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Physical characteristics of parboiled Korean glutinous rice *(Olbyeossal)* using a modified method

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ABSTRACT

A modified parboiling method was developed to parboil Korean glutinous rice and the physical characteristics of partially milled parboiled rice (PMPR) were investigated before and after cooking. The modified parboiling method involved tumbling to replace soaking the rice grains, tempering the wet grains, and retorting and drying were applied to prepare the PMPR. The conventional parboiling method included soaking at room temperature for 24 h, steaming, and drying the rice. PMPR made by the conventional method was prepared as a control. The modified parboiling method successfully produced PMPR with a higher hardness and thousand-grain weight by taking less processing time and less energy for soaking, which resulted in higher milled rice yield and head rice yield. However, no significant difference was observed in the PMPR bulk density. Rice kernel size tended to be longer and less thick due to parboiling. The color of the PMPR tended to be darker, as higher temperature was applied for processing. However, the color of the PMPR after cooking was lighter than that of PMPR before cooking. Cook-modified PMPR was as hard as cooked conventional PMPR but was less sticky compared to that of conventional cooked PMPR.

1. Introduction

Rice is a main staple food in many parts of the world, particularly Asia. Most people consume >50% of the energy they need from carbohydrates (starch). In Korea, the energy obtained from carbohydrates was about 64.3% of the total energy intake in 2006, which was a significant decrease from 78.5% in 1970. Rice consumption per capita reached 69.8 kg in 2012 and fell by 1.4 kg during the previous year and has decreased by 17.2 kg since 2002. Moreover, rice consumption in farming households (111.2 kg) is 1.66 times higher than that in non-farming households (67 kg) (Anonymous, 2012). A kind of processed rice called *Olbyeossal* is available in Korea. During the Korean food shortage era, *Olbyeossal* was prepared from premature glutinous rice that was consumed as a snack or table food. *Olbyeossal* is made by soaking, steaming, sun-drying, and partial milling. This process is commonly called parboiling (Park, Choi, Kum, & Lee, 2007). *Olbyeossal* is commonly consumed by elderly people as a snack, and some companies recommend that consumers mix parboiled rice and regular white rice proportionally to make cooked rice with the high nutritional value of parboiled rice. Some studies have reported that parboiling retains some phytochemical compounds (Bhattacharya, 2011; Manful, Swetman, Coker, & Drunis, 2007; Heinemann, Fagundes, Pinto, Penteado, & Lanfer-Marquez, 2005).

Parboiling is an old process in parts of Asia, particularly India, Africa, and to a limited extent in some European countries and the United States (Ali & Ojha, 1976). Parboiling is a hydrothermal treatment given to paddy rice to improve storage stability and involves soaking or steeping, steaming, and drying. This process improves milling recovery of paddy rice, salvages poor quality spoiled paddy rice, and meets the demand of some consumers. Along with the traditional way, a number of modern processes have been developed using new or existing technologies to improve product quality in different countries (Chattopadhyay & Kunze, 1986; Igathinathane, Chattopadhyay, & Pordesimo, 2005). The severity of parboiling, particularly that related to starch gelatinization, may be responsible for many of the attributes of parboiled rice, such as milling quality and physicochemical characteristics (Dutta & Mahanta, 2012, 2013).

Soaking rice at room temperature is widely practiced but a long time is required to reach a moisture content of about 30 g/100 g wb.

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Warm- or hot-water soaking is a common method to shorten soaking time because increasing temperature increases hydration rate. A soaking temperature below that of starch gelatinization is recommended to minimize kernel splitting and subsequent leaching of solids and phytochemicals (Subba Rao & Bhattacharya, 1966). Several parboiling rice plants use the conventional way to make parboiled rice to avoid high solid leaching by warm-water soaking, in which cold-water soaking and steaming at 100 °C are used. However, a problem arises when cracks occur in the final product. These cracks possibly occur due to steaming in a big cylindrical tank, which causes rice at the bottom to split.

Furthermore, excess water absorption could cause rice kernels to split. Thus, parboiling requires a shorter soaking time to prevent excess water absorption and shelves to prevent excess pressure on the rice during steaming. Therefore, tumbling, tempering, and retorting were introduced in this study. Tumbling is a process in which paddy rice and water roll together inside a tumbler for 4, 5 and 6 h to force water into the rice kernels. Tumbling replaced soaking. Tempering is a process in which wet paddy rice is kept at room temperature for 2, 4, 5 and 6 h to equalize moisture content inside the rice kernels. A decrease in the moisture gradient inside the rice kernel during tempering has been observed objectively by magnetic resonance imaging (Hwang, Cheng, Chang, Lur, & Lin, 2009). The moisture content of wet paddy rice prior to retorting was about 31 g/100 g wb (data not shown). Retorting is a high temperature and high pressure heating process that replaces steaming. Although the moisture content of wet paddy rice prior to retorting was slightly lower than that of paddy rice prior to steaming, the presence of high temperature and high pressure forced water to penetrate the rice kernel more quickly and effectively. It was agreed with results of reported by Unnikhrisnan and Bhattacharya (1987). Consequently, we investigated the effect of a modified parboiling treatment, including tumbling, tempering, and retorting, on the physical characteristics of partially milled parboiled rice (PMPR) prepared with Korean glutinous rice *(Sinseonchalbyeo)*.

2. Materials and methods

2.1. Materials

Paddy rice of the early harvested Korean glutinous rice variety *(Sinseonchalbyeo)* was obtained from Ungchi, Boseong, South Korea, harvested in early autumn 2012. This paddy rice was vacuum-packaged in plastic bags laminated with polyethylene and nylon and stored at 4 °C before treatment. The initial moisture content of this paddy rice prior to storage was 13–14 g/100 g.

2.2. Conventional parboiling process

Parboiled rice is conventionally made in Korea by soaking at room temperature for 1–1.5 days followed by steaming at 100 °C for 1 h. Parboiling was done on a lab scale to compare the product with modified-parboiled rice. Paddy rice (500 g) was washed and separated from foreign material and dehydration before soaking. Soaking was done at room temperature (25 °C) for 24 h in a laboratory incubator (LABTECH, Daihan, Korea). The moisture content of the wet paddy rice after soaking was about 33 g/100 g wb (data not shown). Hereafter, the soaked paddy rice was steamed at 100 °C for 30 min to gelatinize the rice starch. After steaming, the paddy rice was dried prior to milling. Drying was done using a hot-air dryer (DSD-060, Daesungenertec, Seoul, Korea) at 38 °C for 4 h. Finally, the dried paddy rice was milled using a small scale rice mill (FS-3000, Misul Brown Rice System, Seoul, Korea) to produce partially milled parboiled rice. A 7.5% degree of milling was used. The degree of milling was calculated using the method described by Marshall (1992).

2.3. Modified parboiling process

First, 500 g of paddy rice was washed and separated from foreign material and dried. After washing, the rice was tumbled in a tumbler for 4, 5 and 6 h to increase moisture content, drained, and allowed to stand at 25 °C in a laboratory incubator for 2, 4, 5 and 6 h to equalize moisture prior to retorting. Tumbling is a process in which paddy rice and excess water (1 kg per 5 L) are rolled together inside a tumbler to force the water to permeate the rice kernels. The tumbler was a V-shaped mixer that moved counter clockwise with a rotation speed of 21 rpm. Tempering was a process in which the wet paddy rice after tumbling was put in sealed pouch at 25 °C for 2, 4, 5 and 6 h to equalize the moisture content inside the rice kernels. Tumbling and tempering were done as the moisture content of the paddy rice reached about 31 g/100 g wb (data not shown). High-moisture paddy rice was steamed by retort (STERIACE, KRS-300/Touch Sc. Type, Seoul, Korea) for 5 min at 120 °C (14.71 N/cm^2) to gelatinize the starch. High temperature and high pressure during retorting pressurizes the water to penetrate the rice kernels more quickly and effectively so that it could gelatinize the rice faster compared to steaming. The paddy rice was dried after retorting. Direct drying at high temperature tended to increase breakage during milling, so low temperature air drying was applied. The retorted paddy rice was placed on a metal basket to facilitate drying and dried using a hot-air dryer (DSD-060) at 30 °C for 5 h, then allowed to stand overnight at 25 °C before milling. Finally, the dried paddy rice was milled using a small scale rice mill (FS-3000, Misul Brown Rice System) with 7.5% degree of milling. The degree of milling was calculated using the method described by Marshall (1992). The conditions for tumbling, tempering, and retorting are shown in Table 1.

2.4. Cooking method

PMPR (14 g/100 g wb moisture content) was placed in an electric rice cooker (WM-0641, MD Consumer Electric Mfg. co. Ltd, Guangzhou, China) with a 1 kg per 1.5 L ratio of rice and water, and the cooking process was completed automatically. The rice was not washed before cooking, although much powder remained from milling.

2.5. Milled rice yield and head rice yield

Head rice yield (HRY) was defined as the mass percentage of rice kernels that were at least three-quarters their original kernel length after milling. Rough rice is processed into several different fractions throughout the milling process. Rough rice becomes brown rice as hulls are removed; milling removes the bran from brown rice, resulting in milled rice; milled rice can be separated into head rice and broken kernels. Milled rice yield (MRY) includes head rice and broken kernels. All kernels in the sample; head rice and broken kernels, whereas HRY includes all kernels that are at least three-quarters of their original length after milling. MRY and HRY were calculated as follows:

$$\mathrm{MRY}(\%) = \frac{\text{Mass of milled rice}}{\text{Mass of rough rice}} \times 100$$

$$\mathrm{HRY}(\%) = \frac{\text{Mass of head rice}}{\text{Mass of rough rice}} \times 100$$