PROJECT REPORT
COMPREHENSIVE RESEARCH ON RICE

January 1, 2007– December 31, 2007

PROJECT TITLE: Rice Utilization and Product Development
- Development of Quick Cooking Brown Rice

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OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES

Objectives

1. Study the effect of ultrasonic treatments on brown rice cooking characteristics including optimum cooking time, water uptake ratio, volume expansion and length expansion ratios.
2. Evaluate the cooking characteristics and dissolved materials of ultrasonic treated brown rice, untreated brown rice and white rice.

Experimental Procedures

Effect of ultrasonic treatments on brown rice cooking characteristics

Materials and Ultrasonic Treatments

Rough rice samples of medium grain variety M202 with original MC of 12.0 ± 0.2 (wet basis) were used for this study. The rough rice was dehusked using Yamamoto Husker (FC-2K) to produce brown rice. Then the brown rice sample was split into two large samples. One of them was used for brown rice study. The other one was milled using Yamamoto Rice Mill (VP-222N, Yamamoto Co. Ltd., Japan) to produce white rice. It was milled four times to achieve the well milled rice as defined by the Federal Grain Inspection Service (USDA FGIS, 1994). For the first and second times, the settings of Throughput and Whitening were 1 and 5, respectively. For the third and fourth times, the settings were 1 and 4, respectively. The Whiteness Index (WI) and milling degree (MD) of white rice were determined with the Milling Meter, MM1D, (Satake Corporation, Hiroshima 739-8602, Japan).

The brown rice samples were treated with ultrasonic system with frequencies of 16 kHz at full power for four durations, 15, 30, 45, and 60 min with water temperature of 25 and 40°C (fig. 1). The treated samples were dried with air at temperatures of 35 °C to achieve original MC. The dissolved materials during ultrasonic treatment were evaluated by measuring the rice samples moisture content and weight before and after ultrasonic treatments.

Figure 1. Ultrasonic system

Evaluation of cooking characteristics of ultrasonic treated brown rice

After ultrasonic treatments, optimum cooking time, water uptake ratio, length expansion ratio and volume expansion ratio of brown rice samples were evaluated and compared with untreated and white rice samples. The optimum cooking time was determined using a method developed by Ranghino. In a 50 ml beaker, 25 ml-distilled water was boiled (98 -100ºC) using a hot plate (Fisher Scientific, CAT 11-60049SH- Heater) and then 5g brown rice was added into the boiling water. After cooking for 10 minutes, 10 rice kernels were taken out of the beaker at a two minute interval. Then the cooked rice kernels were placed on a glass plate and pressed with another glass plate. The rice kernels were considered fully cooked when at least 90 % of the pressed kernels had no opaque portion or uncooked centers. The rice was then allowed to simmer for another 2 min to ensure that it is well cooked. The total cooking time is considered as the optimum cooking time. The rice samples experienced different treatments could have different optimum cooking times.

Water uptake ratio, volume expansion ratio and length expansion ratio of rice samples, were determined by cooking 1g of the rice sample in 15 ml boiling water, till their optimum cooking times. The water uptake ratio was calculated as the ratio of water absorbed during cooking to uncooked rice weight. The sample weights were measured using an electronic balance with an accuracy of 0.01g (Model No.602, Denver Instrument Co., Arvada, CO).

$$\text{Water uptake ratio} = \frac{WCR - WUCR}{WUCR}$$

Where:

WCR= Weight of cooked rice, g.

WUCR= Weight of uncooked rice, g.

The ratio of the initial and final volumes of rice when optimally cooked was referred to volume expansion ratio. The initial and final volumes of rice were determined by volume displacement method.

$$\text{Volume expansion ratio} = \frac{FV}{IV}$$

Where:

FV= Final volume, mm^3

IV= Initial volume, mm^3

The ratio of the initial and final lengths of rice when optimally cooked was referred to length expansion ratio. The initial and final lengths of rice were determined by Electronic Digital Caliper (1.55 v).

$$\text{Length expansion ratio} = \frac{FL}{IL}$$

Where:

FL= Final length, mm
IL= Initial length, mm

Dissolved materials in treating water during ultrasonic treatment were evaluated by measuring the moisture content and weight of samples before and after treatment. The moisture content of samples were measured using oven method (130°C, 24 hrs). *2.8. Scanning Electron Microscopy*

To determine the effect of ultrasonic treatment on the microstructures of brown rice kernels, the scanning electron microscopy (SEM) was used to observe the microstructures of kernel surfaces of different rice. The equipment was Hitachi S-4700 scanning electron microscope (Hitachi Ltd., Tokyo, Japan).

SUMMARY OF 2007 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVES

Effect of ultrasonic treatments on brown rice cooking characteristics

The cooking characteristics of ultrasonic treated brown rice were evaluated in terms of optimum cooking time, water uptake ratio, and volume and length expansion ratios. The measured values of optimum cooking time, water uptake ratio, and volume and length expansion ratios are shown in Figs 2-6.

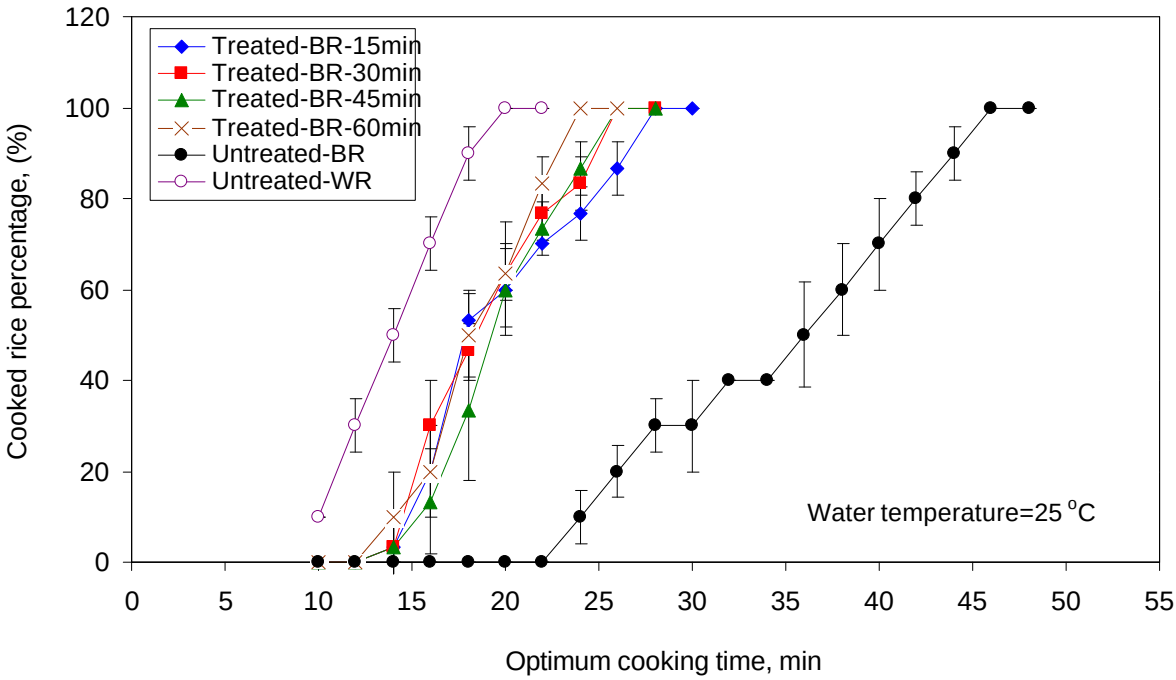
Optimum cooking time

The results indicated that the optimum cooking time of treated brown rice dramatically decreased with ultrasonic treatments compared to untreated brown rice. For example, when the brown rice samples were treated with ultrasonic at water temperature of 25ºC, optimum cooking time values were 28, 26, 26 and 24 min for treatment durations of 15, 30, 45 and 60 min, respectively (fig. 2a). The optimum cooking time of white rice and untreated brown rice were 22 and 48 min, respectively. This means that optimum cooking time of ultrasonic treated brown rice decreased form 48min to 28, 26, 26 and 24 min for treatment durations of 15, 30, 45 and 60 min, respectively. Also when the brown rice samples were treated with ultrasonic at water temperature of 40ºC, optimum cooking time values were 24, 24, 24 and 22 min for treatment durations of 15, 30, 45 and 60 min, respectively (fig. 2b). This means that by increasing the water temperature form 25ºC to 40ºC, the optimum cooking time of brown rice slightly decreased from 28, 26, 26 and 24 min to 24, 24, 24 and 22 min for treatment durations of 15, 30, 45 and 60 min, respectively.

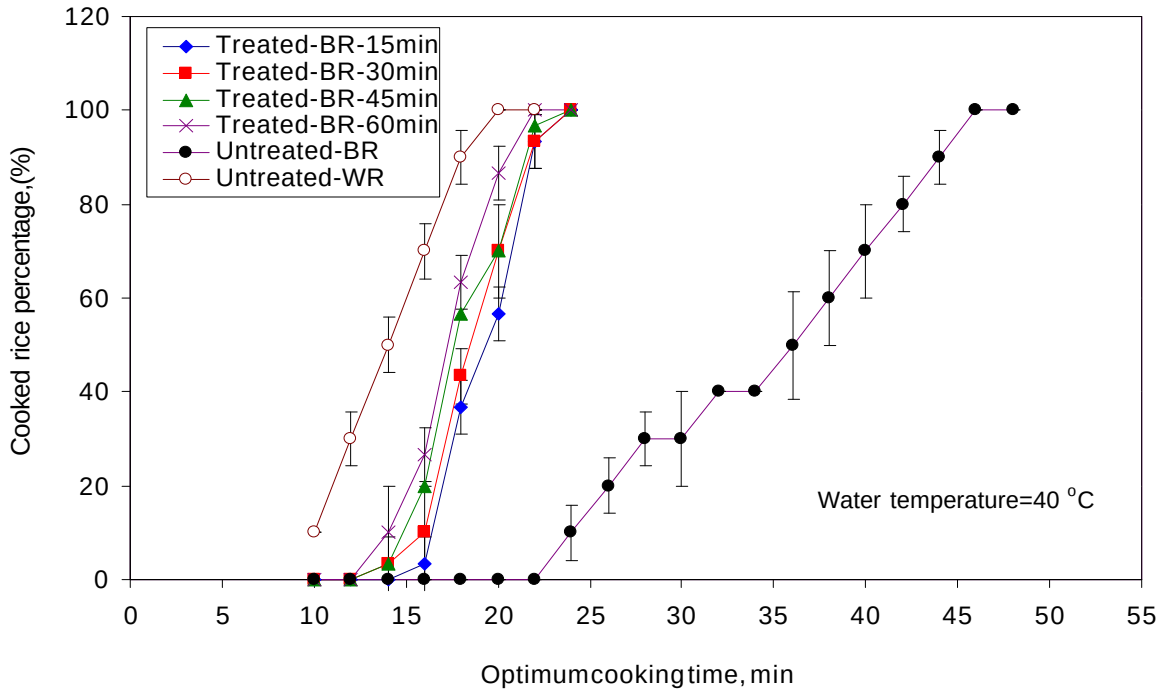
Water uptake ratio

The results showed that water uptake ratio increased with increase of ultrasonic treatment duration. For example, water uptake ratios of brown rice treated at water temperature of 25 ºC were 1.33, 1.4, 1.7 and 1.75 for treatment durations of 15, 30, 45 and 60 min, respectively compared to water uptake ratio of 2.05 and 0.95 for white rice and untreated brown rice (fig. 3a). Water uptake ratios of treated brown rice at water temperature of 40 ºC were 1.34, 1.42, 1.73 and 1.80 for treatment durations of 15, 30, 45 and 60 min, respectively (fig. 3b). This means that the

ultrasonic treatment improved water up take ratio of treated brown rice compared to untreated brown rice, which is consistent with the results of optimum cooking time.



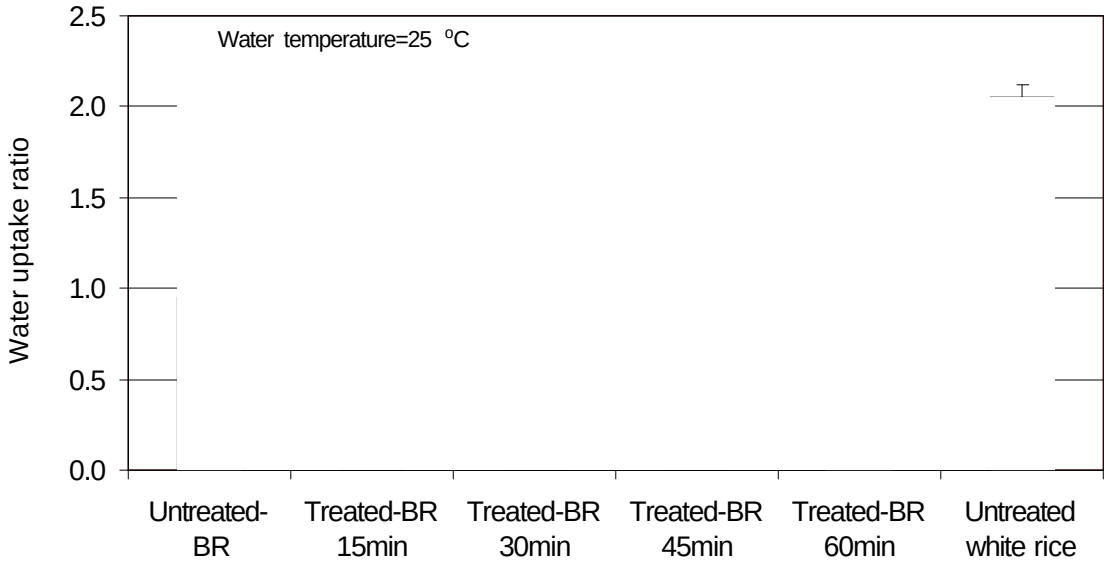
(a)



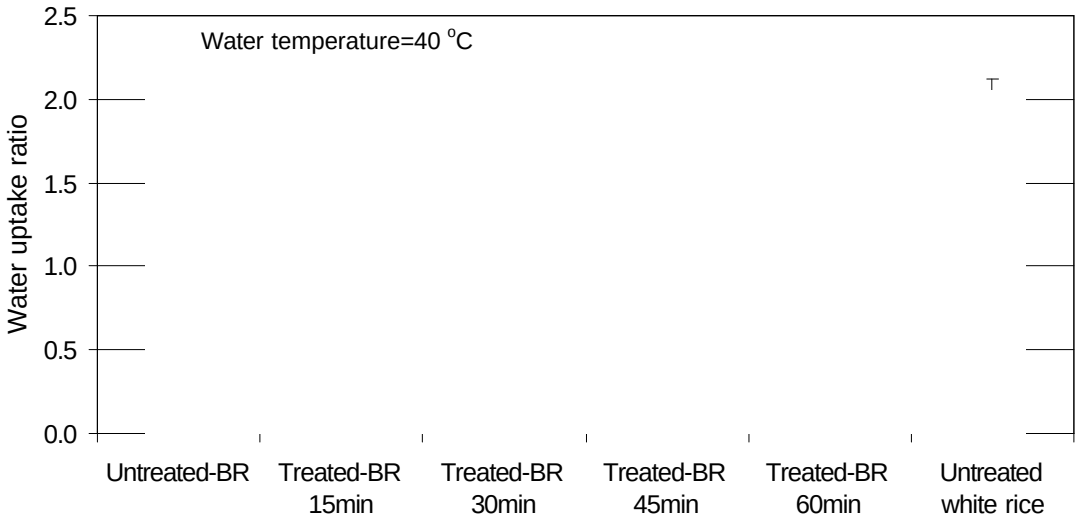
(b)

Figure 2. Effect of ultrasonic treatment durations on optimum cooking time of brown rice at water temperatures of (a) 25 ºC and (b) 40 ºC.

(BR=brown rice, WR=White rice)



(a)



(b)

Figure 3. Water uptake ratios of brown rice under different ultrasonic treatment durations on at water temperatures of (a) 25 ºC and (b) 40 ºC.

(BR=brown rice, WR=White rice)

Volume and length expansion ratios

The results of volume and length expansion ratios are shown in figs. 4 and 5. The volume expansion ratio increased with increase of ultrasonic treatment duration. For example, volume expansion ratios of treated brown rice at water temperature of 25 ºC, were 0.97, 1.75, 1.84 and 2.33 for treatment durations of 15, 30, 45 and 60 min, respectively, which are higher than the volume expansion ratios of 2.9 and 0.45 of white rice and untreated brown rice (fig. 4a). Volume expansion ratios of brown rice treated at water temperature of 40 ºC were 1.08, 1.79, 1.86 and 2.38 for treatment durations of 15, 30, 45 and 60 min, respectively (fig. 4b). This means that the ultrasonic treatment had positive effect on the volume expansion ratio and improved the capacity of starch granule to absorb water and expanded compared to untreated brown rice.

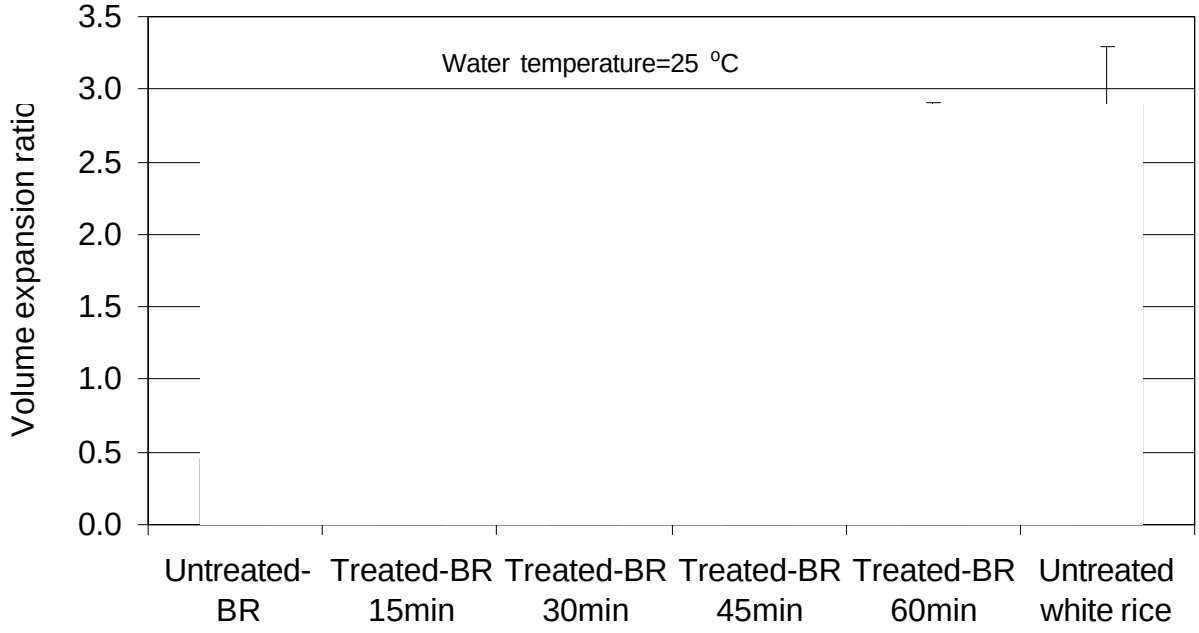
Length expansion ratios of treated brown rice at water temperature of 25 ºC were 0.38, 0.39, 0.40 and 0.39 for treatment durations of 15, 30, 45 and 60 min, respectively, compared to length expansion ratios of 0.48 and 0.23 for white rice and untreated brown rice (fig. 5a). Also, length expansion ratios of treated brown rice at water temperature of 40 ºC were 0.38, 0.40, 0.40 and 0.41 for treatment durations of 15, 30, 45 and 60 min, respectively (fig. 5b). This indicates that ultrasonic treatment duration had little effect on length expansion ratio. This can be explained by the fact that ultrasonic treatment improved the capacity of starch granule to absorb water and expanded in all orientations rather than the liner expansion.

Dissolved solids in water

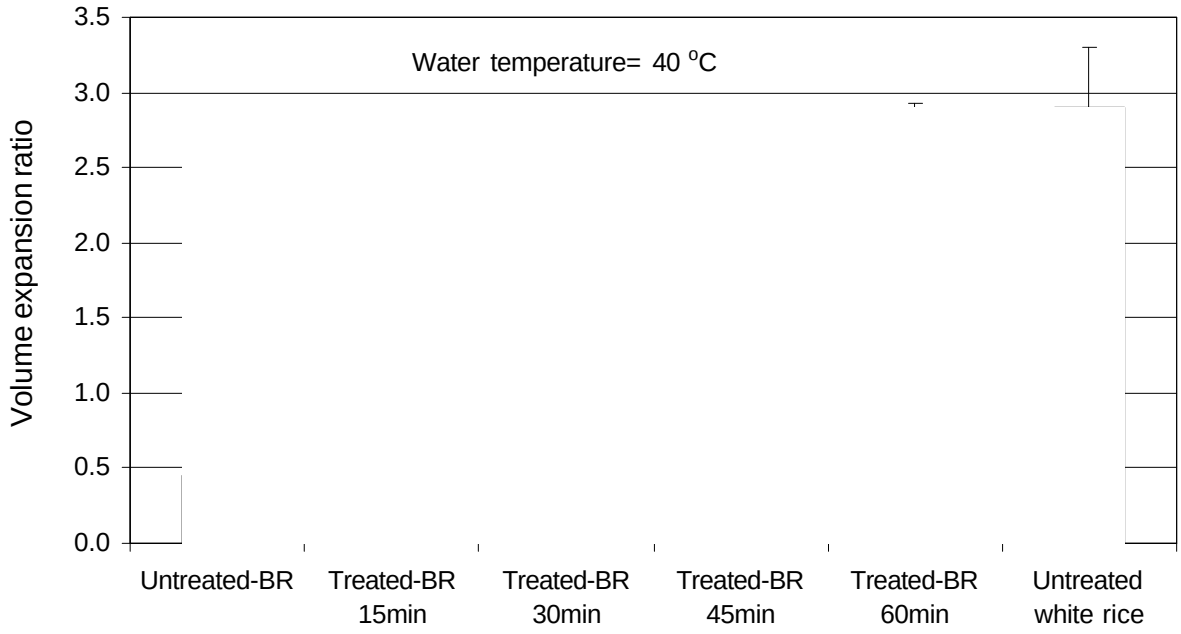
The relationships between dissolved solids in water and ultrasonic treatment duration for brown rice and white rice are shown in fig.6. In general, brown rice had less dissolved solids compared to white rice. Also, dissolved solids increased with increase of treatment duration. For example, when the brown rice samples were treated at water temperature of 25°C, dissolved solids were 0.01, 0.012, 0.024 and 0.02 g per gram of brown rice for ultrasonic treatment durations of 15, 30, 45 and 60 min, respectively. When the white rice samples were treated at water temperature of 25°C, dissolved solids were 0.043, 0.055, 0.064 and 0.062 g per gram for ultrasonic treatment durations of 15, 30, 45 and 60 min, respectively. Dissolved solids at water temperature of 40°C were 0.01, 0.013, 0.026, and 0.024 g per gram of brown rice and 0.045, 0.058, 0.065, and 0.068 g for ultrasonic treatment durations of 15, 30, 45 and 60 min, respectively. This means that the effect of water temperature on dissolved solids was not significant, but the dissolved solids increased with the increase of treatment time.

Surface microstructures of rice kernels

The SEM result clearly showed that the microstructures of brown rice and white rice were different (fig. 7). The ultrasonic treatment modified the surface structures of brown rice and resulted in increased water uptake during cooking and reduced cooking time.



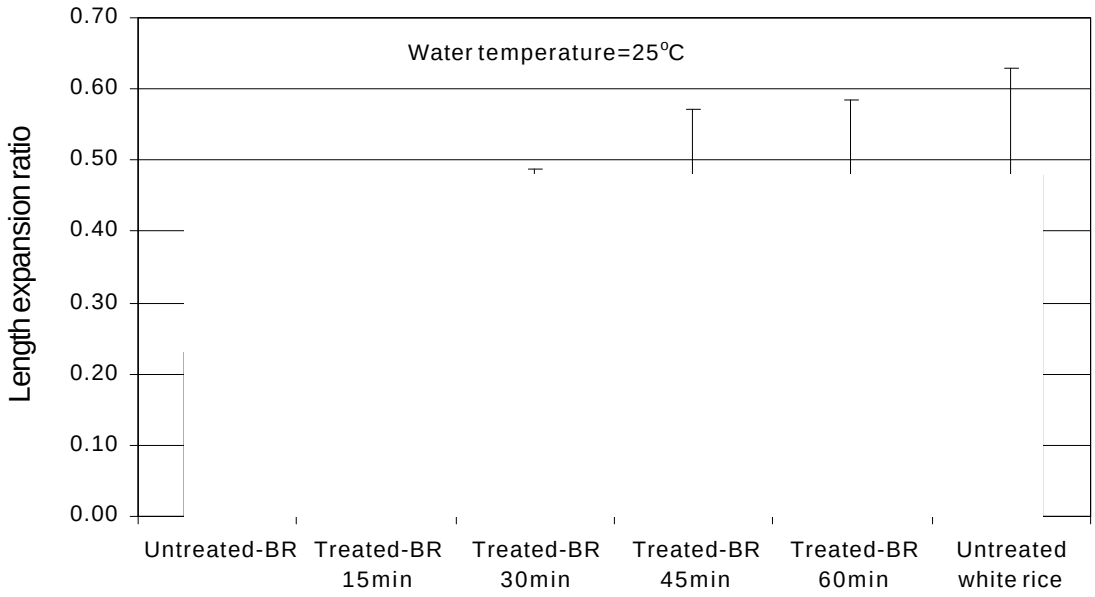
(a)



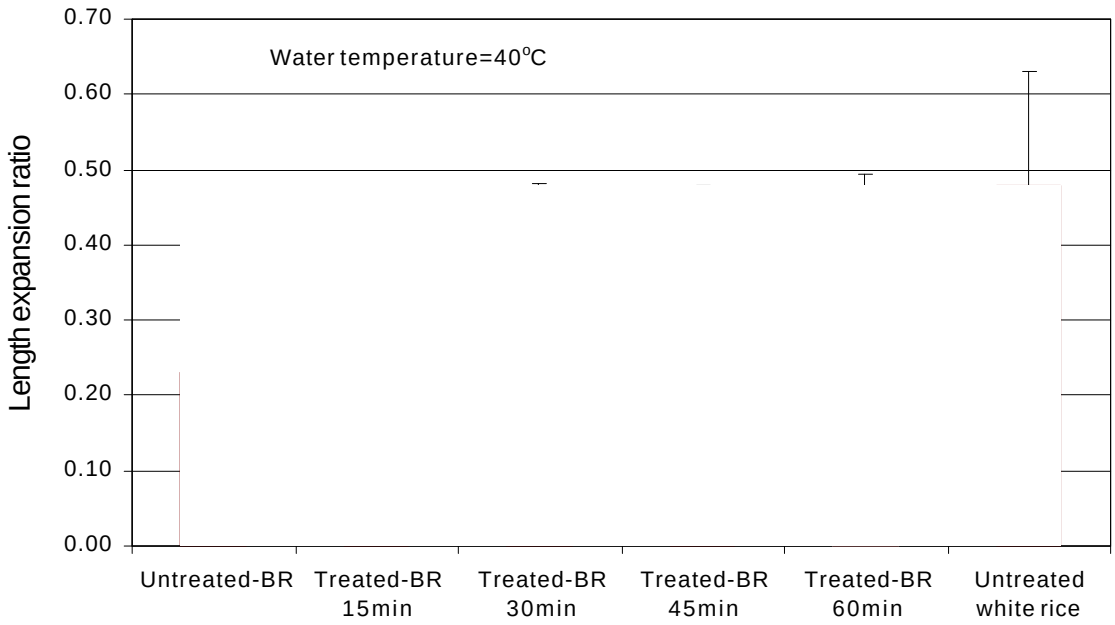
(b)

Figure 4. Volume expansion ratios of brown rice under different ultrasonic treatment durations on at water temperatures of (a) 25 ºC and (b) 40 ºC.

(BR=brown rice, WR=White rice)



(a)



(b)

Figure 5. Length expansion ratios of brown rice under different ultrasonic treatment durations on at water temperatures of (a) 25 ºC and (b) 40 ºC.

(BR=brown rice, WR=White rice)

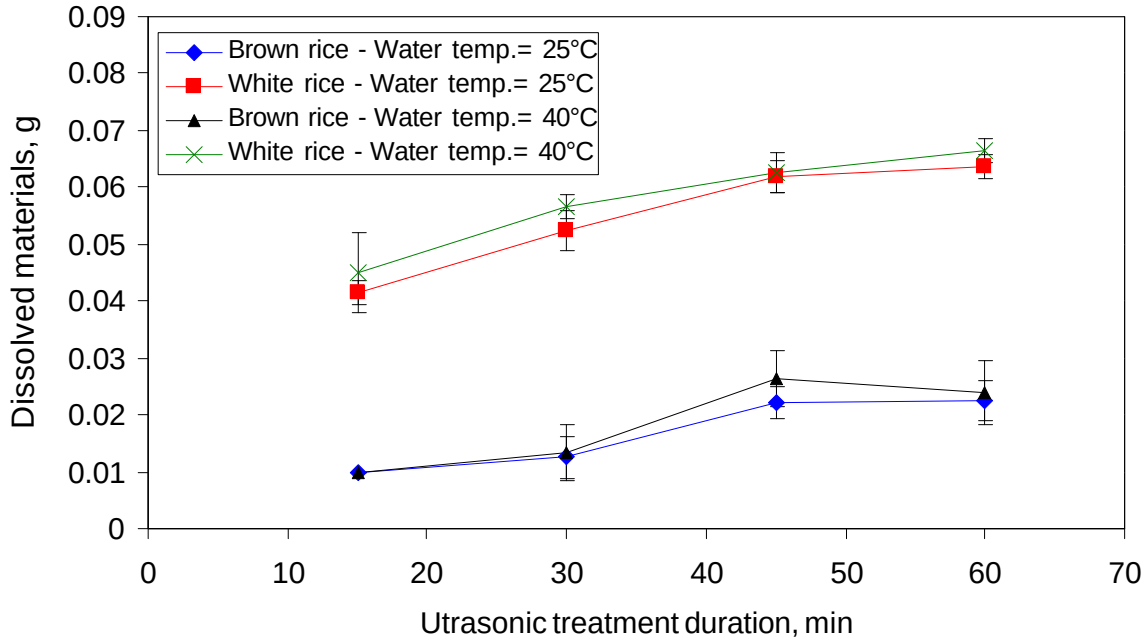


Figure 6. Relationship between dissolved solids and ultrasonic treatment durations

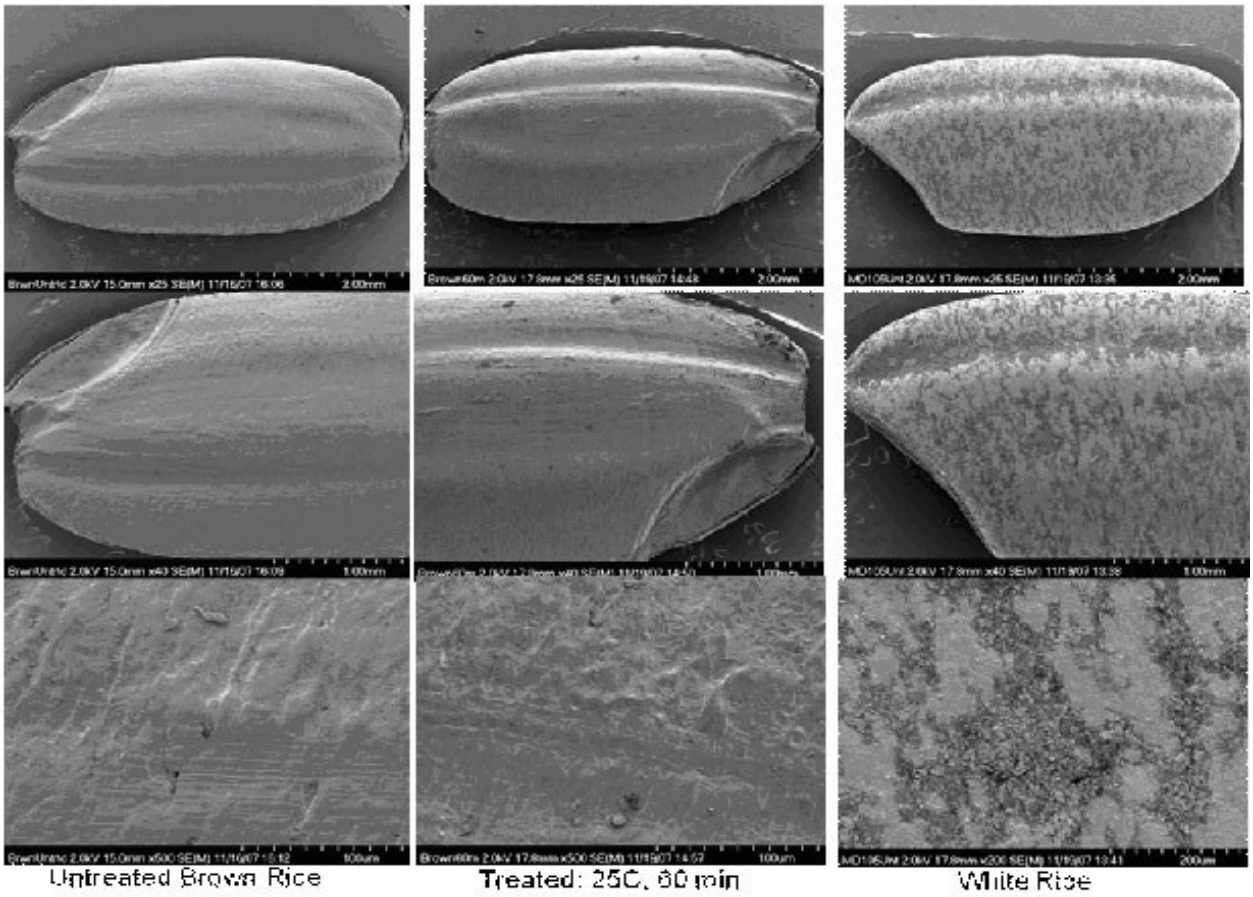


Figure 7. Surface microstructures of different rice samples.

Recommendations

Based on the results of brown rice cooking characteristics, ultrasonic treatments improved water uptake ratio and volume expansion ratio of brown rice. Optimum cooking time of brown rice considerably decreased after the ultrasonic treatment. It is suggested that quick cooking of brown rice could be achieved using ultrasonic treatments.

PUBLICATIONS OR REPORTS

N/A

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS

The research in this report focused on studying the effect of ultrasonic treatments on brown rice cooking characteristics, including optimum cooking time, water uptake ratio, and volume expansion and length expansion ratios.

For achieving the research objective, rough rice samples of medium grain variety M202 with original MC of 12.0 ± 0.2 (w.b.) were used for this study. They were dehusked and milled to obtain brown rice and white rice. The brown rice samples were treated with an ultrasonic system at frequency of 16 kHz and full power for four durations, 15, 30, 45, and 60 min under two different water temperatures of 25 and 40°C. Then the treated samples were dried with air at temperatures of 35 °C to achieve original MC before used for cooking tests. The cooking characteristics of treated and untreated brown rice and white rice were evaluated and compared. The surface microstructures of these rice samples were also determined using scanning electron microscopy.

The cooking results showed that ultrasonic treatments improved water uptake ratio and volume expansion ratio of brown rice. Optimum cooking time of brown significantly decreased after the ultrasonic treatment. The surface microstructure revealed that ultrasonic treatment changed the surface structure and resulting in high water uptake during cooking and reduced cooking time. It is concluded that quick cooking of brown rice can be achieved using ultrasonic treatment.

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