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DETERMINATION OF HARDNESS CHARACTERISTIC OF COOKED RICE SAMPLES IN RICE INDUSTRY

*Somchai KLADSUK[1], Panmanas SIRISOMBOON[1]
[1]*Curriculum of agricultural engineering, Department of mechanical engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand*
Corresponding author: Somchai KLADSUK. E-mail: lt.somchai@gmail.com

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ABSTRACT

This research was to evaluate the hardness characteristic of cooked rice samples in rice industry. Milled rice samples were collected at a raw material purchasing station of the factory, behind a colour sorter station and under a storage bin station. The cooked rice samples were subjected to a texture analyzer using back extrusion test. Determined parameters, hardness and toughness, were compared among different types of milled rice and sampling positions. These parameters could be further applied to the rice factory and are valuable information for rice exporters, agricultural engineers and rice researchers.

INTRODUCTION

Rice (*Oryza sativa*) was an important crop in Thailand. The minimal processing industry for milled rice in the country for export and domestic consumption is highly valued and has a strong effect on the country economic. Properties of cooked rice texture including hardness were the most important quality factors. Texture of cooked rice affects the price, consumer acceptance and processes. Most of the customer acceptance takes into account of the rice hardness.

The processes in minimal processing (physical quality improvement) rice industry are consisted of cleaning of raw material (milled rice) by removing the big pieces of contaminant and then the small pieces, destoning and polishing to eliminate the bran residual and to make the rice grain glitter, size grading to separate head rice and broken rice, color sorting to remove the dis color kernel, objectionable seeds such as grass kernel, and foreign material such as small pieces of glass, stone, resin and chinaware, winnowing to remove dust obtained from the previous processes, storaging in silo and finally packaging.

In research works, Yu et al. [1] measured the hardness and adhesiveness of cooked rice using Texture Profile Analysis. Gujral and Kumar [2] measured the hardness, cohesiveness, adhesiveness and springiness of cooked rice using Texture Profile Analysis. The methods used in Asian Institute of Technology for texture of cooked rice adapted from Reyes and Jindal [3] was back extrusion test. Hardness of cooked rice was considered from maximum force [4]. Although texture is multidimensional, hardness and stickiness are critical and these textural characteristics govern palatability of cooked rice in Asian markets [5] and the hardness is the most important and most commonly measured parameter [6] Therefore, the objective of this research was to evaluate of the hardness properties, including hardness and toughness, of cooked rice at different process (sampling) positions, including raw material purchasing station, behind a colour sorter station and under a storage bin station, for different categories, including new Jasmine rice, aged Jasmine rice, parboil rice and white rice. This information is very useful for rice minimal process industries, rice mills and rice exporters.

MATERIALS AND METHODS

Sample and sample preparation

Thai milled rice of 276 samples was collected from rice improvement factory (C.P. Rice Co., Ltd., Thailand). The rice samples were collected from 3 points in the factory including raw material purchasing station of a rice factory, behind a colour sorter station and under a storage bin station where the random sampling has been done for quality and processing control of the factory. Type of milled rice samples fed into the factory included parboiled rice, white rice, new (harvested in 2012) Jasmine rice and aged (harvested in 2006, and during 2007-2011) Jasmine rice (52, 23, 16 and 185 samples, respectively). Each milled rice sample was weighed about 200 g and kept in a plastic zipper bag in an ambient temperature until experiment.

Cooking rice by putting rice in beakers in a pot of rice cooker

As reported by Somchai and Panmanass [7], the rice cooking method by putting rice in beakers in a pot of rice cooker was the better method than normal cooking by directly cooking in the pot in term of less variation (lower coefficient of variation) in texture property of cooked rice.

Each rice type were cooked at different water to rice ratio recommended by the factory: 2.5:1; 1.6:1; 1:1 (harvested in 2012); and 1.2:1 (harvested in 2007-2011) and 1.4:1 (harvested in 2006) for parboiled rice; white rice; new Jasmine rice and aged Jasmine rice, respectively. Weighed 25 g milled rice and water ratio by electronic balance (ARC120, Adventurer, OHAUS) and immediately put in a 100 ml beakers (spread evenly). Put 5 beakers of rice sample in a pot of rice cooker (RC-10 MM (WT) A, Toshiba) and poured 400 g water in the pot. Inserted the thermocouple (FLUKE-52-2) into the rice cooker to measure the temperature while cooking rice. When the temperature reached about 100^{o} c or water vapor came up, waited for another 20 min and then press the "Cancel" button and then left it in the rice cooker for another 10 min. Then put the beakers upside down on the screen and covered with plastic lid and left it for one hour. Then knocked out the cook rice from the beaker and put only the middle portion into plastic cup for 3 g. There were 3 cups per sample.

Determination by Texture analysis

As reported by Nuttagorn and Panmanas [8], the back extrusion test was the best objective method compared to other methods such as texture profile analysis and Ottawa test, to measure the texture of cooked rice to be used in research and industry.

Fig.1 Cooking rice by putting rice in beakers in a pot of rice cooker

The 3 g cooked rice sample was subjected to the texture analyzer (HD Plus, Texture Analyzer, Stable Micro Systems) using Back Extrusion test platform as shown in Fig. 2. The condition of the test was compression speed of 1 mm/s and moving distance of 99 mm of the 100 mm starting point from the surface of platform. The texture parameters were determined from force-deformation curve. They were hardness (maximum force, N), toughness (area under curve above zero force, Ns)

Fig. 2 Back Extrusion test platform

Statistical analysis

One-Way ANOVA (Duncan's multiple range) was conducted, assuming there were significant differences among the means when the statistical comparison gave $p < 0.05$.

RESULT AND DISCUSSION

Figure 3 shows the hardness of different cooked rice, including parboiled rice, new Jasmine rice, aged Jasmine rice and white rice, from different stations including raw material purchasing station, behind a colour sorter station and under a storage bin station, in rice factory. The hardness is the maximum force (N) of the compression to 99% strain. The higher the hardness, the more difficult to be compressed the rice. The white rice was the hardest while the parboiled rice was the softest. The hardness of white rice was higher than aged Jasmine rice, new Jasmine rice and parboiled rice, respectively. The white rice, which was from several rice varieties which were not Jasmine rice, mostly had high amylose content and Jasmine rice had low amylose content [9]. Hardness of cooked rice was mainly influenced by amylose content and the hardness of cooked milled rice positively correlated with amylose content ($0.706 \le r \le 0.866$, $P < 0.01$) [10]. Since, the hardness of cooked rice increased as a consequence of storage [10], the aged Jasmine rice was harder than new Jasmine rice. In this study, the parboiled rice was the softest because the water to rice ratio recommended by the factory was very high (2.5:1), though in general if the ratio was the same, the parboil rice should be the hardest.

The hardness of the rice behind a sorter and under the storage bin was mathematically and/or statistically higher than at the purchasing station. This was because before the process of color sorter, there was the process of polishing where the water spray was fed to the rice which was rubbed against each other in a small chamber and the heat was generated. This induced the starch gelatinization in the rice. Yu [10] indicated that the starch gelatinization occurring during the heating step has the most impact on the organoleptic properties of cooked parboiled rice.

The hardness of rice behind a colour sorter station and under a storage bin station was not different because after colour sorter station there was no process that effect on the texture of the rice only the dust was removed.

The hardness of new Jasmine rice at the purchasing station was slightly higher than that of aged Jasmine rice. This might be because of different planting area and the number of sample tested for new Jasmine rice was small (16 samples).

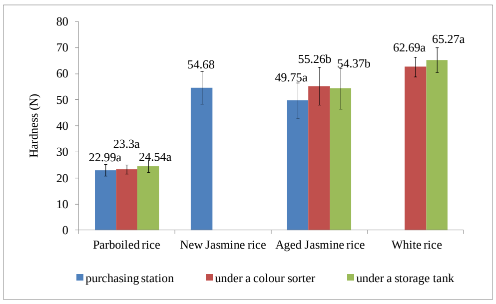

Fig. 3 Hardness of parboiled rice, new Jasmine rice, aged Jasmine rice and white rice from different stations in rice factory. Each bar represents mean ± S.D. Values not sharing a common letter differ significantly at $P < 0.05$ (DMRT).

Figure 4 shows the toughness of different categories of cooked rice, including parboiled rice, new Jasmine rice, aged Jasmine rice and white rice, from different stations including raw material purchasing station, behind a colour sorter station and under a storage bin station, in rice factory. The toughness (Ns) is the area under force-deformation curve during the cooked rice compression to 99% strain. The higher the toughness, the more energy needed for deforming the rice. The white rice was the toughest while the parboiled rice was the least tough. Like in case of hardness, the toughness of white rice was higher than aged Jasmine rice, new Jasmine rice and parboiled rice, respectively. As shown in Fig. 3 and 4, the change of hardness and toughness had the same trend.

The toughness of the rice behind a sorter and under the storage bin was significantly higher than at the purchasing station. The reason was because of the starch gelatinization as in case of hardness.

The toughness of rice behind a colour sorter station and under a storage bin station was not different, except for white rice, because after colour sorter station there was no process that effect on the texture of the rice only the dust was removed. It was difficult to give the reason why the white rice samples under the storage bin had higher toughness than at the color sorter. It might be because the rice lost its moisture content during kept in the storage bin which might effect on the toughness.

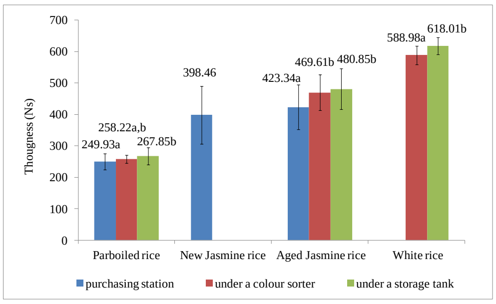

Fig. 4 Toughness of parboiled rice, new Jasmine rice, aged Jasmine rice and white rice from different stations in rice factory. Each bar represents mean ± S.D. Values not sharing a common letter differ significantly at $P < 0.05$ (DMRT).

CONCLUSION

The processes in the rice industry had an effect on texture of cooked rice, in this case, hardness and toughness. Hardness and toughness increased during the process. The aged Jasmine rice was more affected than parboiled rice. The hardness and toughness of white rice was higher than aged Jasmine rice, new Jasmine rice and parboiled rice, respectively. The information is useful for texture quality control of products and product development in rice industry.

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