KOREAN J. FOOD SCI. TECHNOL.
Vol. 23, No. 2, pp. 192~199(1991)

Effects of Salt and Alkaline Reagent on Rheological Properties of Instant Noodle Flour Differing in Protein Content

Gu-Sik Chung and Sung-Kon Kim

Department of Food Science and Nutrition, Dankook University

소금과 알칼리제가 단백질 함량이 다른 라면 밀가루의 리올로지 성질에 미치는 영향

정구식 · 김성곤

단국대학교 식품영양학과

Abstract

The rheological properties of various flour blends of HRW-WW and DNS-WW having protein contents of 9.12~9.78% in the presence or absence of salt and alkaline reagent (an equal mixture of Na_2CO_3 and K_2CO_3) were studied. The farinograph absorptions of HRW-WW and DNS-WW blends was increased by 1% and 0.6%, respectively, with increasing protein content by 0.33%. Salt (1.7%) decreased the absorption by 1% regardless protein contents. Alkaline reagent (0.17%) or a combination of salt and alkaline reagent had no effect on absorption of flours, indicating that the effect of salt on decreasing absorption is masked by alkaline reagent. The protein content of the flour in the presence or absence of salt, alkaline reagent or both showed a highly positive correlation with all reference points of farinograph and extensograph, but the peak viscosity of amylograph was negatively correlated with protein content only in the presence of salt, alkaline reagent or both.

Key words : salt, alkaline reagent, rheological property, amylograph, farinograph, extensograph, wheat flour

Introduction

The most common flour used in noodles including Ramyon (deep-fried instant noodle) in Korea is all-purpose flour, which is a composite of western white (WW) and hard red winter (HRW) wheat flours. Since the introduction of Ramyon in Korea in 1963, its consumption has been increased gradually and reached almost 10 kg per capita per year.

The basic ingredients for Ramyon manufacture are flour, salt, alkaline reagent and water. The quality criteria of Ramyon flour in Korea are protein content of about 9.5% and ash content of below 0.55%. However, no data are available on the effects of ingredients on Ramyon quality.

The flour quality requirement of instant noodles is reported to be less stringent and the procedures adopted in manufacture are more important in governing the quality of the final product[1,2]. Moss[1] suggested that the flour manufactured from sound wheat which has low starch paste viscosity is associated with noodles having the best eating quality, and that there is an inverse relationship between oil and protein content of instant noodles.

The purpose of this study was to investigate the rheological properties of flours differing in protein contents in the presence or absence of salt and alkaline reagent. For the possible replacement of HRW with dark northern spring (DNS) wheat flour in Ramyon manufacture, flour blends of DNS-WW were prepared and compared with HRW-WW flour blends. The properties of Ramyon prepared with HRW-WW and DNS-WW blends will be published in the separate paper.

Corresponding author : Sung-Kon Kim, Department of Food Science and Nutrition, Dankook University, San 8, Hamam-dong, Yongsan-ku, Seoul 140-714, Korea

Materials and Methods

Materials

The U.S. wheats (WW, HRW and DNS) were commercially milled. The flours were equilibrated to moisture content of 13.5%. The properties of wheat flours are given in Tables 1 and 2.

Various flour blends of HRW-WW and DNS-WW having protein content of 9.12~9.78% were prepared and stored at −20℃ until used.

Table 1. Proximate composition of flours

Flour	Protein (%)	Ash (%)	Color grade[a)]
Western white	8.62	0.44	1.60
Hard red white	10.28	0.45	0.50
Darl northern spring	13.19	0.47	−0.75

[a)]Determined by Kent-Jones and Martin Color-Grader, Series III(Henry Simon Co., England)

Salt used was commercial food grade. Alkaline reagent employed was a 50-50 mixture of sodium carbonate and potassium carbonate.

Measurement of rheological properties of flours

The rheological properties of flours in the presence and absence of salt and alkaline reagent were examined with farinograph, extensograph and amylograph. The concentrations of salt anf alkaline reagent used were 1.7 and 0.17%, respectively, based on flour weight.

The farinograph and extensograph were performed using 300g bowl according to AACC method 54-21 and 54-10[3], respectively. Extensogram was recorded after rest periods of 45 min and 135 min. The measurements were repeated at least 2 times, and the data were reported on 13.5% moisture basis.

Pasting properties of flours were measured with Visco/amylo/Graph using 12% (db) concentration according to the method of Medcalf and Gilles[4]. The total weight of flour suspension was 500g.

Results and Discussion

Farinograph characteristics

The farinograph absorption of HRW-WW blend was 55.0% at 9.12% protein, 56.0% at 9.45% protein and 57.2% at 9.78% protein, and that of DNS-WW blend was 54.7%, 55.3% and 55.9% at the corresponding protein content of HRW-WW blend (Fig. 1). The absorptions of HRW-WW and DNS-WW blends was increased by 1% and 0.6%, respectively, with increasing protein content by 0.33%. These unexpected results may be due to the lower proportion of DNS than HRW in the preparation of flour blends at the same protein content.

Salt decreased the absorption of flour by 1% regardless protein contents (Fig. 1). Salovaara[5] reported that the farinograph absorption of wheat flour was decreased by addition of 2% sodium chloride. Hlynka[6] studied the influence of salt on rheological properties of dough in the farinograph and reported that consistency of a dough at 60% absorption was decreased by 70 and 90 B.U. with the addition of salt by 1 and 2%, respectively. A similar result was observed by Tanaka *et al.*[7]

Alkaline reagent did not influence the farinograph absorption (data not shown). The absorption of flour in the presence of both salt and alkaline reagent was essentially the same as that of flour alone (data not shown), which indicates that the effect of salt on decreasing absorption was masked by alkaline reagent.

The development time was increased as protein content increased (Table 3). Salt increased the development time, which agrees with the results of Galal *et al.*[8], Dick *et al.*[9] and Harinder and Bains[10]. The dough development time of HRW-WW remained steady but of DNS-WW increased in the presence of alkaline reagent (Table 3). The combination of salt and alkaline reagent increased the development time of both HRW-WW and DNS-WW, but the effect was more pronounced in case of the former (Table 3). Dick *et al.*[9] observed an increase and then a decrease in the dough development time as the concentration of sodium and potassium carbonate was increased to 1.0% from 0.3%, and a decrease in the mixing time and stability at concentration greater than 1%, producing characteristic curves of weak flour. Moss *et al.*[11] reported that in the presence of alkaline reagent dough develops and breaks down more rapidly in the farinograph.

The stability and time to breakdown showed an increase with increasing protein content, of which the effect was more greater in HRW-WW than DNS-WW flours (Figs. 2 and 3). The salt and alkaline reagent

Table 2. Physical properties of flours

Flour	Farinograph			Extensograph		Amylograph		
	Absorption (%)	Development time (min)	Stability (min)	Resistance at 135 min (cm)	Extensibility at 135 min (cm)	Initial pasting temperature (℃)	Peak viscosity (B.U.)	Viscosity after 15 min at 95℃ (B.U.)
WW	53.5	1.25	2.0	1.7	15.4	64.5	745	560
HRW	59.1	2.00	13.0	7.3	18.2	64.5	630	430
DNS	64.4	9.50	>20	8.5	22.1	64.5	600	385

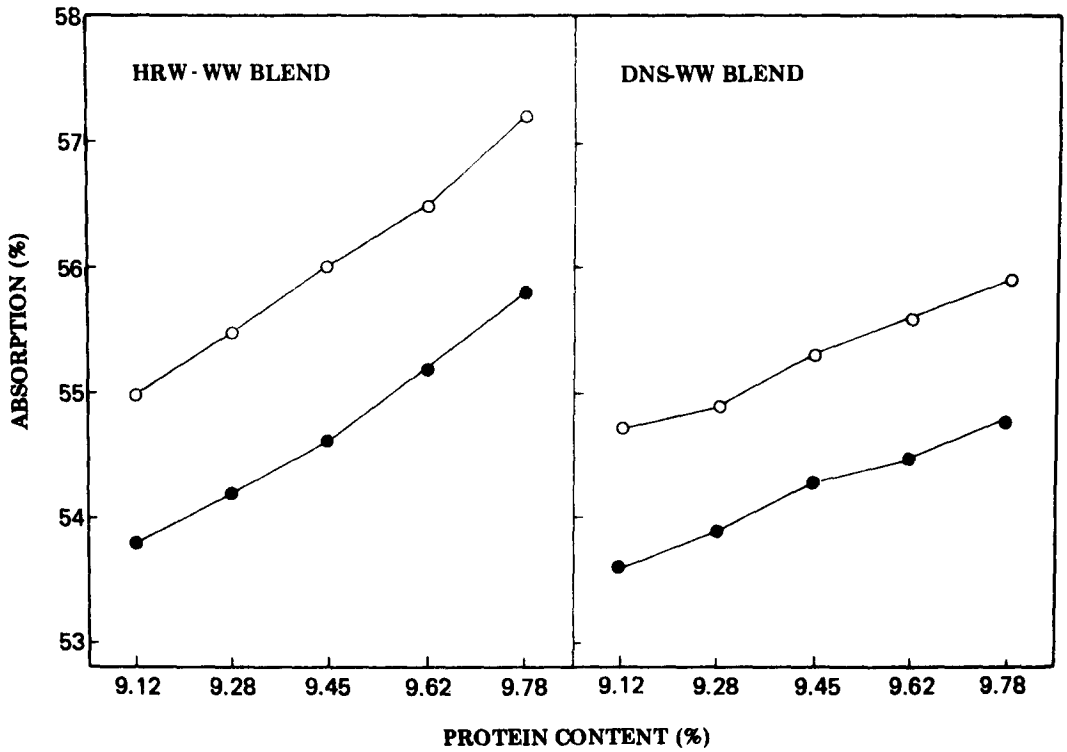

Fig. 1. Effects of protein contents on farinograph absorption of flours in the presence (●) or absence (○) of salt

Table 3. Development time[a)] of farinograph

	Protein content of flour (%)									
	HRW-WW blend					DNS-WW blend				
	9.12	9.28	9.45	9.62	9.78	9.12	9.28	9.45	9.62	9.78
Control	2 : 00	2 : 30	2 : 30	2 : 45	2 : 45	1 : 30	2 : 00	2 : 30	3 : 00	3 : 00
Salt	2 : 00	2 : 40	3 : 00	3 : 00	3 : 10	2 : 00	3 : 00	3 : 00	3 : 00	4 : 30
Alkaline	2 : 00	2 : 30	2 : 30	2 : 30	3 : 00	2 : 30	3 : 00	3 : 00	3 : 00	3 : 30
Salt + Alkaline	5 : 00	7 : 00	7 : 00	9 : 00	9 : 30	4 : 30	5 : 00	5 : 00	5 : 30	5 : 30

[a)]Time in min and sec.

showed a definite effect in increasing stability and time to breakdown.

The mechanical tolerance index of dough decreased with the increase of protein content and the addition of salt and alkaline reagent (Table 4).

To summarize the effects, salt and alkaline reagent strengthened the dough and increased dough development time and stability. The former was more effective than the latter. However, when the combination of salt and alkaline reagent was used, the effect of salt was greatly reduced. In an attempt to observe the effect of a combination of sodium chloride with sodium carbonate on the farinogram, Dick *et al.*[9] observed that the alkaline reagent, in general, played a dominant role, masking the effect of sodium chloride.

The effects of salt and alkaline reagent were more pronounced in HRW-WW than DNS-WW flour at the same protein content, possibly because of the different ratio of HRW and DNS in the preparation of flour blends.

It is known[10,12] that pH affects the dough-mixing properties. Hoseney and Brown[12] reported when the pH of dough was increased to 8.5 with N sodium bicarbonate the mixing time and stability in the mixograph

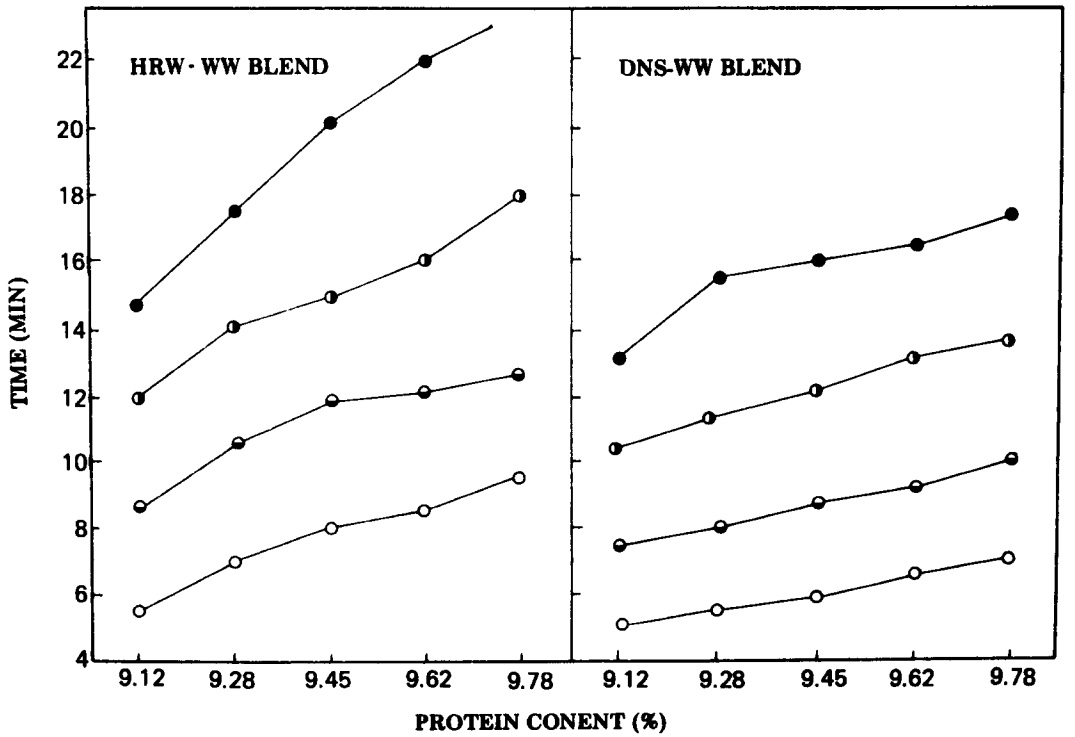

Fig. 2. Effects of protein contents of flours on stability of farinograph
○—○, control ; ●—●, salt ; ◒—◒, alkaline ; ◑—◑, salt+alkaline

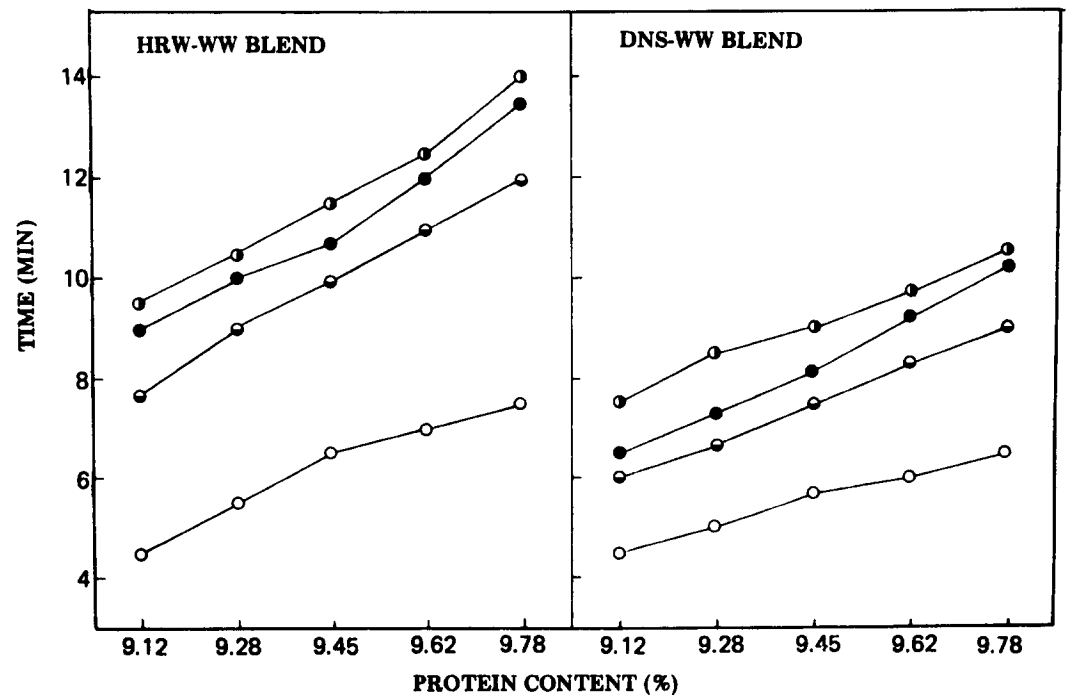

Fig. 3. Effects of protein contents of flours on time to breakdown of farinograph
○—○, control ; ●—●, salt ; ◒—◒, alkaline ; ◑—◑, salt+alkaline

Table 4. Mechanical tolerance index (B.U.) of farinograph

	Protein content of flour (%)									
	HRW-WW blend					DNS-WW blend				
	9.12	9.28	9.45	9.62	9.78	9.12	9.28	9.45	9.62	9.78
Control	85	60	50	50	45	75	60	50	50	50
Salt	45	35	30	25	25	45	40	30	30	30
Alkaline	55	30	25	25	20	50	50	50	35	35
Salt+Alkaline	35	35	35	35	30	60	60	60	40	40

were increased. As the pH increased, the amount of positive charge declines and essentially no negative charge in the gluten protein is generated[13]. The lack of charge at higher pH causes the protein to hydrate more slowly and therefore to require a longer mixing time[12].

Extensograph characteristics

The effects of protein content on extensograph were examined with 1.7% salt only. The extensibility and resistance were increased as the protein content increased, and both parameters were higher in HRW-WW flours than DNS-WW flours at the same protein content (date not shown).

The ratio of resistance to extensibility increased with the increase of protein content (Fig. 4). However, the degress of increase of R/E ratios for HRW-WW and DNS-WW blends were different.

Salt has a definite effect on extensogram. As the salt concentration increases, the extensibility and resistance also increase[9,14] and the difference between the 45 min curve and 180 min curve is less noticeable[9].

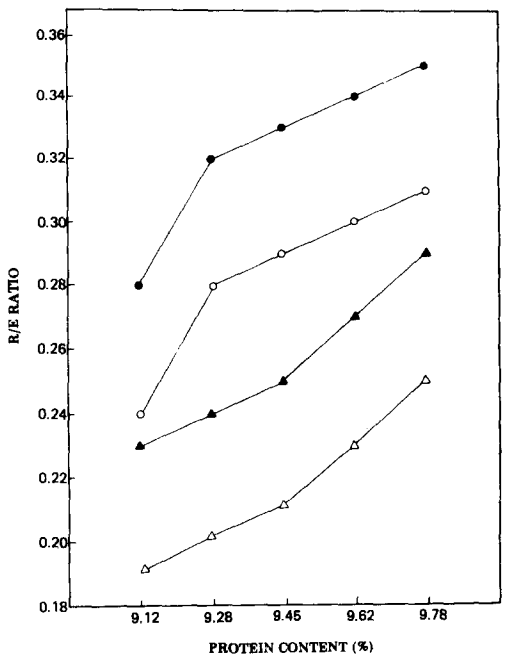

Fig. 4. Effects of protein contents of HRW-WW (○) and DNS-WW (△) blends on R/E ration of extensograph

○—○ and △—△, 45 min ; ●—● and ▲—▲, 135 min

Amylograph characteristics

The initial pasting temperature for HRW-WW and DNS-WW blends was 64.5℃. Salt and alkaline reagent showed no effect on pasting temperature.

The peak viscosity in the presence of salt or alkaline reagent decreased as the protein content increased. However, the protein content itself had minor effect on the peak viscosity (Fig. 5). Salt and alkaline reagent increased the peak viscosity of the flour at the same protein content by 100 and 450 B.U., respectively (Fig. 5). It is interesting to note that the effect of salt and alkaline reagent on increasing the peak viscosity is additive as can be seen in Fig. 5.

The viscosity after 15 min at 95℃ in the presence of salt and alkaline reagent (Fig. 6) showed a similar trend to that of the peak viscosity.

Dick *et al.*[9] reported that, when salt or sodium and possium carbonate was added between 0.5 and 3.0% to the flour, the pasting temperature increased as the concentration was increased to 1% but decreased with 2% and the peak height showed a steady increase with the increase of concentration.

The information is limited with regard to effect of salt on amylograms of flour while reports on the effect on the starch abound[15-18]. The pasting temperature of wheat starch increases in the presence of sodium chloride up to the 4% level[15]. In case of potato starch, Takahashi *et al.*[18] reported that the gelatinization temperature was decreased by the addition of salt. The peak height increases as the concentration of sodium chloride increases[9,15-17], but no peak is observed at

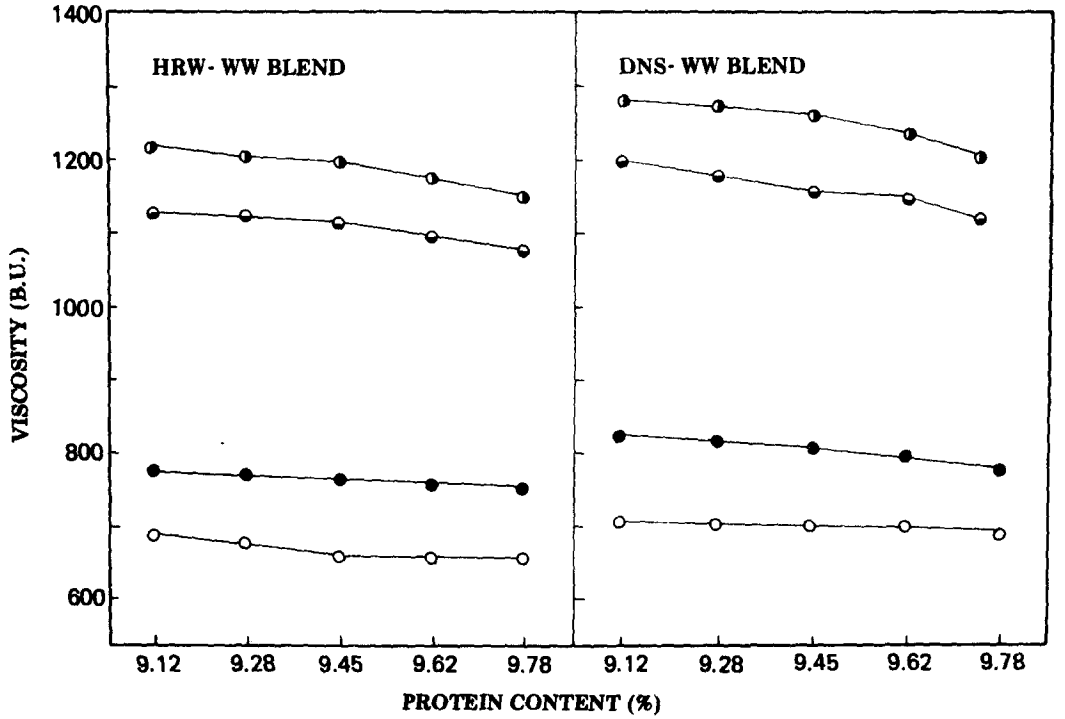

Fig. 5. Effects of protein contents of flours on peak viscosity of amylograph
○—○, control ; ●—●, salt ; ◒—◒, alkaline ; ◑—◑, salt+alkaline

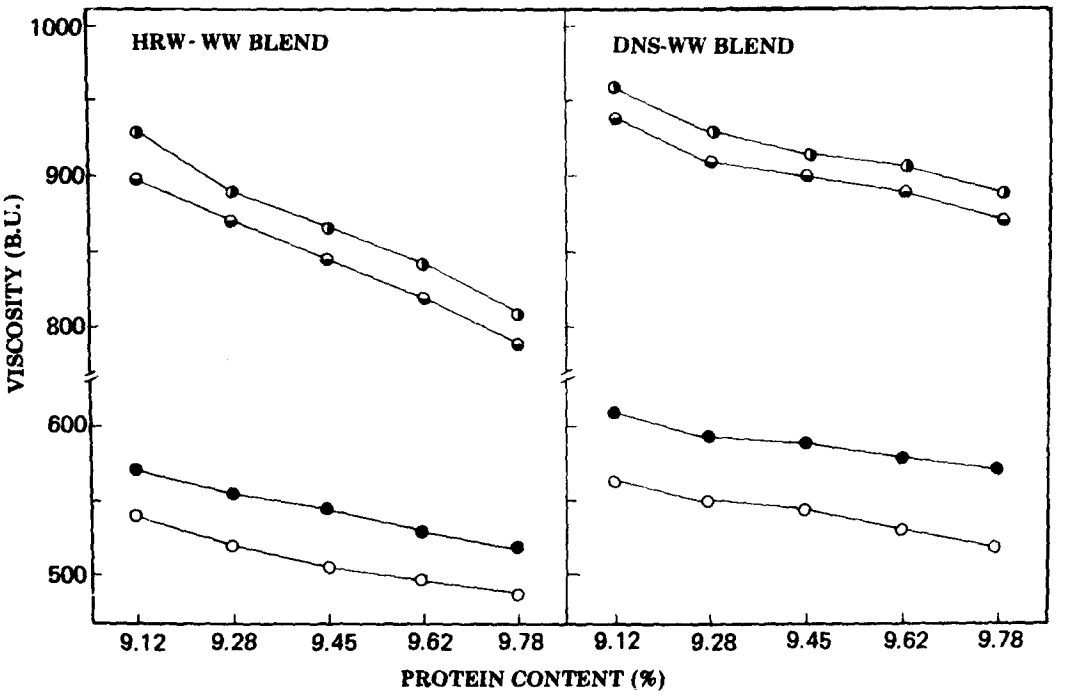

Fig. 6. Effects of protein contents of flours on viscosity after 15 min at 95°C of amylograph
○—○, control ; ●—●, salt ; ◒—◒, alkaline ; ◑—◑, salt+alkaline

Table 5. Breakdown (B.U.) of amylograph

	Protein content of flour (%)									
	HRW-WW blend					DNS-WW blend				
	9.12	9.28	9.45	9.62	9.78	9.12	9.28	9.45	9.62	9.78
Control	140	150	150	160	155	150	150	160	170	170
Salt	200	210	215	220	220	215	220	220	215	215
Alkaline	225	245	270	275	280	255	280	260	260	260
Salt+Alkaline	295	330	335	335	340	320	345	340	330	340

Table 6. Correlation coefficients between flour protein contents and rheological parameters

		HRW-WW	DNS-WW
Farinogrph			
Absorption	Control	+0.9968***	+0.9971***
	Salt(S)	+0.9944***	+0.9955***
	Alkaline(A)	+0.9963***	+0.9969***
	S+A	+0.9969***	+0.9970***
Peak time	Control	+0.9021*	+0.9715**
	S	+0.9037*	+0.8785*
	A	+0.8890*	+0.8890*
	S+A	+0.9642**	+0.9448*
Stability	Control	+0.9841**	+0.9971***
	S	+0.9791**	+0.9463*
	A	+0.9292*	+0.9976***
	S+A	+0.9888**	+0.9894**
Time to breakdown	Control	+0.9847**	+0.9936***
	S	+0.9899**	+0.9990***
	A	+0.9974***	+0.9999***
	S+A	+0.9954***	+0.9952***
Extensograph			
Extensibility	45 min	+0.9807**	+0.9907**
	135 min	+0.9817**	+0.9571*
Resistance	45 min	+0.9544*	+0.9221*
	135 min	+0.9675**	+0.9675**
R/E	45 min	+0.9341*	+0.9876**
	135 min	+0.9341*	+0.9847**
Amylograph			
Peak viscosity	Control	−0.7292	−0.8745
	S	−0.9889**	+0.9905**
	A	−0.9674**	+0.9916***
	S+A	−0.9857**	+0.9625**
Viscosity after 15 min at 95℃	Control	−0.9758**	−0.9964***
	S	−0.9983***	+0.9822**
	A	−0.9983***	+0.9783**
	S+A	−0.9941***	+0.9735**

***significant at p=0.001, **significant at p=0.01 and *significant at p=0.05

4% salt[17]. The peak temperature also increases as the concentration of salt increases, which indicates that the sodium chloride may cause the starch granule to remain intact for a longer period of time before fragmentation takes place[17].

The breakdown of HRW-WW and DNS-WW blends was similar (Table 5). Salt and alkaline reagent increased the breakdown, of which the effect was more pronounced in alkaline reagent than the salt.

Correlations between protein content and rheological properties of flours

Protein contents of flours in the presence or absence of salt and alkaline reagent had significant positive correlations with farinograph and extensograph parameters and significant negative correlations with amylograph indices, except peak viscosity of the control (Table 6).

요 약

단백질 함량이 9.12~9.78%인 HRW-WW와 DNS-WW 밀가루의 리올로지 성질을 조사하였다. 단백질 함량이 0.33% 증가함에 따라 파리노그라프 흡수율은 HRW-WW는 1.0%, DNS-WW는 0.6% 증가하였다. 소금(1.7%)은 단백질 함량에 관계없이 흡수율을 1% 감소시켰으나, 알칼리제(0.17%)는 흡수율에 영향을 주지 않았다. 밀가루의 반죽시간 및 안정도는 단백질의 증가에 따라 또한 소금과 알칼리제의 첨가에 따라 증가하였다. 반죽의 신장도와 저항도도 단백질의 증가에 따라 증가하였으며, 일정한 단백질 함량에서 이들 지표는 HRW-WW가 높았다. 단백질 함량은 아밀로그라프의 최고점도에는 영향을 주지 않았다. 소금 또는 알칼리제의 존재에 관계없이 단백질 함량은 피라노그라프와 익스텐소그라프의 모든 지표와 정의 상관을 보였으나, 아밀로그라프의 최고점도는 소금 또는 알칼리제의 존재시 단백질 함량과 부의 상관을 보였다.

Acknowledgement

Financial support from U.S. Wheat Associates in Seoul for this study is greatly acknowledged. The authors want to express their deep appreciation to Mr. K.H. Park of Daesun Flour Milling Co., Seoul, for the milling of wheat and cooperation of farinograph and extensograph measurements.

References

1. Moss, H.J. : Wheat flour quality requirement for noodle production in Southeast Asia. Bread Research Institute of Australia (1984)
2. Moss, R., Gore, R.J. and Murray, I.C. : The influence of ingredients and processing variables on the quality and microstructure of Hokkien, Cantonese and instant noodle. *Food Microstruct.*, **6**, 63(1987)
3. American Association of Cereal Chemists : *Approved Method of the AACC.* The Association, St. Paul, MN (1983)
4. Medcalf, D.G. and Gilles, K.A. : Effect of a lyotropic ion series on the pasting characteristics of wheat and corn starches. *Staerke*, **18**, 101(1966)
5. Salovaara, H. : Effect of patial sodium chloride replacement by other salts on wheat dough rheology and breadmaking. *Cereal Chem.*, **59**, 422(1982)
6. Hlynka, I. : Influence of temperature, speed of mixing, and salt on some rheological properties of dough in the farinograph. *Cereal Chem.*, **39**, 286(1961)
7. Tanaka, K., Furukwa, K. and Matsumoto, H. : The effect of acid and salt on the farinogram and extensogram of dough. *Cereal Chem.*, **44**, 675(1967)
8. Galal, A.M., Varriano-Marston, E. and Jhonson, J.A. : Rheological dough properties as affected by organic acids and salt. *Cereal Chem.*, **55**, 683(1978)
9. Dick, J.W., Shelke, K., Holm, Y. and Loo, K.S. : The effect of wheat flour quality, formulation and processing on Chinese wet noodle quality. Department of Cereal Science and Food Technology, North Dakota State University, Fargo, ND, U.S.A. (1986)
10. Harinder, K. and Bains, G.S. : High α-amylase flours : effect of pH, acid, and salt on the rheological properties of dough. *Cereal Chem.*, **67**, 588(1990)
11. Moss, H.J., Miskelly, D.M. and Moss, R. : The effect of alkaline conditions on the properties of wheat flour dough and Cantonese-style noodles. *J. Cereal Sci.*, **4**, 261(1986)
12. Hoseney, R.C. and Brown, R.A. : Mixograph studies. V. Effect of pH. *Cereal Chem.*, **60**, 124(1983)
13. Kasarda, D.D., Bernardin, G.B. and Nimmo, C.C. : Wheat proteins. In *Advances in Cereal Science and Technology*, Pomeranz, Y. (ed.), Vol.I, p.158. AACC, St. Paul, MN, U.S.A. (1976)
14. Fisher, M.H., Aitken, T.R. and Anderson, G.A. : Effect of mixing, salt and consistency on extensograms. *Cereal Chem.*, **26**, 81(1949)
15. Ganz, A.J. : Effect of sodium chloride on the pasting of wheat starch granules. *Cereal Chem.*, **42**, 429(1965)
16. Medcalf, D.G. and Gilles, K.A. : Wheat starches. I. Comparison of physicochemical properties. *Cereal Chem.*, **42**, 558(1965)
17. D'Appolonia, B.L : Effect of bread ingredients on starch gelatinization properties as measured by the amylograph. *Cereal Chem.*, **49**, 532(1972)
18. Thakahashi, K., Shirai, K., Wada, K. and Kawamura, A. : Effect of salts and sugars on the gelatinization temperature of starch. *J. Jap. Soc. Starch Sci.*, **27**, 22 (1980)

(Received January 26, 1991)