4, 6, 8 and 10 min. After reaching the predetermined drying time, the experiment was terminated and the whole sample was taken out for moisture content determination. A new experiment