Available online at www.sciencedirect.com

ScienceDirect

Rice Science, 2016, 23(5): 274−281

Effects of Dry-Milling and Wet-Milling on Chemical, Physical and Gelatinization Properties of Rice Flour

Jitranut LEEWATCHARARONGJAROEN, Jirarat ANUNTAGOOL

(*Department of Food Technology, Faculty of Science, Chulalongkorn University, Patumwan, Bangkok 10330, Thailand*)

Abstract: Rice flour from nine varieties, subjected to dry- and wet-milling processes, was determined for its physical and chemical properties. The results revealed that milling method had an effect on properties of flour. Wet-milling process resulted in flour with significantly lower protein and ash contents and higher carbohydrate content. Wet-milled flour also tended to have lower lipid content and higher amylose content. In addition, wet-milled rice flour contained granules with smaller average size compared to dry-milled samples. Swelling power at 90 °C of wet-milled samples was higher while solubility was significantly lower than those of dry-milled flour. Dry milling process caused the destruction of the crystalline structure and yielded flour with lower crystallinity compared to wet-milling process, which resulted in significantly lower gelatinization enthalpy.

Key words: rice flour; physicochemical property; crystallinity; amylose content; milling

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population (Xiang et al, 2015). Rice is consumed mostly as cooked grains, and it is also processed to puffed rice (Joshi et al, 2013) or flour and starch that can be further formulated into a variety of products. In order to successfully incorporate rice or its flour into products, the properties of the material have to be known as they will affect product qualities, consistency and also lead to good consumer satisfaction. Factors influencing the physicochemical properties of rice flour include rice genotype (Iturriaga et al, 2004), amylose content (Varavinit et al, 2003), protein content (Marco and Rosell, 2008) and milling method (Suksomboon and Naivikul, 2006). Rice flour is generally manufactured using wet-milling method as it is believed to yield flour with superior quality. However, wet-milling method results in large amount of waste water. Studies (Chen et al, 1999, 2003; Suksomboon and Naivikul, 2006) have shown that dry-milled flour retains components such as protein, lipid and ash at higher levels than wet-milled flour. If incorporated into food recipes, dry-milled flour can then offer a more nutritive product. Chen et al (1999) studied the physicochemical and functional properties of waxy rice flour prepared from dry-milling, semi-dry-milling, and wet-milling methods, and indicated that dry hammer-milled rice shows higher gelatinization and pasting temperatures, and semi-dry-milled rice results in the lowest pasting temperature, setback viscosity and enthalpy value. Hammer and semi-dry hammer milled rice gives higher percentages of coarse particles (100–300 μm), cyclone and turbo milled rice leads to a more even particle-size distribution, and the wet-milled rice gives the finest particles (10–30 μm). The dry-milled rice flour is reported to have more damaged starch, thus giving better solubility, and lower peak and final viscosities. Therefore, the final quality of rice flour is profoundly affected by the milling type and milling method. Provided that the physical and functional properties of both dry-milled and wet-milled rice flour are thoroughly elucidated, they can both find application

Received: 12 October 2015; **Accepted:** 8 December 2015

Corresponding author: Jirarat ANUNTAGOOL (Jirarat.t@chula.ac.th; j.anuntagool@gmail.com)

Peer review under responsibility of China National Rice Research Institute

http://dx.doi.org/10.1016/j.rsci.2016.08.005

in the food industry. This study aimed to investigate the physical and chemical properties of flour from several rice varieties as affected by dry-milling and wet-milling methods.

MATERIALS AND METHODS

Rice materials

Nine Thai rice varieties, Ayutthaya 1 (AY1), Plai Ngahm Prachin Buri (PNG), Prachin Buri 1 (PB1), Prachin Buri 2 (PB2), Rice Department 45 (RD45) (from Prachin Buri Rice Research Center in Thailand, harvested during March, 2011), Khao Dawk Mali 105 (K105; from Pathum Thani Rice Research Center in Thailand, harvested during December, 2010), Shaw Lung 97 (SL97; from Pattani Rice Research Center in Thailand, harvested during March, 2011), Rice Department 41 (RD41) and Rice Department 47 (RD47) (from Phitsanulok Rice Research Center in Thailand, harvested during November, 2010), were used in this study. The rice samples were obtained as milled rice. All samples were stored at 4 °C until further analyses.

Milling methods

Dry-milling process

Milled rice grains (500 g) were ground twice using a vertical disc mill. Flour samples were passed through a 100-mesh sieve (149 µm opening), sealed in polypropylene plastic bags and stored in a desiccator at room temperature until further analyses.

Wet-milling process

Approximately 1 kg milled rice was soaked overnight in 2 L $NaHSO_3$ solution (1.25%) before it was ground using a stone-mill under continuous addition of water to obtain rice slurry. The slurry was filtered through a filter bag to obtain rice cake. The cake was dried overnight in a tray dryer at 40 °C. The dried rice flour was ground and sieved through a 100-mesh sifter. Flour samples were packed in polypropylene plastic bags and stored in a desiccator at room temperature for further use (Varavinit et al, 2003).

Analysis of physicochemical properties of rice sample and rice flour

Particle size analysis

Particle size distribution was analyzed by a Laser Light Scattering Particle Size Analyzer (Beckman Coulter, model LS 13320, USA) according to the method of Park et al (2010) with minor modification.

Morphology observation

Light microscopy and scanning electron microscopy (SEM) were used to examine the morphology of starch granules. Samples were observed using a polarized light microscope (Model CH30RF200, Olympus, Japan). Rice flour was also investigated using an SEM (Model JSM-5800 LV, JEOL, Japan) with the procedure of Scientific and Technological Research Equipment Centre, Chulalongkorn University, Thailand.

X-ray diffraction analysis

X-ray diffraction analysis was performed using an X-ray diffractometer (Model D8 Discover, Bruker AXS, Germany) with the procedure of Scientific and Technological Research Equipment Centre, Chulalongkorn University, Thailand.

Water binding capacity, swelling power and solubility

Water binding capacity was determined following the method of Medcalf and Gilles (1965). Approximately 1 g sample was weighed (W_1) and transferred to a centrifugal tube in which 15 mL of distilled water was added and mixed. The tube containing the sample was then incubated in a shaker water bath at 30 °C and 174 r/min for 30 min before it was centrifuged at 5 000 × g for 20 min. The supernatant was decanted carefully and the residue was weighed (W_2). Water binding capacity was calculated as follows:

$$\text{Water binding capacity} = (W_2 - W_1) / W_1$$

Swelling power and solubility were determined following the method of Schoch (1964). Approximately 0.5 g sample was weighed (W_3) and transferred to a centrifugal tube, and 15 mL distilled water was added and mixed. The tube was then incubated in a shaker water bath at constant temperatures (60 °C, 70 °C, 80 °C and 90 °C) at 174 r/min for 30 min. The tube was cooled to room temperature and centrifuged at 6 000 × g at 4 °C for 20 min. The supernatant was decanted carefully and the residue was weighed (W_4). The supernatant was dried in an aluminum dish at 105 °C in a hot-air oven to a constant weight (W_5). Swelling power and solubility were calculated as follows:

$$\text{Solubility (\%)} = (W_4 / W_3) \times 100$$

$$\text{Swelling power} = W_5 / [W_3 \times (1 - \text{Solubility}) / 100]$$

Chemical analysis

Rice and flour samples were prepared for proximate analyses following the method of AOAC (2005).