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A Type of Post-Harvest Loss: Nutritional Losses During Washing and Cooking of Rice*

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米穀의 洗米및 炊飯에 依한 營養成分의 損失

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In Korea, rice is a major item of food, and is served three times a day with soup and other side dishes. In 1975, the daily supply of rice per capita in Korea was 328g, Koreans rely heavily on rice for their supply of nutrients, with 47% of their calories and 30% of their protein being derived from this cereal[1]. Rice is usually washed before it is cooked to remove dust, insects, husks and other foreign materials, and this process has a direct effect on its nutrient contents. After washing, rice is cooked by the boiling or steaming process. Cooking may also affect the loss of nutrients. Consequently, it is desirable to determine the effects of washing and cooking on the loss of nutrients in rice. A number of investigators [2~8] have reported losses of vitamins, minerals and other nutrients in rice during washing and/or cooking. In this paper, we wish to discuss the effects of washing and cooking on the loss of nutrients in rice, taking into consideration typical rice varieties and various degrees of polishing in Korea[2,12].

Losses of Nutrients in Rice During Washing

It is a common practice among families of Asian countries to wash polished rice, with from one to five changes of water. The intensity of washing varies from place to place. The actual percentage loss of nutrients during washing reported by different workers varies considerably, because the method of washing and the variety of rice varied in the different experiments.

In our experiment, which was carried out to determine the effect of washing on losses of nutrients in various types of rice, we used Japonica and Indica varieties which were polished to different degrees. The washing process was similar to that usually used for the preparation of cooked rice by Korean families: 200g of cleaned rice was placed in a beaker and covered with 400ml of water, stirred, and the supernatant liquid discarded. This process was repeated twice more, with 300 ml of water being used each time. All the discarded supernatant water was collected and combined for chemical analyses.

Table 1 shows the total loss of rice solids during the washing process, according to variety and the degree of polishing. The results indicated an apparent loss of about 2.1% in the case of Japonica polished rice and 2.5% for Indica. The loss in 90% polished rice was higher than in 70% or 50%. Damage to the structure of the rice during the polishing process facilitates the extraction of solids by water.

In Table 2, the losses of nitrogen-free extract,

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Table 1. Total loss of solids during washing

Type of rice	Loss of total solids(%)	
	Akibare*	Tongil*
Brown rice	0.43	0.34
50% polished rice	2.11	2.32
70% polished rice	2.14	2.56
90% polished rice	2.20	2.64

* Akibare and Tongil are typical Japonica and Indica types in Korea.

protein, calcium and iron during washing are compared; the figures(expressed as percentages) are: 1.1~1.9 for N-free extract, 5.4~6.7 for protein, 18~26 for calcium and 18~47 for iron. About 55% of the total solids in the washing water was nitrogen-free extract. This means that about half of the total loss of solids due to washing consists of carbohydrate material. It was usually observed that Indica rice had a relatively higher loss of nutrients than Japonica varieties. On the other hand, it was reported that washing

Table 2. Loss of several nutrients during washing

Type of rice		Loss (%)			
		N-free ex.	Protein	Calcium	Iron
Akibare	50% polished rice	1.1	5.5	18.2	17.7
	70% polished rice	1.2	5.6	22.1	18.9
	90% polished rice	1.2	5.6	20.4	22.4
Tongil	50% polished rice	1.4	6.7	20.4	33.7
	70% polished rice	1.7	6.4	25.6	36.3
	90% polished rice	1.9	6.1	23.3	46.9

polished rice by the Japanese method resulted in a loss of 2% of carbohydrates, 16% of protein and 73% of inorganic substances[3]. Presumably, washing by the Japanese method is more intensive than the method used in the Korean experiment.

The loss of amino acids during the washing of rice is shown in Table 3. The total amino acid content of rice before washing was 6,691 mg per 100g of rice, of which the washing process removed 281 mg. The average percentage of loss of some amino acids(such as lysine, glycine histidine and alanine) was greater than that of other amino acids. Since lysine is considered to be the major limiting amino acid in rice protein, there is some possibility that the washing process may slightly decrease the protein quality of rice.

The effects of the loss of thiamine, riboflavin and niacin during the washing of polished rice according to the variety and degree of polishing is shown in Table 4. The average percentage of loss during was hing is from 22~40% of thiamine, 12~24% of riboflavin and 36~45% of niacin. The losses of vitamins in 90% polished rice were relatively higher than those in 70% or 50% polished rice.

It was observed that washing rice twice removed an average of from 28 to 41% of the thiamine originally present, and that washing three times removed

Table 3. Effect of washing on losses of amino acids in rice*

Amino acid	Before washing (mg/100g rice)	Loss (%)
Lysine	281	6.2
Histidine	188	5.8
Arginine	561	4.8
Aspartic acid	653	4.6
Threonine	243	4.6
Serine	339	3.4
Glutamic acid.	1,325	3.5
Proline	356	3.4
Glycine	314	5.6
Alanine	377	5.6
Valine	439	4.1
Methionine	154	2.7
Isoleucine	281	3.8
Leucine	576	3.7
Tyrosine	232	3.7
Phenylalanine	372	3.6
Total	6,691	4.2

* 90% polished rice (Akibare variety).

Table 4. Effect of washing on losses of thiamine, riboflavin and niacin in rice

Type of rice		Loss (%)		
		Thiamine	Riboflavin	Niacin
Akibare	50% polished rice	21.5	15.5	41.6
	70% polished rice	31.7	18.3	40.9
	90% polished rice	40.3	24.4	42.3
Tongil	50% polished rice	23.5	11.5	35.8
	70% polished rice	29.0	14.4	35.6
	90% polished rice	93.4	18.8	45.0

an average of 32~53%[3]. Kik *et al*[4,5] reported that white milled rice lost 43% of thiamine, 26% of riboflavin, and 23% of niacin during washing. Similar observations have been reported by Aykroyd *et al*[6] and Miller[7] for polished rice.

Losses of Nutrients in Rice During Cooking

Cooking procedures adopted throughout the world have been reviewed by Kik and Williams[5]. In most countries, rice is usually prepared by boiling or steaming, the amounts of cooking water vary from just enough to be taken up by the rice to large excessive volumes. In the typical Korean method of cooking, a relatively small amount of water is used and none is discarded.

While cooking losses of nutrients are, in general, less serious than those due to washing, cooking may reduce the availability of nutrients. The method of cooking which causes most depletion is one in which excess water is used and where the surplus water is subsequently discarded[3]. Cooking losses of thiamine, riboflavin and niacin have been reported[3~8].

In our experiment, the preparation of cooked rice was based on the method usually used by Korean families: 250g of cleaned raw rice was immersed in 370ml of water, allowed to swell for 30 minutes in a closed cooking vessel and cooked according to the time/temperature profile shown in Fig. 1. During cooking, the water is fully absorbed into the rice and there is very slight charring in the bottom layer of the cooked rice.

Relative losses of essential amino acids during cooking are given in Table 5, which indicates that there

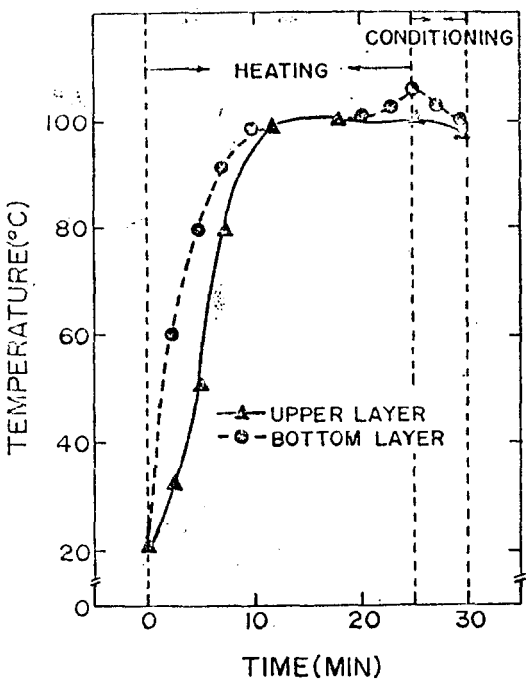

Fig. 1. Time/temperature profile of rice during cooking

was a slight loss of amino acids, including lysine. Tara and Bains[9] reported that cooking has a negligible effect on the stability of lysine and threonine when milled rice is cooked in boiling water. In their experiments, the milled rice was cooked in four times the volume of water for 14 minutes. On the other hand, our cooking method was much more severe, with a relatively small amount of water which was just sufficient to be taken up by the rice, a longer cooking time and a higher cooking temperature at the end of cooking. Therefore, cooked and roasted rice

(slightly charred)was produced on the bottom layer; this had a nut-like or roasted cereal-like flavor,which is characteristic of Soong-Neung[10] (Soong-Neung is a traditional Korean beverage served after meals and is made from cooked and roasted rice obtained as a by-product of rice-cooking).

Fig. 2 illustrates the effect of cooking on total lysine, available lysine and free lysine before and after cooking. There was a very slight loss in the various types of lysine during cooking (that of available lysine was 3.4%). Juliano[11] reported that cooking in boiling water did not reduce the availability of the epsilon-amino group of lysine in rice protein. However, cooking rice by the usual Korean method may result in lysine decomposition or, in some cases, in the binding of its epsilon-amino group.

The relative vitamin losses during cooking are shown in Table 6. The average percentage losses of thiamine, riboflavin and niacin during cooking were 19.0%, 14.3% and 22.5%, respectively. In general, our results are comparable with those of Kik[4] and show that

Table 5. Effect of cooking on losses of essential amino acids*

	Content of amino acid (mg/100g of rice)**		
	Washed rice	Cooked rice	Loss(%)
Lysine	264	258	2.2
Threonine	232	222	4.3
Valine	421	406	3.5
Methionine	150	147	2.3
Isoleucine	270	263	2.7
Leucine	555	546	1.7
Phenylalanine	359	352	2.1
Tryptophan	106	104	1.9

* 90% polished rice (Akibare variety)
** On 11.0% moisture basis

Table. 6. Effect of cooking on loss of vitamins*

	Content of vitamin**		Loss(%)
	Washed rice	Cooked rice	
Thiamine (ug/g)	1.37	1.11	19.0
Riboflavin (ug/g)	0.19	0.16	14.3
Niacin (mg/100g)	1.01	0.78	22.5

* 90% polished rice (Akibare variety)
** On 11.0% moisture basis.

Table 7. Combined effects of washing and cooking on nutrients in rice*

	Losses in washing and cooking (%)
Total solids	2.2
Protein (N×5.95)	7.2
Lysine (total)	8.1
Calcium	21.0
Iron	23.1
Thiamine	51.5
Riboflavin	34.8
Niacin	55.3

* 90% polished rice (Akibare variety)

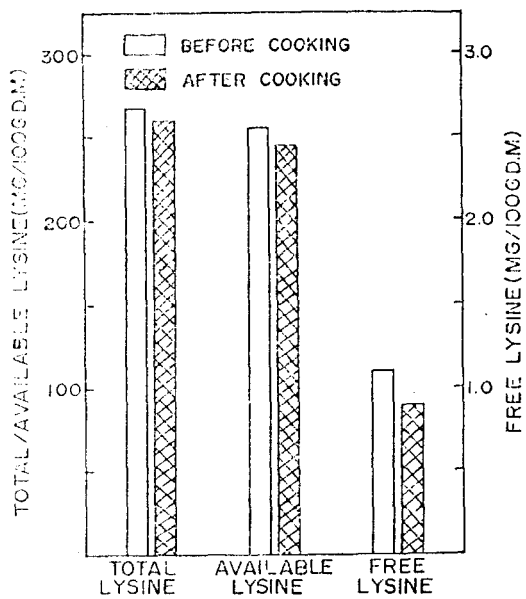

Fig. 2. Effects of cooking on the stability of total lysine, available lysine and free lysine (90% polished rice used).

the percentage losses in our experiment were lower than those in open vessel cooking, but higher than those in double boiler cooking. In some areas, cooking with excessive water which is discarded after cooking removes a large proportion of the vitamins (3,8).

Conclusion

Throughout the world, there are numerous methods of washing and cooking rice, and only regional studies in given areas can determine the actual effect of local washing and cooking practices on the loss of nutrients.

The combined effects of washing and cooking by the usual Korean methods on the nutrients in rice are summarized in Table 7, which shows a loss of 2.2% of total solids, 7.2% of proteins, 8.1% of lysine, about 22% of calcium or iron, about 53% of thiamine or niacin and 35% of riboflavin. This is really a part of post-harvest losses, considering that,in Korea, the losses during storage, processing and consumption of food grains are estimated to amount more than 10% of the total food grains[13]. In an experiment, it was shown that washing combined with cooking was responsible for more than 2.2% losses of total solids.

The nutritional importance of not washing rice before cooking is now clearly evident. Therefore, it is more desirable to distribute sanitary cleaned rice to households. In this way, washing mights be unnecessary or could be reduced so that nutrient losses will be minimal. Educational efforts are required to induce improved household practices in rice washing and cooking.

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