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Formation of Coating Film on Rice Surface during Cooking and Artificial Coating Method with Glutinous Rice Powder

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밥짓기 과정중 皮膜 形成 現象과 찹쌀粉 添加에 의한 皮膜層의 補强

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Abstract

The relationship between rice and the fluid during cooking was investigated to examine the factors affecting the quality of cooked rice and a new rice cooking method was proposed to improve the unpalatability of aged *Milyang* 23-long grain rice variety.

The changes of heights of rice-bed and the fluid during cooking were measured with a laboratory cooking apparatus made of flat bottomed graduated glass cylinder. Around the boiling, a sudden disappearance of the fluid was observed and then thin film was formed on the rice grains.

This film coating was fortified by the addition of 1-2%(w/w) of glutinous rice powder as a film forming agent. The artificial coating on the cooked rice of low quality remarkably improved the gloss, moisture content and shape and the extent of leaching of rice solid into the fluid was reduced with the treatment.

Introduction

As the demand of rice increased in Korea, Indica-Japonica hybrid of long grain variety was introduced as a high-yielding new variety.[4] But it exhibits less stickiness than the short grain variety, common in Korea.[6] The similar eating quality was observed in aged rice, displaying poorer chew-feeling and worse off-flavor than new rice.[8] Therefore, it is necessary to develope a method improving the unpalatability of these rices of low quality.

The factors affecting the palatability of coo-

ked rice were regarded as appearance, texture, flavor and doneness, and those were reported to be closely related to rice varieties,[2] changes of rice property on storage[3] and rice cooking methods used.[10,11]

The physical characteristics of rice were determined by water absorption, volume expa nsion, color and gloss of cooked rice and the total solid in the residual cooking water. They were intimately related to the chemical characteristics such as amylose and amylopectin contents, bluevalue, alkali number and gelatinization temperature.[7,9]

Since the quality of traditional Korean rice is remarkably different from that of long grain, studies on the physical properties in the cooking process are required to find a way to improve the unpalatability of Indica Japonica hybrid rice.

We analyzed physical phenomena during cooking to determine the factors of cooking quality on the palatability of the rice. An artificial film coating method with glutinous rice powder was developed to improve the unpalatability of the rice of low quality.

Materials and Methods

Materials

Two year old rice *Milyang* 23, Indica Japonica hybrid), purchased from market, used as the rice in cooking.

Milled glutinonous rice, *Hangang*, was powdered to 120 mesh and used as a coating agent in cooking rice.

Experimental apparatus and cooking method

For the observation of the physical behavior of rice and the fluid, a graduated glass cylinder equipped with reflux condenser, as shown in Fig. 1, was used.

Fifty gram of rice and 100 ml of tap water were mixed and cooked in the apparatus on electric heater.

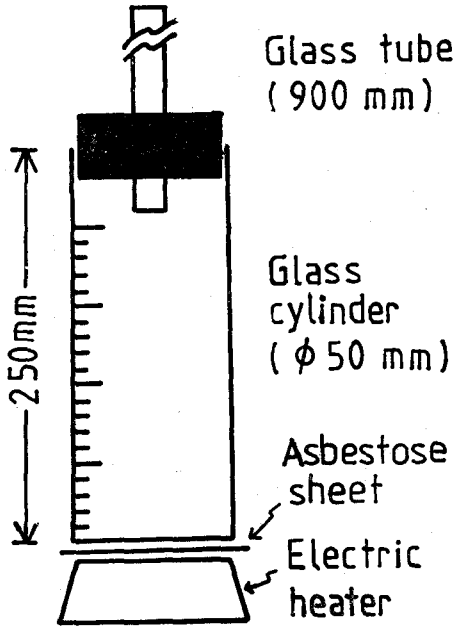


Fig. 1. Experimental apparatus for rice cooking.

The heights of rice-bed and the fluid were measured by reading the graduated scale and the physical behavior of rice and the fluid was observed during cooking.

Artificial film coating method

Rice of 150g was washed and soaked with 370 ml of tap water for 30min. at 20°C and then a various amount of glutinous rice powder in the range of 0, 1 and 2%(w/w) was added. The rice cooking was carried in a electric rice cooker(Samyang Co., Ltd.) for 18min.

Measurement of grain dimension and moisture content of cooked rice

The cooked rice grains were measured for length and width by calipers to examine the effect of the added glutinous rice powder on the dimension of cooked grain. The moisture content(wet basis) was determined by the conventional drying oven method.

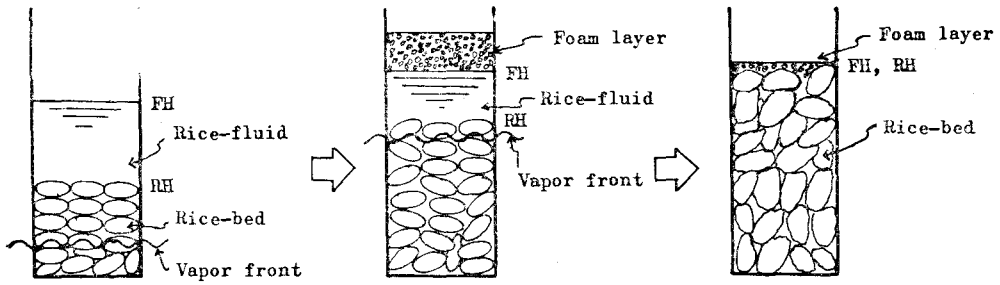


Fig. 2. Schematic representation of rice cooking process in the experimental apparatus. FH: height of rice-fluid, RH: height of rice-bed.

Drying method of cooked rice

Fifteen grains of cooked rice were dried on 5cm×3cm metal wire mesh at 40°C and air velocity of 5cm/sec.

The moisture retention ratio(M/M. was determined, where M. and M were the moisture contents(%, dry basis) of the cooked rice at the initial and final states of drying, respectively.

Leaching of rice in rice-fluid

Ten gram of rice and 0.4g of glutinous rice powder were put together into 70ml of distilled water equilibrated at 87°C in a beaker. The beaker was kept at 87°C and then the content of the leaching rice solid in the fluid was measured. The grains leached for 10,20,30,40, 50 and 60min. were placed into a small circular basket(15cm dia.,8cm height) of 0.8mm plastic screen and carefully washed five times with 500ml of distilled water. The grains were dried and the content of the leaching rice solid determined by the following equation.

$$\text{Content of leaching solid}(\%) = \{(W_1-W_2)/W_1\}\times 100 \quad \cdots\cdots(1)$$

Where, W_1 and W_2 are the weights of dry materials of the unleached and leached rice, respectively.

The leached grains were spreaded on filter paper for 1 min. to remove the surface fluid[1] and weighed to determine the water absorption with the following equation.

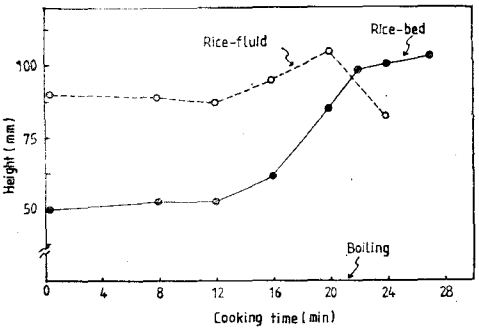


Fig. 3. Changes of heights of rice-bed and the fluid during cooking.

$$\text{Water absorption}(\%) = \{(W_3-W_4)/W_4\}\times 100 \quad \cdots\cdots(2)$$

Where, W_3 and W_4 are the weights of the surface fluid-removed leached rice and its dry material, respctively.

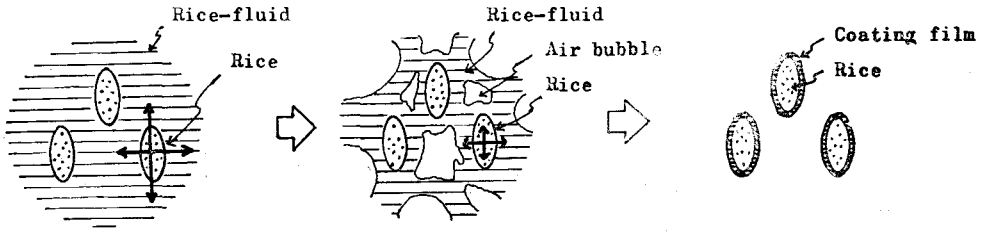
Results and Discussion

Interaction between rice and the fluid during cooking

In order to examine the factors affecting the quality of cooked rice, it was necessary for physical phenomena during cooking to be observed.

The time course cooking patterns were traced and the changes of heights of rice-bed and the fluid were measured as shown in Fig. 2 and 3.

The heights of rice and the fluid gradually went up and the changes of the fluid heights were accompanied with those of rice-bed until



Rice movement in boiled rice-fluid (arrows indicate birections)

Rice vibration in gelatinized thick rice-fluid

Probable film coating on rice surface

Fig. 4. Patterns of the coating film formation on the rice.

boiling. This is probably attributed to the fluidity of rice- fluid through the voids in the bed due to the solid content increase.

After the vapor front reached the upper suface of rice-bed, the fluid level was suddenly disappeared and a little changes of the bed-structure were observed. This reveals that it is possible for the surface of the rice to be covered with the thick rice-fluid at the last stage of the cooking process and results the formation of coating film on the grains.

Since the coating phenomena were occurred at the last stage of the cooking process, it was regarded as an important factor determining the cooked rice quality.

Movement of rice grains in rice-fluid

The movement of the individual rice grains in the fluid during cooking was observed in the apparatus(Fig. 1) and its patterns were given in Fig. 4. During the vigorous boiling period, the rice was mixed well and then the mixing extent gradually was decreased. Thereafter, only mild vibration was continued until the end of the cooking process.

A mild vibration is believed to help the formation of coating film on the rice grains.

Effects of the treatment with glutinous rice powder on the cooked rice

As mentioned before, the relationship between rice and the fluid during cooking was considered as an important factor affecting the quality of cooked rice and the leaching rice solid in the fluid was reasoned to determine the properties of the surface of cooked rice. Hogan et al.[5] reported that the more the amount of total solid taken into the fluid from rice during cooking was stickier the cooked rice was. Therefore, a rice cooking method treating with a sticky glutinous rice powder and some characteristics on that were investigated on the various aspects.

1. Shape and moisture content of the cooked rice

Figure 5. shows that the cooked rices treated with the powder are glossy and have the shapes of elliptical type, while the untreated one having dull club type. The reason for this can be explained as follows. First, the artificial increase of total solid in rice-fluid by the added powder causes the formation of the glossier coating film on the cooked rice. Sec-

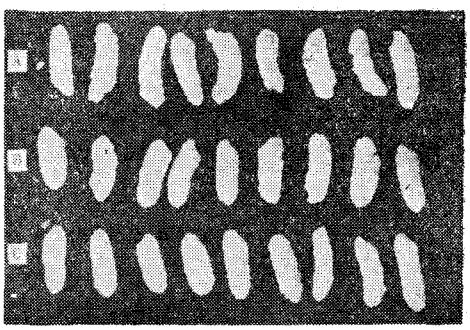


Fig. 5. Effects of the amount of added glutinous rice powder on the the rice appearance.
A: control, B: 1%, C: 2%

Table 1. Effects of the addition of glutinous rice powder on water content and dimension of the cooked rice.

Addition of glutinous rice powder(%)	Water content (%)	Dimension(mm)	
		Length	Breadth
0	57.55	11.2	2.1
1	60.8	9.8	2.45
2	61.45	10.5	2.3

ond, the decrease of soluble solid concentration gradient between rice and the fluid, reduces the extent of the leaching of rice solid, prevents the surface of rice from cracking, and keeps the cooked rice retaining its intact elliptical shape.

Table 1 presents data of the moisture contents and the dimensions of cooked rice. The powder-treated rice showed the higher moisture content than het untreated one. This is attributed to the addition of the moisture in the crevice of the powder-treated rice surrounded by the fortified coating film and that of the moisture of the glutinous rice powder film itself. The powdertreated rice had a tendency to be shorter in length and wider in breadth than the untreated one, and this indicates that the excessive volume expansion of the grains was reduced.

2. Effect of the coating film on moisture retention

From both Fig. 5 and Table 1 a fortified coating film was certainly formed on the cooked rice by the solubilized glutinous rice powder. The coating film was expected to affect the drying of the cooked rice represented by the moisture retention ratio.

The moisture retention ratios of cooked rice in hot air drier at 40°C were shown in Fig.6.

Those of the powder-treated rice were higher for 1 hour and then a little lower than those of the untreated one. This effect is probably because the fortified coating film with the added powder influenced the resistance to the water vapor transfer from the surface

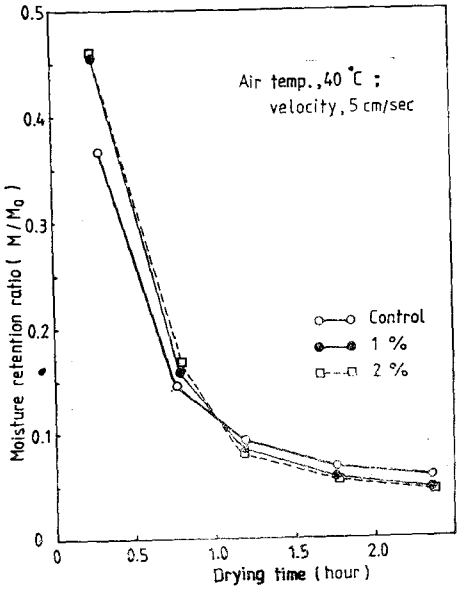


Fig. 6. Comparision of the moisture retention capability between the film coated and uncoated rice drying condition.

of cooked rice.

From this result, the existance of the coating film of glutinous rice powder could be ascertained and the effect of the fortified film on the restraint of the hardening of the cooked rice was expected.

3. Leaching rice solid in the fluid

When rice was cooked at 87°C with more water than that of conventional cooking method, the extent of the rice leaching lowered with 4%(W/W) powder treatment(Fig. 6). This is due to the decrease of the concentration gradient of the soluble solid as previously discussed.

Desikachar et el.[3] reported that the loss of rice solid to rice-fluid was attributed to the damage of cell structure accompanied with the swelling of the starch during cooking. We could, therefore, postulate that the treatment with glutinous rice powder might decrease the damage of the rice structure to a great extent and this closely agreed with the fact that the powder-treated rice had a undamaged shape after cooking as resulted before.

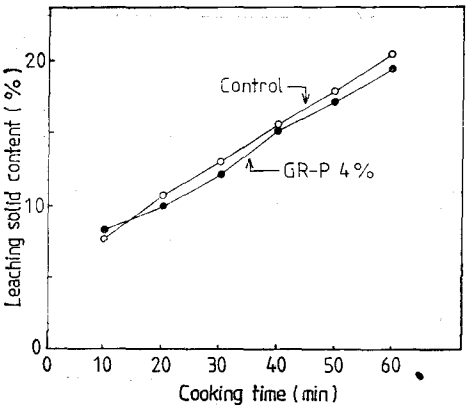


Fig. 7. Effect of the added glutinous rice powder on the leaching in rice-fluid at 87°C.

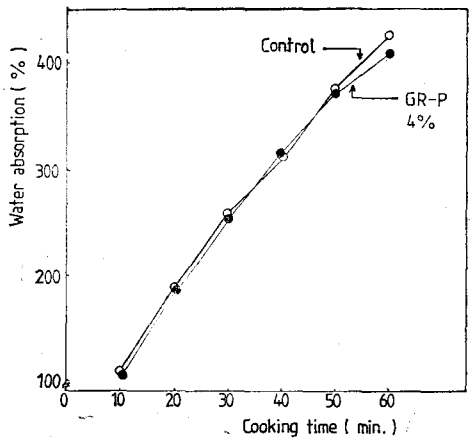


Fig. 8. Comparison of water absorption between the glutinous rice powder(GR-P) treated rice and the untreated one at 87°C.

4. Water absorption of rice in the fluid

The reduction of the rice leaching was expected to restrain the swelling of rice starch represented by the water absorption.

The water absorption values of the powder-treated rice were less than those of the untreated one as observed in Fig. 8. This reveals that the powder treatment prevent the starch of the rice from swelling and this effect is expected to promote the cohesiveness of the cooked rice.

The coating effect on cooked rice become a new physical factor of cooking quality and provide a new approach to improve the unpalatability of the rice of low quality.

요　약

쌀밥 품질의 영향 요인을 규명하기 위하여 밥짓기 과정중 밥과 밥물의 상호 관계를 분석하고, 저급의 장립종 밀양 23호의 밥맛 증진의 수단으로 새로운 밥짓기 방법을 제시하였다.

밥짓기 과정중 밥과 밥물의 높이 변화를 측정하였다. 끓는점 부근에서 밥물이 급격히 감소하고, 이어서 농축된 밥물이 밥알 표면에 엷은 피막층을 형성함을 관찰할 수 있었다.

피막 보강 물질로 찹쌀분 1,2%(W/W)를 첨가한 후 밥짓기를 한 결과, 피막이 크게 보강되었으며 이렇게 제조된 밥은 윤기와 외관이 향상되고 수분 함량이 증가하였으며 밥짓기중 가용성 쌀 고형분 함량의 용출을 감소시킬 수 있었다.

밥알 피막의 형성은 밥짓기의 최종단계에서 밥알의 진동과 밥물의 고형분 농도와 유관함을 보였고, 밥의 품질 결정의 중요 요소로 작용할 수 있음을 제안하였다.

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