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Studies on the Rheological Properties of Korean Noodles

III. Correlation between Mechanical Model Parameters and Sensory Quality of Noodles

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한국 재래식 국수류의 유체변형성에 관한연구

제 3 보 : 기계적 모델파라메터와 관능적 품질평가와의 상관관계

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Abstract

The changes in the mechanical model parameters during cooking and subsequent storage, were related to the sensory quality of the noodles. The sensory hardness and chewiness were tested by Milestone method and the overall preference was evaluated by hedonic scale test.

Hardness was affected primarily by increasing cooking time and in lesser degree by storage time after cooking. Chewiness was diminished by increasing cooking time and subsequent storage. The preference of wheat flour noodle was not significantly affected by cooking time, while that of wheat-sweet potato starch noodle decreased significantly by excess cooking time.

Instantaneous elasticity represented the softness of noodle. The elastic components and viscosity components had significant relationship with the sensory quality of wheat noodle.

On the other hand the retardation time was important for the sensory quality of wheat-sweet potato starch noodle.

Introduction

In the previous papers[1,2] the mechanical model parameters of wheat flour noodle and wheat-sweet potato starch noodle were determined.

Some of the parameters, for instance, instantaneous elasticity, retarded elasticity, retarded viscosity, retardation time and Newtonian viscosity showed certain tendency of change during cooking and subsequent storage, depending on the type of noodle. Although the mechanical model parameters are well defined physically, their effect on the ultimate sensory quality, particulary textural parameters of noodles, are not understood. The textural manifestation of mechanical characteristics are very complicate. In addition, sensory textural parameters of noodles are not defined satisfactorily yet.

Lee and Park[3] surveyed the texture describing terminology for Korean noodles and concluded that hard-

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ness, chewiness, springiness, adhesiveness were the important textural parameters.

The present study tested the relationship between sensory quality and the mechanical model parameters, which were determined by creep test in the previous paper[2], of traditional Korean noodles.

Materials and Methods

Test samples

The Korean wheat flour noodle and wheat-sweet potato starch noodle were cooked and stored as described in the previous paper.[2]

Mechanical model parameters

The data of the mechanical model parameters of cooked and stored noodles reported in the previous paper were used.[2]

Sensory evaluation

The sensory panel were consisted of 12 members selected from the graduate students of the Department of Food Technology of Korea University. Panels were trained for the sensory techniques to be used. The panel leader made certain that they understood the methods, scales, score sheets and terminology to be used in the test.

Samples were coded by three-digit random number, and were served randomly in order to avoid "position" and "contrast" effects described by Peryam and Pilgrim.[4] The randomized samples were presented simultaneously to the judges who were instructed to taste from left to right. Samples were all served at room temperature which was the similar temperature condition for the creep test.

According to the result of Lee and Park,[2] the hardness and chewiness of noodles were tested by Milestone method. The Milestone method which was firstly introduced by Lee et al.[5] to evaluated cheese texture was modified as follows by using the results of preliminary ranking test and the standard rating scale of Szczesniak et al.[6]

From a preliminary ranking test the milestone for texture of wheat flour noodle was adjusted so that score of 2 would represent hardness and chewiness of 4 *min* cooked noodle, and score of 6 for hardness of 10 *min* cooked and chewiness of 4 hrs stored noodle. Hardness of wheat-sweet patato starch noodle was adjusted for 2 *min* cooked one to have a score of 2 and one cooked for 6 *min* to be 6. Chewiness score of 2 *min* cooked wheat-sweet potato starch noodle the and one stored for 12 hrs were adjusted to be 2 and 6, respectively.

Using these milestones, each panelist was asked to set up their own scale using reference samples. At the same time, the hedonic scale test was also made with the same samples.

The test samples were provided immediately after the standards were tasted, and the panelists were asked to give the hardness and chewiness ratings for each sample according to their reference scale. In this way, the sensory stimulation was quantified in relation to the given milestones. Fig. 1 shows the master chart used for the milestone method for sensory testing. The results of Milestone and Hedonic scale methods were evaluated by variance analysis and Duncan's Multiple Range Test.[7]

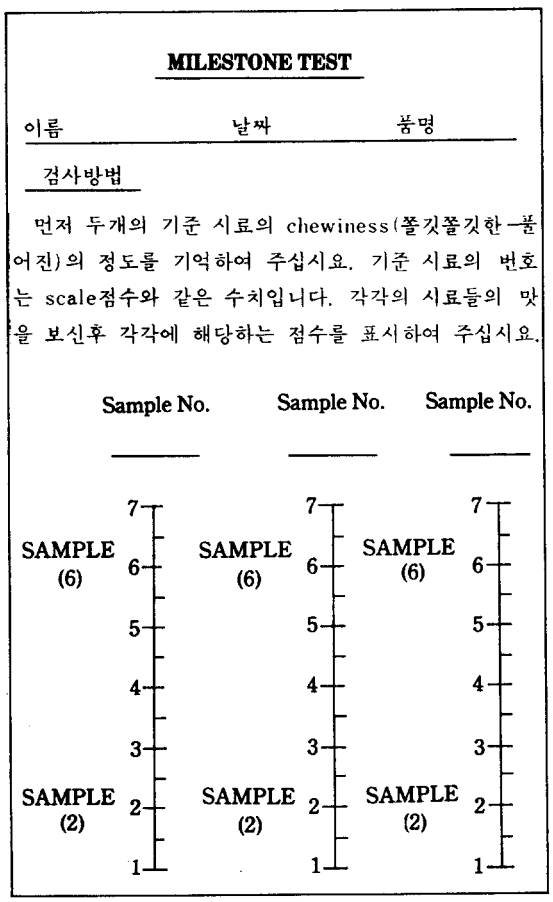

Fig. 1. An example of the master chart used for the Milestone method of sensory evaluation

Results

Sensory evaluation of cooked noodles

Table 1 and 2 show the quantitative sensory rating of 11 kinds of wheat flour noodles and wheat-sweet potato starch noodle samples, respectively. The rating scores of reference sample tested were quite similar to the reference number given.

The data showed that significant differences in hardness and chewiness between samples were existed in both wheat flour noodle and wheat-sweet patato starch noodle.

The differences between samples were tested by using Duncan's Multiple Range Test within 5% level of significance. The samples are presented in order from most soft to most firm in hardness and most tender to most tough in chewiness.

The hardness of wheat flour noodle showed the following results.

$$C_{12}\ C_{10}\ S_{24}\ S_2\ C_8\ S_{12}\ S_4\ S_6\ C_6\ C_4\ C_2$$

The broken underlines divides the groups which are significant difference. The results indicated that the hardness of wheat flour noodle became noticeably soft by cooking longer than 10 *min*. Cooking up to 6 *min* did not significantly change the hardness. Storage of cooked noodle slightly decreased the hardness, but storage time up to 24 *hrs* did not appear to change much the hardness of the product.

The result of chewiness test of wheat flour noodle was as follows.

$$S_{24}\ S_{12}\ C_{12}\ S_6\ S_6\ S_4\ C_{10}\ C_6\ C_2\ C_8\ C_4$$

The most chewy character of wheat noodle was attained by cooking for 4 *min*. Storage of cooked noodle diminished the chewiness significantly.

The result of hardness test of wheat-sweet potato starch noodle was as follows.

$$C_{10}\ C_6\ S_{12}\ S_2\ S_4\ S_6\ C_4\ S_{24}\ C_3\ C_2\ C_{1.5}$$

The hardness of wheat-sweet potato noodle decreased significantly by cooking over 6 *min*. The effect of storage after cooking was less prominent compared to wheat flour noodle.

The result of chewiness test of wheat-sweet potato starch noodle was as follows.

$$C_{10}\ S_{12}\ S_2\ C_6\ S_{24}\ S_4\ S_6\ C_4\ C_{1.5}\ C_3\ C_2$$

It showed that the chewiness was influenced mainly by cooking time. Cooking over 6 *min* and storage after cooking diminished the chewiness of wheat-sweet potato starch noodle.

The results of hedonic score method were also shown in Table 1 and 2. The samples are presented in order from dislike extremely to like extremely.

Results of hedonic scale test in wheat noodle was as follows.

$$C_2\ S_{24}\ S_4\ S_6\ S_{12}\ C_4\ S_2\ C_{12}\ C_{10}\ C_8\ C_6$$

Table 1. Means of sensory parameters for wheat flour noodle

Source of variation	Milestone		Hedonic scale[e]
	Hardness[c]	Chewiness[d]	
C[a]2	1.40	3.56	8.30
C 4	2.11	2.00	5.30
C 6	2.50	4.25	3.30
C 8	4.85	3.50	3.50
C18	5.38	4.44	4.00
C12	6.62	5.25	4.10
S[b]2	5.00	4.69	5.00
S 4	4.55	4.44	5.80
S 6	3.80	4.94	5.60
S12	4.55	5.25	5.60
S24	5.05	5.44	5.90
Significance level	p 0.005	p 0.05	p 0.005

[a]Cooking time in *minutes*

[b]Storage time in *hours* after cooking for 6 *min*.

[c]The hardness scale was adjusted so that wheat flour noodle cooked for 4 *min* would have a standard rating of 2 and the one cooked for 10 *min* a standard rating of 6 on a total scale of 1-7.

[d]The chewiness scale was adjusted so that wheat flour noodle cooked for 4 *min* would have a standard rating of 2 and the one stored for 4 *hrs* a standard rating of 5 on a total scale of 1-7.

[e]Points checked on scale scored with 1 = Like extremely and 9 = Dislike Extremely.

Table 2. Means of sensory parmeters for wheat-sweet potato starch noodle

Source of variation	Milestone		Hedonic scale[e]
	Hardness[c]	Chewiness[d]	
C[a]1.5	1.38	2.42	3.33
C 2	2.00	2.08	3.56
C 3	3.31	2.25	3.00
C 4	4.06	2.83	4.44
C 6	6.44	4.58	7.11
C10	6.81	6.17	8.44
S[b]2	4.38	4.67	4.33
S 4	4.31	4.42	4.67
S 6	4.19	4.42	5.22
S12	4.44	5.25	5.33
S24	3.63	4.42	6.89
Significance level	p 0.005	p 0.05	p 0.005

[a]Cooking time in *minutes*.

[b]Storage time in *hours* after cooking for 3 *min*.

[c]The hardness scale was adjusted so that wheat and sweet potato starch noodle cooked for 2 ***min*** would have a standard rating of 2 and the one cooked for 6 ***min*** a standard rating or 6 on a total scale of 1-7.

[d]The chewiness scale was adjusted so that wheat sweet potato starch noodle cooked for 2 ***min*** would have a standard rating of 2 and the one stored 12 ***hrs*** a standard rating of 6 on a total scale of 1-7.

[e]Points checked on scale scored with 1=Like Extremely and 9=Dislike Extremely.

C_2 was significantly disliked than other samples, which was presumably due to incomplete cooking. Wheat noodle cooked for 6 ***min*** was most liked by panel and cooking up to 12 ***min*** did not affect the preference, while storage after cooking reduce the preference significantly.

The result of hedonic scale test for wheat-sweet potato starch noodle was as follows.

$$C_{10}\ C_6\ S_{24}\ S_{12}\ S_4\ C_4\ S_2\ S_6\ C_2\ C_{1.5}\ C_3$$

Over cooking and long term storage after cooking were detrimental to the taste quality. A significant less preference was found in compaired to C_{10}, C_6 and S_{24}, S_{12}, S_4, C_4, S_2, S_6, C_2, $C_{1.5}$ and C_3, while S_{12} was less preferable than C_2, $C_{1.5}$, C_3 but not significantly different from S_4, C_4, S_2 and S_6.

Correlation between mechanical model parameters evaluation data

Correlation between sensory data and the mechanical model parameters reported in the previous paper[1] were computed. The correlation coefficients between sensory mean value and mechanical model parameters of wheat noodle and wheat-sweet potato starch noodle are shown in Table 3 and 4, respectively.

For wheat noodle, sensory hardness were well correlated with instantaneous elasticity, E_0, retarded viscosity η_{r_1}, which meant that the higher instantaneous elasticity and higher retarded viscosity were representing lower degree of hardness. Hedonic score were highly correlated with instantaneous elasticity, E_0, retarded elasticity Er_1, $E_0+Er_1+Er_2$ and η_n (Newtonian Viscosity) + $\eta_{r1}+\eta_{r2}$. It indicates that the less in-

Table 3. correlation coefficient between sensory parameters and mechanical model parameters of wheat noodle

Mechanical parameters(X)	Sensory parameter(Y)		
	Milestone		Hedonic scale
	Hardness	Chewiness	
Instantaneous elasticity, E_0	0.653*	0.303	0.798*
Retarded elasticitity, Er			
Er_1	0.264	-0.275	-0.658*
Er_2	0.165	-0.170	-0.318
Er_1+Er_2	0.232	-0.241	-0.524*
Retarded viscosity, η_r			
η_{r1}	0.604*	0.174	-0.529
η_{r2}	-0.069	-0.144	0.186
$\eta_{r1}+\eta_{r2}$	0.591	0.164	-0.511
Retaralion time τ_r			
τ_1	0.588	0.433	-0.105
τ_2	-0.182	-0.118	0.472
$\tau_1+\tau_2$	0.540	0.409	-0.044
Newtonian viscosity, η_N	-0.202	-0.443	-0.354
$E_H+Er_1+Er_2$	0.422	-0.058	-0.691*
$\eta_N+\eta_n+\eta_{r2}$	0.150	-0.330	-0.651*

* : P 0.05

Table 4. Correlation coefficient of wheat-sweet potato starch noodle between sensory parameters and mechanical model parameters

Mechanical parameters(X)	Sensory parameter(Y) Mlestone Hardness	Chewiness	Hedonic scale
Instantaneous elasticity, E_0	0.086*	0.466	0.505*
Retarded elasticitity, Er			
Er_1	0.176	-0.308	-0.007*
Er_2	0.754	0.394	0.519
$Er_1 + Er_2$	0.548*	0.037	0.297
Retarded viscosity, η_r			
η_{r1}	0.254	-0.210	-0.022
η_{r2}	0.656*	0.409	0.482
$\eta_{r1} + \eta_{r2}$	0.374	-0.127	0.071
Retaralion time, τ_r			
τ_1	0.685*	0.514	0.422
τ_2	0.688*	0.369	0.692*
$\tau_1 + \tau_2$	0.882*	0.577	0.572*
Newtonian viscosity, η_N	0.018	-0.382	-0.159
$E_0 + Er_1 + Er_2$	0.579*	0.068	0.319
$\eta_N + \eta_{r1} + \eta_{r2}$	0.090	-0.342	-0.118

* : $P<0.05$

Table 5. Relationship between sensory preference and mechanical model parameters

Type of noodle	Sensory preferance (Y)	P
Wheat noodle	$Y = 5.34 + 0.63X_1 - 0.01X_2$	0.004
Wheat-sweet potato starch noodle	$Y = 8.64 + 1.04X_1 - 0.05X_2$	0.14

X_1: Instantaneous elastic modulus (E_0): $\times 10^6$ $dynCm^{-2}$
X_2: Retardation time (τ_r): *sec*

stantaneous elasticity and the larger elastic components and viscosity conponents represents the greater acceptance. The relationship between chewiness and mechanical parameters was not approved.

For wheat-sweet potato starch noodle, sensory hardness was highly correlated with E_0, Er_2, η_{r2}, and the retardation times $\tau_1 + \tau_2$, which indicated that the higher instantaneous elasticity and longer retardation time represented low value of hardness. Chewiness were not significantly related to the mechanical parameters. Hedonic scores were related to the retardation time in creep test. Summarizing these results, the regression equations relating the mechanical parameters to the hedonic sensory quality were made as shown in Table 5. The instantaneous elasticity and retardation time were considered very important parameters representing the sensory quality of Korean noodle.

요 약

밀국수와 냉면국수의 삶음 시간과 삶은후 저장시간에 따른 조직감의 변화를 관능검사에 의하여 평가하고 국수의 굳기(hardness), 씹힘성(chewiness) 및 기호도와 creep test에서 얻은 기계적 모델 상수와의 상관관계를 시험하였다.

국수의 굳기는 삶음 시간에 민감하게 영향을 받았으며 삶은후 저장시간이 경과함에 따라 다소 연화되는 경향을 나타내었다. 씹힘성은 삶음 시간과 저장시간에 거의 같은 정도로 감소됨을 나타내었다. 국수의 기호도는 밀국수의 경우 삶음시간에 크게 영향받지 않았으나 냉면국수는 삶음 시간이 경과함에 따라 기호도가 크게감소하였다.

Creep test에서 측정되는 순간탄성이 크면 클수록 국수는 굳기가 감소되는 관계를 나타내었다. 밀국수의 조직감 및 기호도는 Creep test의 탄성요소 및 점성요소와 유의적인 상관관계를 나타내었으며 냉면국수는 지연시간과 유의적 상관관계가 있음을 관찰하였다.

References

1.Lee, C.H. and Kim, C.W.: *Korean J. Food Sci., Tech.*, **15**, 182 (1983)
2.Lee, C.H. and Kim, C.W.: *Korean J. Food Sci., Tech.*, **15**, 295 (1983)
3.Lee, C.H. and Park, S.H.: *Korean J. Food Sci., Tech.*, **14**, 21 (1982)
4.Peryam, D.R. and Pilgrim, F.G.: *Food Tech.*, **11**, 9 (1957)
5.Lee, C.H. Imoto, E.M. and Rha, C.K.: *J. Food Sci.*, **43**, 1600 (1978)
6.Szczesniak, A.S., Brandt, M.A. and Friedman, H.H.: *J. Food Sci.*, **28**, 397 (1963)
7.Larmond, E.: *Methods for Sensory Evaluation of Foods*, Canada Department of Agriculture, Publication. No.1284 (1970)