한국농화학회지 Vol. 29, No. 1, Mar. 1986
J. Korean Agricultural Chemical Society

Alkali Gelatinization of Starches Isolated from Various Hydration Groups of Milled Rice

Sung-Kon Kim and Hye-Min Chung*

Department of Food Science and Nutrition, Dankook University, Seoul
*Department of Home Economics, Gijun Junior College, Junju, Korea
(Received February 13, 1986)

수화그룹별 쌀 전분의 알카리 호화

김 성 곤 · 정 혜 민*

단국대학교 문리과대학 식품영양학과, *기전여자전문대학 가정학과

초 록

수분흡수속도가 다른 쌀로부터 추출한 전분의 알카리 호화양상을 조사하였다. 일정한 알카리 농도에서 최고점도와 점도의 증가속도 및 알카리 농도를 증가시킬 때의 점도의 증가속도는 다수계 쌀 전분이 일반계 쌀 전분보다 높았다. 쌀전분의 점도양상은 쌀가루의 점도양상 및 쌀의 수화속도와는 상관관계를 보이지 않았다.

Introduction

It was demonstrated in the previous study[1] that milled rices could be tentatively classified into six groups based on hydration rate of rice grain at room temperature. To investigate possibility that the hydration rate of milled rice could be used for quality classification, the relations between the hydration rate and rice properties,[1] alkali gelatinization[2] and pasting properties[3] of rice flours were examined.

In this study, alkali gelatinization of starches isolated from various hydration groups of milled rice in aqueous sodium hydroxide is presented.

Materials and Methods

Rice starch

Starch was isolated according to the method of Chung *et al.*[4] from 26 varieties of Japonica and 19 varieties of J/Indica milled rices which were the same varieties employed in the previous study.[1]

Alkali gelatinization

The procedure of alkali gelatinization and viscosity measurement was described in the paper concerning rice flours in alkaline solution.[2]

Starch concentration of 5% was used throughout the experiment.

Results and Discussion

Maximum viscosity and viscosity development rate of Japonica and J/Indica rice starches at various NaOH concentrations are tabulated in Tables 1 and 2, respectively. From these data, it is clear that each starch had a characteristic viscosity development pattern. In the study of alkali gelatinization of various grain starches and flours, Maher[5,6] showed that the viscosity development patterns of the starches or flours were not superimposable. The same observation was reported for rice flours.[2]

The maximum viscosity and the viscosity development rate of Japonica rice starches at a given NaOH concentration(Table 1) were lower than those of J/Indica ones(Table 2). The time at which the maximum viscosity was occurred also showed that J/Indica rice starches reached at the maximum value at a faster rate. These results indicate that J/Indica rice starches was gelatinized slightly easily compared with Japonica rice starches, which agreed with the previous findings on rice flours.[2]

At a given concentration of starch, the viscosity development rate was increased as alkali concentration increased(Table 3). This was more pronounced in J/Indica rice starches than in Japonica counterparts. As was expected from the data in Tables 1 and 2, the difference in the viscosity development rate of rice starches by increament of 0.1N NaOH (0.02meq/g starch) was greater in J/Indica rice starches in comparison with Japonica ones.

Under the experimental conditions, it was assumed that when considerable viscosity was developed up to a plateau the gelatinization of rice starch was terminated. The strength of the alkali for complete gelatinization of most rice starches was 0.18N (0.36meq/g starch). This value was somewhat higher than the strength of the alkali that was needed for the gelatinization of the rice flours, 0.33 meq/g flour.[2] These results support the suggestion of Maher[6] who reported that the flour from a species seemed to be a little easier to gelatinize than the starch isolated from the species. He[6] suggested four possible reasons for this phenomenon: 1) the lesser amount of starch present in the flours; 2) the increasing of effective NaOH concentration by the removal of water by substrate binding of water, a process that might be enhanced with flours as compared to starches because of strong water binding of proteins in the former; 3) the flourmaking process which affects some changes in some, but not all, physical properties of the starch granules, as was shown with the wheats;[7] or 4) the presence of carbohydrate polymers other than starch such as galactan in soybean flour[8] and glucan in oat flour.[9]

It was shown that the maximum viscosity and the viscosity development rate of rice flours in NaOH aqueous system had no correlation with protein content.[2] Maher[6] also reported that differences in the magnitude of viscosity developed among 12 varied botanical sources did not seem correlative to protein or starch contents of the flours. However, viscosity of rice starch was not correlated to that of rice flour(Table 4). These results imply that some other factor than protein content may be responsible for the difference in viscosity of rice flour and rice starch. It was reported 0.02% water-soluble and 0.1% of 0.5N alkali-soluble hemicelluloses.[10] Although the water-soluble hemicellulose had a variable effect on amy lograph viscosity when added to hemicellulosefree rice flour,[11] their viscous nature in alkaline solution is not known. Therefore, the reasons why rice flours were slightly eas ier to gelatinize than the rice starches remain to be explored.

Ranges of the maximum viscosity and the viscosity development rate of rice starches isolated from various hydration groups of milled rice are given in Table 5. Although, as mentioned earlier, the maximum viscosity and

Table 1. Maximum viscosity and viscosity development rate of Japonica rice starches at various alkali concentrations

Hydration group[a]	Variety	0.17N Maximum viscosity (CP×10³)	0.17N Rate[b]	0.18N Maximum viscosity (CP×10³)	0.18N Rate	0.19N Maximum viscosity (CP×10³)	0.19N Rate
I	Kwanakbyeo	5.0(—)[c]	0.15	12.5(—)	0.80	12.6(26)	1.35
	Odaebyeo	9.1(—)	0.30	12.3(27)	1.03	14.2(15)	2.15
	Nonglim 6	11.9(19)	1.63	12.7(14)	2.20	15.9(3)	4.10
	Pungok	12.5(23)	1.47	14.2(13)	3.90	14.8(4)	5.70
	Suwon 320	7.6(—)	0.48	10.2(26)	0.83	12.9(24)	1.62
II	Sulakbyeo	6.2(—)	0.20	9.6(—)	0.52	15.8(15)	2.67
	Sobaegbyeo	5.9(—)	0.15	9.6(—)	0.55	12.0(29)	0.90
	Chucheongbyeo	10.0(—)	0.65	12.1(26)	1.22	13.2(18)	1.90
	Taechangbyeo	7.1(—)	0.30	12.8(—)	0.92	14.8(15)	2.20
	Jinjubyeo	9.7(—)	0.82	12.2(23)	1.90	14.3(4)	4.50
	Sangpungbyeo	10.4(—)	0.76	11.3(27)	1.15	15.0(8)	4.65
	Tamakeum	8.2(—)	0.67	11.3(13)	2.25	14.6(4)	4.00
	Sasanishiki	11.0(—)	0.74	14.5(19)	1.75	16.2(8)	4.55
	Suwon 306	13.8(18)	2.65	15.8(7)	4.00	17.2(4)	5.60
	Namyang 1	9.7(—)	0.57	13.6(28)	1.40	14.6(18)	2.70
III	Yeomyungbyeo	7.8(—)	0.16	10.9(—)	0.69	16.3(21)	1.80
	Bonggwangbyeo	9.9(—)	0.73	13.4(18)	1.83	14.1(13)	2.66
	Palkeum	10.9(—)	0.76	12.9(20)	1.93	15.0(8)	4.05
	Tongjinbyeo	7.5(—)	0.31	11.2(27)	0.91	14.3(9)	4.05
	Sumjinbyeo	13.1(—)	0.98	15.4(20)	2.13	16.8(11)	4.50
	Koshihikary	10.3(—)	0.71	13.0(17)	1.96	15.9(6)	3.30
	Nakdongbyeo	8.6(—)	0.51	11.7(25)	1.12	14.4(11)	4.00
IV	Chiakbyeo	5.4(—)	0.20	8.6(—)	0.37	13.1(—)	1.00
	Seonambyeo	13.1(26)	1.20	16.6(12)	3.55	18.4(9)	5.35
	Nongbaeg	6.3(—)	0.14	8.6(—)	0.68	14.0(21)	1.56
	Nonglim 8	14.2(14)	2.20	15.6(16)	4.25	16.6(12)	4.60
	Maximum	14.2	2.65	15.8	4.25	17.2	5.70
	Minimum	5.0	0.14	8.6	0.37	12.0	1.00
	Mean	9.2	0.75	12.4	1.61	14.9	3.29
	SD	2.7	0.64	2.1	1.08	1.5	1.48

a : Hydration rate increases from Group I to IV (see reference 1).
b : Viscosity development rate (CP×10³/min).
c : Figures in parenthesis indicate time(min) at which maximum viscosity was developed.

Table 2. Maximum viscosity and viscosity development rate of J/Indica rice starches at various alkali concentrations

Hydration group[a]	Variety	0.17N Maximum viscosity (CP×10³)	0.17N Rate[b]	0.18N Maximum viscosity (CP×10³)	0.18N Rate	0.19N Maximum viscosity (CP×10³)	0.19N Rate
I	Kayabyeo	10.0(—)[c]	0.57	15.5(15)	2.20	18.3(9)	4.80
II	Mansukbyeo	15.4(20)	1.83	15.9(12)	2.15	18.7(7)	5.10
	Yushin	13.7(22)	2.13	14.3(9)	3.03	16.3(9)	4.25
	Seogwangbyeo	11.7(—)	0.92	12.1(21)	1.53	14.1(19)	1.53
	Youngpungbyeo	13.1(24)	1.33	15.7(14)	2.86	19.4(5)	6.75
III	Chupungbyeo	12.6(—)	1.24	13.4(26)	1.28	18.2(14)	2.63
	Baegyangbyeo	14.0(—)	1.00	14.0(—)	1.28	18.5(19)	2.63
	Shingwangbyeo	12.5(—)	0.28	12.6(25)	1.10	15.3(19)	1.97
	Milyang 23	14.4(10)	2.52	15.5(6)	5.00	19.5(4)	7.25
	Milyang 42	15.5(21)	2.20	16.2(16)	2.70	18.1(12)	4.25
	Iri 357	10.5(—)	0.82	13.6(25)	1.45	18.9(5)	6.45
	Iri 360	14.5(—)	1.38	15.5(17)	2.05	21.5(5)	7.60
IV	Nampungbyeo	11.7(26)	1.27	14.4(10)	3.60	16.9(8)	4.20
	Milyang 30	13.1(—)	1.36	14.7(11)	3.50	18.4(9)	4.15
	Suwon 318	9.6(—)	0.68	11.4(20)	1.18	14.1(6)	4.60
	Suwon 312	13.1(—)	0.94	15.3(24)	1.47	20.0(10)	4.16
V	Sujeongbyeo	14.2(25)	1.73	16.6(9)	4.00	17.5(10)	4.00
	Samgangbyeo	13.7(—)	1.18	18.4(12)	3.95	20.5(6)	7.10
	Iri 362	11.2(—)	0.88	14.1(16)	2.25	16.0(6)	5.10
	Maximum	15.5	2.52	18.4	5.00	21.5	7.60
	Minimum	9.6	0.28	11.4	1.10	14.1	1.53
	Mean	12.8	1.28	14.7	2.45	17.9	4.66
	SD	1.7	0.59	1.6	1.14	2.3	1.77

a : Hydration rate increases from Group I to V (see reference 1).
b : Viscosity development rate (CP×10³/min).
c : Figures in parenthesis indicate time (min) at which maximum viscosity was developed.

Table 3. Effect of increment of alkali concentration on viscosity development rate of rice starches

Hydration group	Japonica variety	Difference in rate between 0.17～0.18N	Difference in rate between 0.18～0.19N	Hydration group	J/Indica variety	Difference in rate between 0.17～0.18N	Difference in rate between 0.18～0.19N
I	Kwanakbyeo	0.65	0.55	I	Kayabyeo	1.63	2.60
	Odaebyeo	0.73	1.12				
	Nonglim 6	0.57	1.90	II	Mansukbyeo	0.32	2.95
	Punpok	2.43	1.80		Yushin	0.90	1.22
	Suwon 320	0.35	0.79		Seogwangbyeo	0.61	0.00
					Youngpungbyeo	1.53	3.89
II	Sulakbyeo	0.32	2.15				
	Sobaegbyeo	0.40	0.35	III	Chupungbyeo	0.04	1.35
	Chucheongbyeo	0.57	0.68		Baegyangbyeo	0.28	1.35
	Taechangbyeo	0.62	1.28		Shingwangbyeo	0.82	0.87
	Jinjubyeo	1.08	2.60		Milyang 23	2.48	2.25
	Sangpungbyeo	0.39	3.50		Milyang 42	0.50	1.55
	Tamakeum	1.58	1.75		Iri 357	0.63	5.00
	Sasanishiki	1.01	2.80		Iri 360	0.67	5.55
	Suwon 306	1.35	1.60				
	Namyang 1	0.83	1.30	IV	Nampungbyeo	2.33	0.60
					Milyang 30	2.14	0.65
III	Yeomyungbyeo	0.53	1.11		Suwon 318	0.50	3.42
	Bonggwangbyeo	1.10	0.83		Suwon 312		
	Palkeum	1.17	2.12				
	Tongjinbyeo	0.60	3.14	V	Sujeongbyeo	2.27	0.00
	Sumjinbyeo	1.15	2.37		Samgangbyeo	2.77	3.15
	Koshihikary	1.25	1.34		Iri 362	1.37	2.85
	Nakdongbyeo	0.61	2.88	Japonica	Range	0.17～2.43	0.35～3.50
					Mean	0.94	1.60
IV	Chiakbyeo	0.17	0.63		SD	0.61	0.89
	Seonambyeo	2.35	1.80	J/Indica	Range	0.04～2.77	0.00～5.55
	Nongbaeg	0.54	0.88		Mean	1.21	2.18
	Nonglim 8	2.05	0.35		SD	0.86	1.62

Table 4. Correlation coefficients between maximum viscosity (MV) and viscosity development rate of rice starch and of rice flour

		MV of starch at 0.18N NaOH	Rate of starch at 0.18N NaOH
MV of flour at 0.2N NaOH	J	0.029	0.221
	J/I	0.372	0.073
Rate of flour at 0.2N NaOH	J	0.457*	0.300
	J/I	0.152	0.280
Hydration rate[a]	J	0.017	0.050
	J/I	0.223	0.250

a : Data from reference 1

Table 5. Ranges of maximum viscosity and viscosity development rate of rice starches

	Hydration group	No. of varieties	Maximum viscosity			Viscosity development rate		
			0.17N	0.18N	0.19N	0.17N	0.18N	0.19N
Japonica	I	5	5.0～12.5[a] (9.2±3.1)[b]	10.2～14.2 (12.3± 1.4)	12.6～15.9 (14.0± 1.4)	0.30～1.63 (0.80±0.69)	0.83～3.90 (1.75±1.33)	1.35～5.70 (2.98±1.86)
	II	10	5.9～13.8 (9.2± 2.4)	9.6～15.8 (12.2± 2.0)	12.0～17.2 (14.7± 1.5)	0.15～2.65 (0.75±0.70)	0.52～4.00 (1.56±1.02)	0.90～5.60 (3.36±1.49)
	III	7	7.8～13.1 (9.7± 1.9)	10.9～15.4 (12.6± 1.5)	14.1～16.8 (15.2±1.07)	0.16～0.98 (0.59±0.28)	0.69～2.13 (1.51±0.58)	1.80～4.50 (3.48±0.95)
	IV	4	5.4～14.2 (9.7± 4.5)	8.6～16.6 (12.3± 4.3)	13.1～18.4 (15.5± 2.4)	0.14～2.20 (0.93±0.97)	0.37～4.25 (2.21±1.97)	1.00～5.35 (3.12±2.16)
J/Indica	I	1	10.0	15.5	18.3	0.57	2.20	4.80
	II	4	11.7～15.4 (13.4± 1.5)	12.1～15.9 (14.5± 1.7)	14.1～19.4 (17.1± 2.4)	0.92～2.13 (1.55±0.53)	1.53～3.03 (2.39±0.68)	1.53～6.75 (4.40±2.18)
	III	7	10.5～15.5 (13.4± 1.6)	12.6～16.2 (14.4± 1.3)	15.3～21.5 (18.5± 1.8)	0.28～2.52 (1.34±0.78)	1.10～5.00 (2.12±1.38)	1.97～7.60 (4.68±2.38)
	IV	4	9.6～13.1 (11.8± 1.6)	11.4～15.3 (13.9± 1.7)	14.1～20.0 (17.3± 2.5)	0.68～1.36 (1.06±0.31)	1.18～3.60 (2.43±1.29)	4.15～4.60 (4.27±0.21)
	V	3	11.2～14.2 (13.0±1.60)	14.1～18.4 (16.3±2.15)	16.0～20.5 (18.0± 2.3)	0.88～1.73 (1.26±0.43)	2.25±4.00 (3.40±0.99)	4.00～7.10 (5.40±1.57)

a : Range
b : Mean+SD

the viscosity development rate of Japonica rice starches were lower at a given alkali concentration than those of J/Indica counterparts, there was no clear-cut tendency among hydration groups. Furthermore, as shown in Table 4, the hydration rate of milled rice had no correlation with viscosity of rice starch. It was therefore not possible from the results in Table 5 to differentiate each hydration group of milled rice, as reported in the previous study concerning the alkali gelatinization of rice flours.[2]

Abstract

Viscosity development pattern, in aqueous sodium hydroxide, of rice starches isolated from various hydration groups of milled rice was investigated. The maximum viscosity and viscosity development rate of Japonica rice starches at a given alkali concentration were loswer than those of J/Indica counterparts. The difference in the viscosity development rate of starches by increment of 0.1N (0.02 meq/g) was greater in J/Indica rice starches in comparison with Japonica ones. Viscosity of rice starch was not correlated to that of rice flour and to hydration rate of milled rice.

References

1. Kim, S.K., Han, K.Y., Park, H.H., Chae, J.C. and Ree, J.H.: J. Korean Agr. Chem. Soc., 28 : 62(1985).
2. Kim, S.K., Lee, K.H. and Kim, S.S.: J. Korean Agr. Chem. Soc., 28 : 106(1985).
3. Kim, S.K. and Kim, S.S.: J. Korean Agr. Chem. Soc., 28 : 142(1985).
4. Chung, H.M., Ahn, S.Y. and Kim, S.K.: J. Korean Agr. Chem. Soc., 25 : 67(1982).
5. Maher, G.G.: Staerke, 35 : 226(1983).
6. Maher, G.G.: Staerke, 35 : 271(1983).
7. Kulp, K.: Cereal Chem., 49 : 697(1972).
8. Sathe, S.K. and Salunkhe, D.K.: J. Food Sci., 46 : 1276(1981).
9. Wu, Y.V., Clusky, J.E., Wall, J.S. and Inglett, G.E.: Cereal Chem., 50 : 481(1973).
10. Cartano, A.V. and Juliano, B.O.: J. Agr. Food Chem., 18 : 40(1970).
11. Mod, R.R., Normand, F.L., Ory, R.L. and Conkerton, E.J.: J. Food Sci., 46 : 571(1981).