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Effect of Stewing in Cooking Step on Textural and Morphological Properties of Cooked Rice

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Abstract: Stewing of rice grains by steam after boiling in excess water can be used for cooking rice perfectly. The effects of this procedure in cooking of three varieties of Iranian rice (Sang Tarom, Domsiyah and Fajr) on textural and morphological properties of cooked rice grains were investigated. The results showed that this step in rice cooking reduced the hardness and increased the adhesiveness of rice grains significantly. By the use of the scanning electron microscopy, it was shown that the outer surface of cooked rice stewed by steam had less porosity and closer pores due to the modification during cooking, and better gelatinization and more expansion of starch granules compared to non-stewed samples. The use of this procedure in rice cooking to provide a fully cooked and gelatinized, softer and stickier final product is recommended.
Key words: rice; cooking; stewing; gelatinization; texture; morphological properties

Rice is one of the major staple foods for nearly half of the world's population for centuries. There are about 90% of its production and consumption in Asia. Consumers' preferences vary from place to place. The Japanese prefers sticky rice [1], Americans like a semi-milled long grain rice or even brown rice, Asian culinary dominates spicy and scented Basmati/ Jasmine rice, and the Indian prefers a well-milled white rice [2].

Starch is the main constituent of rice that is made up of two major fractions, amylose and amylopectin. Amylose is the key determination of eating and cooking quality of cooked rice [3]. One of the most important processing steps to provide desirable texture in rice grains is cooking. It involves heat and mass (water) transfer. The rice grains are boiled in limited or excess amount of water for cooking. The starch of milled rice grain absorbs moisture and swells during cooking due to its gelatinization [4].

In general, rice qualities are evaluated based on flavor, texture, color and other properties like glossiness, looseness and kernelness [5]. Since the consumers' choice and textural preferences in various regions are different, it is difficult to determine a standard procedure for cooking rice. There are some methods for rice cooking in Iran like open pan cooking, pressure cooking, cooking in an electric rice cooker and microwave cooking [6].

A different method for domestic rice cooking is applied in this work, and the effects of stewing (by steam) of three Iranian rice varieties after boiling in excess distilled water on textural and morphological properties of cooked rice grains were investigated.

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MATERIALS AND METHODS

Rice samples

Milled rice grains of three Iranian varieties (Sang Tarom, Domsiyah and Fajr) were used. These varieties were grown in the northern part of Iran. The milled rice grains were placed in airtight polyethylene bags and kept in a cold room. The average moisture contents of raw rice were equal to 8.0%, 9.5% and 7.0% for Sang Tarom, Domsiyah and Fajr, respectively.

Cooking method

The rice grains were cleaned from foreign materials and washed five times with water. Rice cooking was performed as follows: 10 g of crude rice and 100 mL of distilled water were subjected to constant boiling for 15 min in a 250 mL beaker. Cooking water was eliminated and cooked rice was allowed to cool [7]. After this stage, the semi-cooked samples were allowed to stew (by steam cooking method) for 30 min.

Amylography

The raw rice were cleaned and ground in a grinder for rice flour preparation. The rice gelatinization behaviour was studied with a Brabender amylograph (type 800120, Germany) using rice flour slurry with a concentration of 6% on a dry basis [8]. The mixture was made up to 460 g with distilled water and heated from the room temperature to 90°C at a rate of 1.5°C/min.

Texture measurement

A texture analyzer (QTS, CNS FARNELL) was utilized to examine the texture of cooked rice samples using the back extrusion test. A 15-gram sample of cooked rice was placed inside the test cylinder of 6 cm in diameter and pressed with a 100-gram weight for 30 s before conducting the cylindrical test. The cell was compressed by a spherical plate plunger of 35 mm in diameter. Pre-test speed, test speed and post-test speed of plunger were set at 1.0, 1.0 and 10.0 mm/s, respectively. Compression distance was 50% strain [9]. A force-time curve was obtained from the test and the following textural parameters were determined: 1) Hardness, namely the maximum compressive force during extrusion (N); and 2) Adhesiveness, namely the negative area under the curve (Ns).

Scanning electron microscopy (SEM)

The morphological changes of cooked rice grains were observed using a scanning electron microscopy (LEO 1450VP, Germany) at 10 kV.

The cooked rice grains were freeze-dried by liquid nitrogen. The outer surface on the lateral side of the grains was observed. Samples were attached to a SEM stub using a double-backed cellophane tape. The stub and sample were coated with gold-palladium by a sputter coater (SC7620), and then examined and photographed.

Statistical analysis

The experiments were conducted in a completely randomized design with 6 treatments and 3 replications. An analysis of variances (ANOVA) was used to analyze the data and significant differences between the treatments. Means were compared at a significant level of 95%.

RESULTS AND DISCUSSION

Amylography results

Fig. 1 shows the Brabender Viscograms of 6% rice flour for the three varieties. The gelatinization temperatures of rice were 90, 90 and 85.5°C for Sang Tarom, Domsiyah and Fajr, respectively.

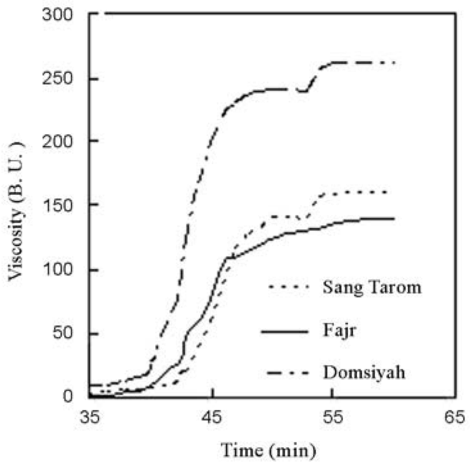


Fig. 1. Pasting behaviour of rice flour (6%) for three varieties.

As seen in Fig. 1, the rice flour of Domsiyah shows the highest viscosity. Different viscosities of these rice varieties may be related to the amylose contents of samples. It seems that the starch granules of the high amylose content sample are harder and more rigid than other samples with lower amylose content and thus do not rupture immediately when they are being heated and sheared [8].

Textural properties

The hardness and adhesiveness that are important parameters for evaluation of cooked rice texture were measured. The results showed that the hardness values of the samples that stewed after boiling were significantly lower than those of the samples that were not stewed (P<0.01). Also, the adhesiveness values were significantly increased in the stewed samples (P<0.01) (Fig. 2). This may be due to the better gelatinization and more fluidity of rice starch structure in the stewed samples. Zhou et al [10] reported that hardness and adhesiveness are related to the hydration process of starch granules. During cooking, rice granules absorb moisture and swell to a great

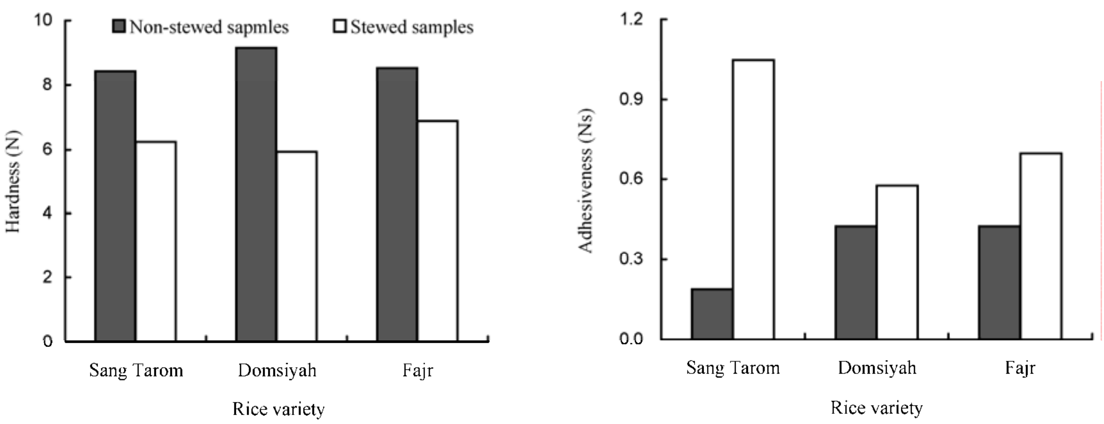


Fig. 2. Hardness and adhesiveness values of cooked rice (stewed and non-stewed) samples.

extent compared to their initial size. The granule expansion causes ruptures and amylose leaching. The leaching components can be responsible for a decrease in hardness and an increase in adhesiveness of cooked rice samples [9]. Since the stewing of rice grains by steam causes the completion of cooking procedure and the modification of gelatinization, the stewed samples are softer and stickier compared to those only boiled in excess water.

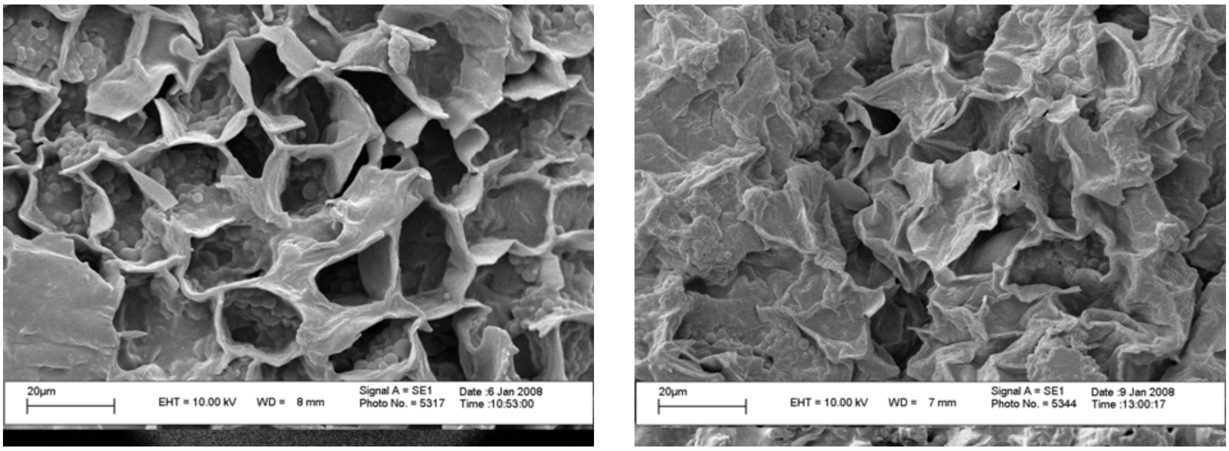
Scanning electron microscopy

The stewing of rice grains by steam produced noticeable changes in the microstructure of cooked rice grains compared to the samples that were not stewed (Figs. 3 to 5). The SEM displayed a more even structure with fine porosity in stewed treatments. It seems that the better gelatinization and swelling of rice starch due to stewing by steam causes a decrease in the pore size and porosity of cooked rice grains.

Responses of starch to heating in different moisture conditions vary with the type of starch. The starch with high amylose content swells more slowly than that with rich amylopectin content, and exhibits a loss of order within the granule, followed by its destruction. Heating leads to the disruption of starch complexes and the molecules adopt a more random orientation [11]. The effect of steam in stewing step on starch and amylose leaching may be the reason of these changes. However, there were differences between stewed and non-stewed rice varieties, especially in Sang Tarom (Fig. 4). The change of cooked rice morphology in Sang Tarom may be corresponded to the decrease of hardness. The finer porosity of stewed rice treatment resulted in fluffy and well-expanded cooked rice, whereas non-stewed sample has a large-pore and thick starch body [9].

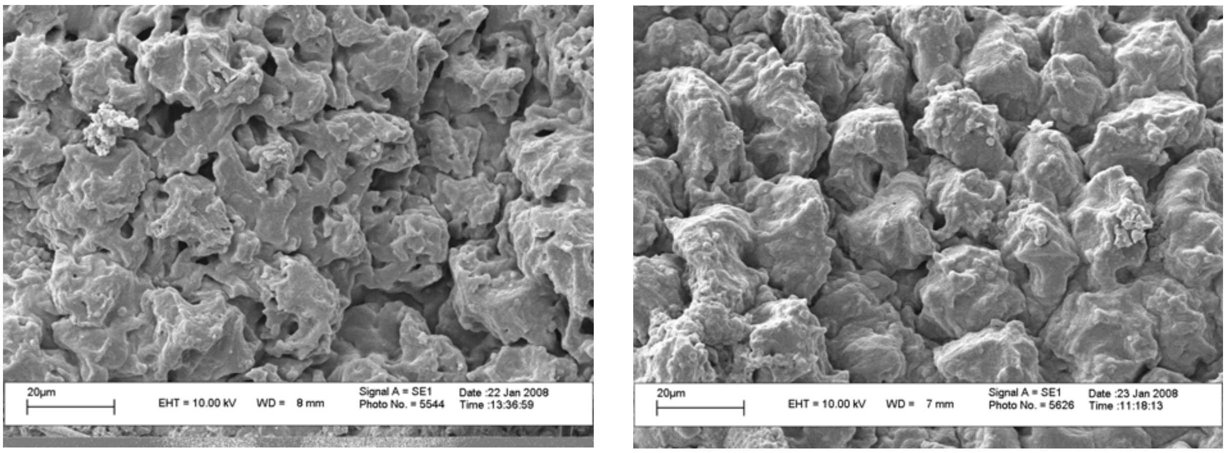
CONCLUSION

Stewing of rice grains by steam after boiling in excess water



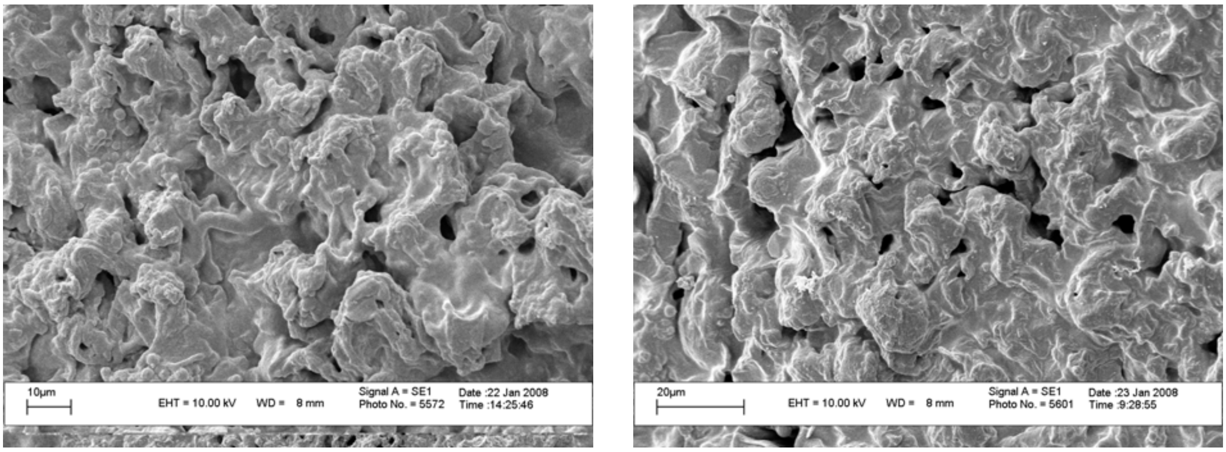
A B

Fig. 3. Scanning electron micrographs of the outer surface of cooked rice variety Sang Tarom.
A, Rice grains that boiled in excess water without stewing; B, Rice grains that stewed and boiled in excess water.



A B

Fig. 4. Scanning electron micrographs of the outer surface of cooked rice variety Domsiyah.
A, Rice grains that boiled in excess water without stewing; B, Rice grains that stewed and boiled in excess water.



A B

Fig. 5. Scanning electron micrographs of the outer surface of cooked rice variety Fajr.

A, Rice grains that boiled in excess water without stewing; B, Rice grains that stewed and boiled in excess water.

affected the textural properties of cooked rice, including hardness and adhesiveness. The scanning electron micrographs for the three rice varieties confirmed the different microstructures of cooked rice grains in stewed and non-stewed treatments. The stewing of rice grains by steam causes a decrease in hardness and an increase in adhesiveness and closer pores in the outer surface of rice grains due to the better gelatinization and modification in cooking.

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