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Hydration Rate of Milled Rice

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백미의 수분 흡수 속도

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초 록

일반계(35 품종) 및 다수계(24 품종) 쌀의 수분 흡수 속도에 미치는 인자에 대하여 조사하였다. 각 품종마다 독특한 수분 흡수 속도를 보였으나, 대체로 다수계 품종이 일반계 품종에 비하여 수분 흡수 속도가 빨랐다. 쌀의 수분 흡수 속도는 단백질, 아밀로스, 쌀알의 표면적 및 부피와 상관 관계를 보이지 않았으나, 쌀알의 길이와 폭의 비와는 부의 상관을 보였다.

Introduction

In the previous study[1], it was demonstrated with 21 rice varieties that milled rice could be classified on the basis of hydration rate of rice grain at room temperature.

In this study, a larger lot (59 varieties) was employed to investigate the factors that influence the hydration rate of milled rice.

Materials and Methods

Rice

Thirty-five varieties of Japonica and twenty-four varieties of J×Indica (J/I) milled rice were obtained from Office of Rural Development, Suwon, Korea.

Analytical methods

The volume and surface area of rice grain were calculated as described previously.[1] Protein content was determined by AACC standard method.[2] Amylose content was analyzed by the method of Williams *et al.*,[3] with using potato amylose as a standard.

One gram of milled rice was immersed in tap water at 23°C for 2～30min. and the hydration rate of rice was calculated by the following equation:[1]

$$\bar{m}-m_0=k\sqrt{t}$$

where $\bar{m}$ is moisture content at given absorption time (g H_2O/g, dry basis), m_0 is initial moisture content (g H_2O/g, dry basis), t is hydration time (min) and k is hydration rate constant (cm/min).

Table 1. Dimension and protein and amylose content of milled rice

Japonica variety	L/W[a]	V[b]	Protein[c] (%)	Amylose (%)	J×Indica variety	L/W[a]	V[b]	Protein[c] (%)	Amylose (%)
Songjunbyeo	1.73	21.9	9.8	20.9	*Kayabyeo*	2.30	17.6	8.5	20.4
Pungok	1.79	19.0	8.2	22.5	*Seogwangbyeo*	2.35	19.0	8.6	20.0
Kwanakbyeo	1.62	19.3	8.9	20.9	*Mansukbyeo*	2.23	17.0	10.3	19.8
Suwon 320	1.77	17.4	7.6	21.1	*Yushin*	2.11	18.4	8.6	21.5
Nonglim 6	1.75	19.1	8.2	22.2	*Youngpungbyeo*	2.41	19.5	nd	19.9
Odaebyeo	1.79	21.0	9.1	19.2	*Taebaegbyeo*	2.61	15.9	9.1	20.0
Jinjubyeo	1.71	20.8	7.8	20.9	*Pungsanbyeo*	2.42	18.6	9.7	20.0
Sangpungbyeo	1.65	20.1	9.0	21.7	*Shingwangbyeo*	2.22	20.6	9.0	18.5
Sasanishiki	1.72	19.0	7.8	20.0	*Iri 357*	2.51	19.5	9.4	19.1
Chucheongbyeo	1.72	18.1	7.6	21.3	*Milyang 42*	1.97	19.7	8.8	22.0
Sulakbyeo	1.76	19.4	9.4	19.1	*Chupungbyeo*	2.55	15.3	9.4	18.3
Tamakeum	1.78	19.5	7.1	24.4	*Baegyangbyeo*	2.07	19.3	8.9	20.3
Chugwangbyeo	1.73	19.5	8.8	20.4	*Iri 360*	2.04	21.0	9.1	21.8
Suwon 306	1.77	19.9	8.2	20.4	*Milyang 23*	2.32	20.1	8.6	20.6
Sobaegbyeo	1.79	18.7	8.9	18.5	*Suwon 312*	2.34	25.7	8.9	20.1
Taechangbyeo	1.67	20.1	8.6	19.6	*Nampungbyeo*	2.33	17.4	8.6	21.8
Namyang 1	1.67	20.7	8.8	20.9	*Milyang 30*	2.01	18.1	8.7	21.7
Palkeum	1.73	19.2	7.2	22.4	*Suwon 318*	2.24	23.6	7.8	21.7
Nakdongbyeo	1.69	19.2	7.8	21.0	*Sujeongbyeo*	2.39	17.9	8.6	18.4
Bonggwangbyeo	1.72	20.6	8.1	20.8	*Samgangbyeo*	2.19	17.7	8.8	19.3
Sumjinbyeo	1.74	21.7	7.1	20.9	*Iri 362*	2.06	20.7	8.2	20.8
Yeomyungbyeo	1.71	20.6	9.0	19.3	*Suwon 317*	1.99	19.5	8.2	nd
Tongjinbyeo	1.68	20.4	7.3	21.8	*Chenogcheongbyeo*	2.02	22.1	9.2	19.1
Koshihikary	1.72	19.0	8.0	19.8	*Baegunchalbyeo* (W)	2.16	20.0	9.3	6.8
Samnambyeo	1.66	21.7	9.3	19.7	*Hankangchalbyeo* (W)	2.37	21.9	7.9	5.2
Boggwangbyeo	1.73	22.1	9.2	20.0	*Japonica*[d] Minimum	1.62	17.4	7.1	18.5
Seoanmbyeo	1.91	16.7	8.4	20.2	Maximum	1.91	22.1	10.6	22.6
Chiakbyeo	1.64	19.3	10.6	19.4	Mean	1.73	19.7	8.39	20.71
Nongbaeg	1.66	19.7	8.2	19.3	SD	(0.06)	(1.3)	(0.85)	(1.29)
Olchal (W)	1.62	18.4	9.5	6.3	*J×Indica*[d] Minimum	1.97	15.9	7.8	18.3
Nonglim 8	1.79	20.5	7.3	22.6	Maximum	2.61	25.7	10.3	22.0
Tobongbyeo	1.79	17.8	8.9	nd	Mean	2.25	19.3	8.86	20.23
Nonglimna 1 (W)	1.81	20.0	8.7	5.9	SD	(0.19)	(2.3)	(0.54)	(1.16)
Shinsunchalbyeo (W)	1.69	20.3	7.1	5.5					

a : Length/width, b : Volume
b : Dry basis.
c : Amylose content of waxy rice (W) was excluded.
nd : Not determined.

Table 2. Initial Water gain and hydration rate of milled rice

Japonica variety	Initial Water gain[a] (gH_2O/g)	$k\times10^2$ (cm/min)	J×Indica variety	Initial Water gain[a] (gH_2O/g)	$k\times10^2$ (cm/min)
Songjundyeo	0.064	6.77	*Kayabyeo*	0.129	7.59
Pungok	0.098	6.91	*Seogwangbyeo*	0.093	8.21
Kwanakbyeo	0.091	7.24	*Mansukbyeo*	0.084	8.33
Suwon 320	0.089	7.71	*Yushin*	0.117	8.41
Nonglim 6	0.098	7.82	*Youngpungbyeo*	0.093	8.42
Odaebyeo	0.071	7.91	*Taebaegbyeo*	0.073	8.43
Jinjubyeo	0.089	8.12	*Pungsanbyeo*	0.099	8.60
Sangpungbyeo	0.078	8.13	*Shingwangbyeo*	0.114	8.60
Sasanishiki	0.080	8.19	*Iri 357*	0.051	8.65
Chucheongbyeo	0.084	8.27	*Milyang 42*	0.087	8.75
Sulakbyeo	0.120	8.39	*Chupungbyeo*	0.100	8.87
Tamakeum	0.097	8.39	*Baegyangbyeo*	0.078	8.95
Chugwangbyeo	0.079	8.40	*Iri 360*	0.072	8.98
Suwon 306	0.086	8.41	*Milyang 23*	0.084	9.00
Sobaegbyeo	0.077	8.45	*Suwon 312*	0.092	9.20
Taechagnbyeo	0.073	8.48	*Nampungbyeo*	0.095	9.29
Namyang 1	0.105	8.49	*Milyang 30*	0.094	9.31
Palkeum	0.080	8.56	*Suwon 318*	0.066	9.34
Nakdongbyeo	0.076	8.58	*Sujeongbyeo*	0.083	9.51
Bonggwanbyeo	0.080	8.66	Samgangbyeo	0.080	9.64
Sumjinbyeo	0.110	8.73	*Iri 362*	0.077	9.82
Yeomyungbyeo	0.085	8.85	*Suwon 317*	0.071	10.39
Tongjinbyeo	0.089	0.86	*Cheongcheongbyeo*	0.093	10.72
Koshihikary	0.086	8.90	*Baegunchalbyeo*	0.140	12.32
Samnambyeo	0.093	9.05	*Hankangchalbyeo*	0.106	12.93
Boggwangbyeo	0.082	9.15	*Japonica* Minimum	0.064	6.77
Seonambyeo	0.068	9.19	Maximum	0.123	10.56
Chiakbyeo	0.078	9.20	Mean	0.088	8.47
Nongbaeg	0.075	9.20	SD	(0.014)	(0.72)
Olchal	0.079	9.21	*J×Indica* Minimum	0.066	7.59
Nonglim 8	0.110	9.40	Maxium	0.140	12.93
Tobongbyeo	0.123	10.24	Mean	0.088	9.00
Nonglimna 1	0.085	10.26	SD	(0.017)	(0.70)
Shinsunchalbyeo	0.101	10.56			

Hydration rate constant was calculated from the soaking time of 5∼20min. The weight of rice grains after 5min. of hydration was used to calculate the initial water gain (g H_2O/g, dry basis).

Results and Discussion

The dimension and protein and amylose content of milled rice samples are given in Table

Table 3. Classification of milled rice by hydration rate at 23°C

	Hydration rate ($k\times10^2$cm/min)					
	Group Ⅰ	Group Ⅱ	Group Ⅲ	Group Ⅳ	Group Ⅴ	Group Ⅵ
	<8.00	8.00~8.50	8.50~9.00	9.01~9.50	9.51~10.00	>10.00
Japonica variety	*Songjunbyeo*	*Jinjubyeo*	*Palkeum*	*Samnambyeo*		*Tobongbyeo*
	Pungok	*Sangpungbyeo*	*Nakdongbyeo*	*Boggwangbyeo*		*Nonglimna 1*
	Kwanakbyeo	*Sasanishiki*	*Bonggwangbyeo*			*Shinsunchalbyeo*
	Suwon 320	*Chucheongbyeo*	*Sumjinbyeo*	*Chiakbyeo*		
	Nonglim 6	*Sulakbyeo*	*Yeomyungbyeo*	*Nongbaeg*		
	Odaebyeo	*Tamakeum*	*Tongjinbyeo*	*Olchal*		
		Chugwangbyeo	*Koshinikary*	*Nonglim 8*		
		Suwon 306				
		Sobaegbyeo				
		Taechangbyeo				
		Namyang 1				
J×Indica variety	*Kayabyeo*	*Seogwangbyeo*	*Pungsanbyeo*	*Suwon 312*	*Sujeongbyeo*	*Suwon 327*
		Mansukbyeo	*Shingwangbyeo*	*Nampungbyeo*	*Samgangbyeo*	*Cheongcheongbyeo*
		Yushin	*Iri 357*	*Milyang 30*	*Iri 362*	*Baegunchalbyeo*
		Youngpungbyeo	*Milyang 42*	*Suwon 318*		*Hankangchalbyeo*
		Taebaegbyeo	*Chupungbyeo*			
			Baegyangbyeo			
			Iri 360			
			Milyang 23			

1. The ratio of length to width indicated that J/I varieties are longer and thinner than Japonica ones, which are in agreement with previous results.[4] The amylose content was ranged from 18.3~22.6% and no difference in the mean value was observed between Japonica and J/I varieties.

The hydration rate of milled rice is given in Table 2. The rice samples were arranged in the increasing order of hydration rate. The initial water gain of milled rice is also tabulated in the same table. As evident in Table 2, no two rice varieties had the same hydration rate, which confirms the previous results.[1] In general, J/I rice varieties hydrated at a faster rate than Japonica counterparts. The initial water gain of milled rice was not consistent with the hydration rate (Table 2). These results may imply that the hydration rate of milled rice under the experimental conditions is not influenced by the initial water gain.

An attempt was made to classify the milled rice samples based on the hydration rate. As shown in Table 3, most Japonica varieties fell into Groups I-IV, while J/I varieties distributed in Groups II-VI.

Properties of milled rice within each hydration group are summarized in Table 4. No clear-cut tendency could be seen in physical or chemical properties of milled rice among hydration groups.

Correlation coefficients between rice properties are given in Table 5. A negative correlation was observed between protein and amylose content only for Japonica varieties. The ratio of length to width was negatively correlated with amylose content only for J/I varieties. It is not certain whether these observations are due to the characteristics of J/I varieties.

Table 4. Properties of milled rice within each hydration group[a]

Group	No. of varieties	Length/(Width)	Volume (mm³)	Protein content (%)	Amylose content (%)	Initial water gain (gH_2O/g)	Water uptake rate (10^2) (cm/min)
Japonica							
I	6	1.62~1.79	17.4~21.2	7.6~ 9.1	19.9~22.5	0.064~0.098	6.77~ 7.91
II	11	1.65~1.79	18.1~20.8	7.1~ 9.4	18.5~24.4	0.073~0.120	8.12~ 8.49
III	7	1.68~1.74	19.0~21.7	7.1~ 9.0	19.3~21.8	0.076~0.110	8.56~ 8.90
IV	6	1.64~1.91	16.7~22.1	7.3~10.6	19.3~22.6	0.068~0.110	9.05~ 9.40
V	1	1.79	17.8	8.9	nd	0.123	10.24
J×Indica							
I	1	2.30	17.6	8.5	21.3	0.129	7.59
II	5	2.11~2.61	15.9~19.5	8.6~10.3	19.8~21.5	0.073~0.117	8.21~ 8.43
III	8	1.97~2.55	15.3~21.0	8.6~ 9.4	18.3~22.0	0.072~0.114	8.60~ 9.00
IV	4	2.01~2.34	17.4~25.7	7.8~ 8.9	20.1~22.6	0.066~0.095	9.20~ 9.34
V	3	2.06~2.39	17.7~20.7	8.2~ 8.8	18.4~20.8	0.077~0.083	9.51~ 9.82
VI	2	1.99~2.02	19.5~22.1	8.2~ 9.2	19.1	0.071~0.093	10.39~10.72

a : Waxy rice was excluded.

Table 5. Correlation coefficients between rice properties[a]

		Protein	Amylose	Length/Width	Surface area	Volume	Initial water gain	Water uptake rate
Protein	J[b]		−0.60**	−0.20	0.12	0.19	−0.19	−0.03
	J/I		−0.42	0.24	−0.35	−0.32	0.03	−0.30
Amylose	J			0.11	−0.06	−0.07	0.31	−0.25
	J/I			−0.51*	0.19	0.20	−0.05	−0.05
Length/Width	J				−0.32	−0.35	0.10	−0.40*
	J/I				−0.27	−0.33	−0.01	−0.46*
Surface area	J					0.96**	−0.01	−0.07
	J/I					0.97**	−0.24	0.32
Volume	J						−0.02	0.26
	J/I						−0.19	0.35
Initial water gain	J							0.25
	J/I							−0.40
Water uptake rate	J							
	J/I							

a : Waxy rice was excluded.
b : J=Japonica; J/I=Japonica×Indica.
*and** : Significant at 5% and 1% level, respectively.

The initial water gain was not correlated with protein, amylose, length/width, suraface area or volume of rice grains (Table 5). No correlation was observed between hydration rate and protein, amylose, surface area, volume or initial water gain. However. the hydration rate was negatively correlated with the ratio of length to width. As mentioned earlier, each rice variety had characteristic values for initial water gain and hydration rate and the former was not consistent with the latter (Table 2). The fact that the hydration rate had no correlation with the initial water gain but was negatively correlated with the ratio of length to width (Table 5) indicate that the hydration rate after the initial water gain is controlled by the ratio of length to width of the rice grain.

In summary, the classification of Japonica and J/I milled rice was attempted based on the hydration rate at room temperature and interrelationships between the hydration rate and some properties of milled rice were investigated. Possibility that the hydration rate of milled rice could be used for quality classification is under investigation in our laboratory.

Abstract

Hydration rate of 35 Japonica and 24 J x Indica rice varieties at 23°C was investigated and an attempt was made for a tentative classification of milled rice into six groups based on hydration rate. Each rice variety had characteristic value for hydration rate. In general, J x Indica rice hydrated at a faster rate than Japonica rice. Hydration rate was negatively correlated with the ratio of length to width of rice grain. No correlation was found between hydration rate and protein, amylose, surface area, volume or initial water grain.

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