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Development of Shear Extrusion Test for the Texture Evaluation of Cooked Noddle

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삶은 국수의 조직감 평가를 위한 층밀림 압출 실험

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Abstract

An objective method for the evaluation of eating quality of cooked noodle was established by using a specially designed shear extrusion cell of Rheometer. From the force-distance curve, the maximum force, initial force, extrusion work, and the slope were determined. In a test with Korean dried noodles made from 17 types of Australian wheat flour, the maximum and initial forces and extrusion work could represent the firm-soft and chewy character, which govern mostly the preference of cooked noodle. On the other hand, the slope could distinguish the textural changes of cooked noodle during the storage after cooking. The parameters showed significant correlation with the protein content, water absorption, development time and extensibility of flour, but no correlation was obtained with the maximum viscosity of viscogram. For the estimation of textural preference, the correlation coefficient obtained from a multiple regression analysis using the maximum viscosity of viscogram and the maximum force of shear extrusion test as the two independent variables was not significantly higher than the coefficient obtained from a simple regression with the maximum force only.

Introduction

The quality of noodle is mainly judged by two distinct aspects; color and eating quality.[1,2] Lee *et al.*[2] estimated that color and textural property contributed 30% and 70%, respectively, to the overall acceptance of cooked Korean dried noodle. The textural properties of noodles important to Korean people were described as chewiness, softness and smoothness.[3] The texture of Japanese noodle has been described by the terms of softness, tenderness and elasticity.[4] Nagao *et al.*[4] concluded that it may not be possible to replace the eating test for cooked noodle by machine method. In fact, the eating quality of cooked noodle is very sophisticated and poorly defined.

Many attempts have been made to evaluate the cooked noodle texture by objective method by using GF Texturometer[5,6] and texturecorder[7]. Lee and Kim[8,9] studied the textural properties of cooked noodle from the data obtained by creep test. The mechanical parameters obtained from the creep test could distinguish the different types of noodle, but could note be satisfactorily correlated to the sensory texture attributes of cooked noodle.[10,11]

The difficulties in the instrumental measurement of Korean dried noodle texture rise from the small dimension and weak structure of cooked noodle strands, which are different from Spaghetti or Japanese Udon. It is hard to obtain reliable and replicable data from the compression test, because the noodle strand is too thin to apply any significant deformation. It is difficult to apply cooked noodle sample to the specimen holder of creep or tensile tester, because of the weak structure and slippery nature of cooked noodle.[8,9,11] The authors have developed a shear extrusion test method for the eating equality of cooked noodle in the course of evaluating the Australian wheat flour quality for Korean dried noodle production.[12] In this paper, the force-distance curve of shear extrusion test was analyzed. The relationships between shear extrusion parameters and sensory textural attributes of cooked noodle were tested. The relationships between shear extrusion parameters and the physicochemical properties of flour were also evaluated.

Materials and Methods

Test Samples

A total of 17 kinds of flour from 7 different varieties of Australian wheat were used to make noodle samples. The extraction rate of all the flour samples was 70-75%. The wheat variety, the protein level of sample flours and the process for the preparation of Korean dried noodle are described in elsewhere.[2,13]

Chemical and Physical Analysis for Flours

A specially designed shear extrusion test cell was made in the laboratory for Rheometer (I&T Co. LTD., Japan, Type R-UDT-DM), as shown in Figure 1. The test cell consists of a steel cylinder of 26.8 mm of inner diameter with a bottom plate having 69 holes of 2.5 mm diameter opening each. Two grams of dried noodle were cooked in boiling water, cooled in cold water and drained, and then put in the test cell. A compression test probe was applied down to the predetermined clearance. The shear extrusion test were made within 10 min after draining. In order to test the effect of storage after cooking, the drained noodle were wrapped in aluminium foil and kept for one hour at room temperature before measurement. The conditions for shear extrusion test are shown in Table 1.

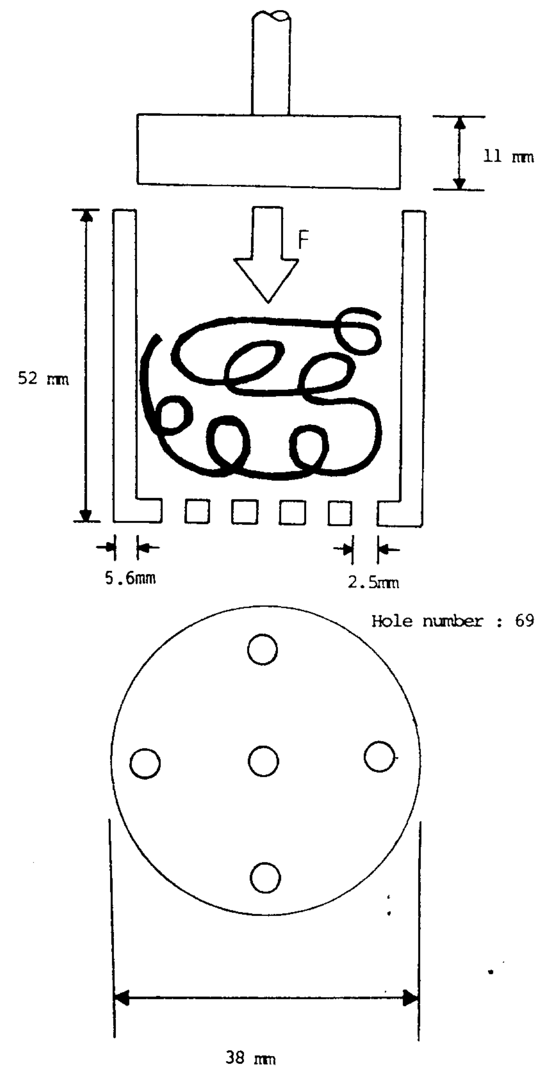

Fig. 1. Design of shear extrusion test unit

Sensory Evaluation for the Quality of Cooked Noodle

The sensory panel consisted of six graduate students of the Department of Food Technology of Korea University. Panel was trained with a representative commercial brand of dried noodle so that they could remember the quality characteristics of this commercial sample as reference. The sensory parameters, chewy, soft and smooth, which were recognized as the important textural characteristics of Korean noodles,[3] were evaluated by using 1-10 scale in which the scores for the commercial product were refered to 5. The textural preference was also asked in 1-100 scale in which the score for the commercial product was refered to 50.

The effect of storage time after cooking was tested by examining within 10 minutes and after 60 minutes of cooked noodle. The method of sample preparation was identical with that used for shear extrusion test of cooked noodle. These tests were made twice with the members of panel.

Table 1. Conditions of shear extrusion test

Probe type	diameter 25.5 mm flat circle
Adapter type	I.D. 26.8mm × length 52 mm cylinder with 69 holes
Force scale	8 Kg
Table speed	0.44mm/sec
Compression depth	8.4mm
Clearance	2.4mm
Chart speed	2mm/sec
Table movement	up and down
Table type	flat plate
Measuring room temperature	15°C

All the results were analyzed by using statistical methods. Both simple and multiple regression analysis were made with the assistance of computer SAS program.

Results and Discussion

Analysis of a Typical Force-distance Curve of Shear Extrusion Test

Figure 2 shows a shear extrusion curve obtained by Rheometer and its analysis. In a typical force-distance curve the force rises slowly at first when the probe first contacts the cooked noodles. A typical force-distance curve of shear extrustion test is explained as follows:

The first stage (I) of the curve represents that the probe doesn't contact the cooked noodle yet. The second stage (II) of the curve represents the packing of cooked noodle down tightly into the shear extrusion cell. In the third stage (III) of the curve, the steep rising occurs when the product is just about to be extruded down through the holes. Point A is taken as the initial force at which shear extrusion begins. In the fourth stage (IV) the curve breaks into many small peaks when shear extrusion begins and these peaks occur as long as shear extrusion continues. Shear extrusion process continued until the test was terminated at point B, the maximum force. The plateau region made with peaks, from A to B, shows the force needed to continue the extrusion process.

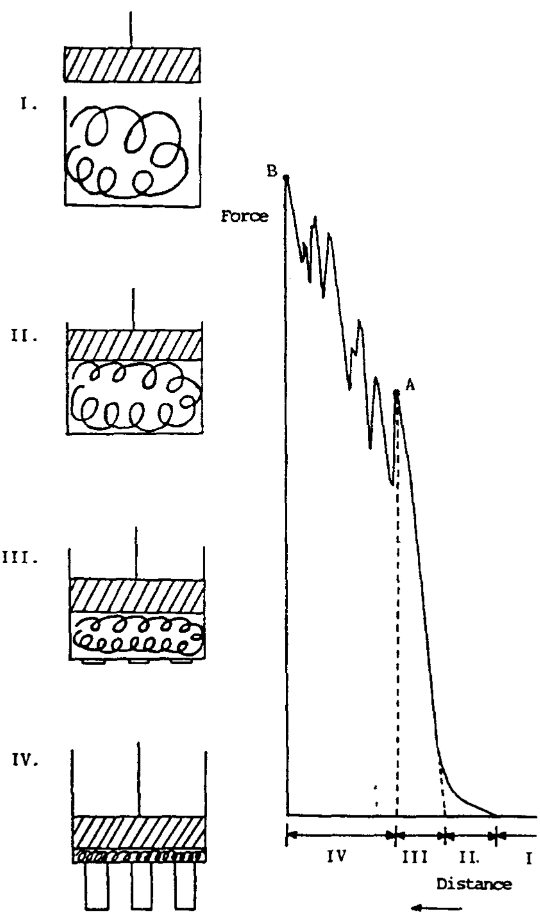

Fig. 2. Analysis for shear extrusion curve obtained by Rheometer

The Parameters Estimated from a Shear Extrusion Test

The parameters obtained from a typical force-distance curve of shear extrusion test are given in Figure 3. They were initial force, maximum force, slope and extrusion work. Initial force (A) was taken as the first peak, maximum force (B) as the last highest peak and slope as the steepness of initial and maximum peak points. Exrusion work was also taken as total area under the curve except for the work used for packing noodles because it could introduce an error in measuring the total work done. The area under the curve was measured by a Polar Planimeter. A distinct changes in the slope between initial and maximum force were noticed by the storage of cooked noodle.

The freshly cooked noodle shoed steep slope, while the noodle stored for 60 minutes after cooking had very low level of slope between initial and maximum forces. The slopes of these curves, in which stress relaxation factors were partly involved, appeared to indicate the elastic characteristics of fresh cooked noodle.

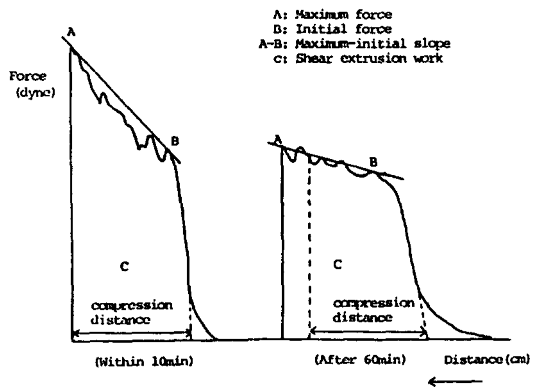

Fig. 3. Shear extrusion curves of cooked noodle measured by Rheometer within 10 min and 60 min after cooking

Correlations

The results of sensory evaluation indicated that the relationship between protein content and textural parameters varied with the variety of wheat. With regard to storage for 60 minutes after cooking the chewiness and smoothness decreased and softness slightly increased, resulting in the reduction of textural preference.

Table 2 shows correlations between extrusion parameters and physicochemical properties. Shear extrusion parameters, except for the slope had a high positive correlation with both Farinogram water absorption, dough development time and Extensogram extensibility. Noodles of 10 minutes after cooking showed higher correlation than noodles stored for 60 minutes after cooking. The protein content was more highly correlated with extrusion parameters except for the slope but Amylogram maximum viscosity which may explain starch quality did not show significant correlation.

Table 3 shows correlations between shear extrusion parameters and sensory parameters. On the while, more significant correlations were observed by the noodles stored for 60 min after cooking than by those with 10 min noodle.

The maximum and initial forces and extrusion work appear to represent the firm-soft and chewy characteristics, which affect mostly the preference note of cooked noodle On the other hand, the slope indicates the textural changes during storage after cooking, which probably cause the loss of elasticity of cooked noodle.

It can be concluded that shear extrusion test evaluatess the noodle quality which is predominantly related with protein content, and it can be used in conjunction with Farinograph and Extensograph measurements. Since the strach property of flour has been considered as important for noodle quality,[1,15] the noodle quality which is exerted by the starch property may be additionally determined by other method such as Viscogram test.

Multiple Regression Analysis for Texture Preference

A multiple regression analysis was made to evaluate the texture prefernece of noodle from the maximum force of shear extrusion test and maximum viscosity of

Table 2. Correlation coefficients between shear extrusion parameters and physico-chemical properties (within 10min and 60 min after cooking)

	Within 10 min				After 60 min			
	Maximum force	Initial force	Extrusion work	Slope	Maximum force	Initial force	Extrusion work	Slope
Protein content	0.739**	0.560*	0.819**	n.s.	0.786**	0.747**	0.627**	n.s.
Water absorption	0.696**	0.685**	0.842**	n.s.	0.582*	0.630*	n.s.	n.s.
Development time	0.672**	0.501*	0.754**	n.s.	0.637**	0.567*	n.s.	n.s.
Extensibility	0.831**	0.631**	0.871**	n.s.	0.726**	0.683**	0.590*	n.s.
Resistance	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Maximum viscosity	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

** : $p<0.01$ * : $p<0.05$ n.s.: not significant

Table 3. Correlation coefficients between sensory textural parameters and shear extrusion parameters (within 10 min and 60min after cooking)

	Within 10 min				After 60 min			
	Chewy	Soft	Smooth	Texture preference	Chewy	Soft	Smooth	Texture preference
Maximum force	n.s.	n.s.	n.s.	-0.728**	0.770**	-0.747**	n.s.	-0.690**
Initial force	n.s.	n.s.	n.s.	-0.685**	0.644*	-0.689**	n.s.	-0.783**
Extrusion work	n.s.	-0.609*	n.s.	-0.686**	0.551*	n.s.	n.s.	- 0.520*
Slope	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

** : $p<0.01$ * : $p <0.05$ n.s.: not significant

Table 4. Multiple regression equation for texture preference

Within 10 min		After 60 min	
$Y = 102.905 + 1.817\times10^{-3}X_1 - 7.064\times10^{-3}X_2$		$Y = 94.180 + 2.641\times10^{-3}X_1 - 1.036\times10^{-3}X_2$	
$p<0.01$	$R=0.736$	$p<0.05$	$R=0.704$

Where,
Y = Texture preference
X_1 = Viscogram Maximum viscosity
X_2 = Maximum force of shear extrusion parameters
P = Significance probability
R = Coefficient of multiple correlation

Viscogram.

The linear regression model was as follows:

$Y = a + bX_1 + cX_2$

where, Y = texture preference, X_1 = Viscogram maximum viscosity, and X_2 = maximum force of shear extrusion test.

The regression equations are shown in Tabel 4. The multiple correlation coefficients were 0.736 for the noodle stored for 10 minutes after cooking and 0.704 for the noodle stored for 60 minutes after cooking. It was evidenced that the combinantion of maximum force of shear extrusion test and maximum viscosity of Viscogram slightly increased the correlation coefficient. Since the increase in the significance level was negligible, the use of multiple regression in combination with maximum viscosity was not justifiable.

Therefore, it was concluded that the maximum force of shear extrusion test alone can be used for the estimation of eating quality of noodle.

Acknowledgement

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요 약

삶은 국수의 식미 평가를 위한 객관적 측정 방법으로 레오메타에 특수하게 고안한 test cell을 사용하는 층밀림 압출 시험법을 개발하였다. 층밀림 압출 시험에서 얻어지는 힘—거리 곡선을 분석하여 최초 압출력, 최고 압출력, 압출일, 경사도 등의 파라메타를 구하였다. 17종류의 호주밀로부터 만든 밀국수(건면)에 대한 실험 결과, 최초 압출력·압출일은 삶은 국수의 기호도를 가장 크게 영향하는 단단하고 무른 성질과 쫄깃쫄깃한 성질의 정도를 나타낼 수 있었다. 한편, 경사도는 삶은 국수의 저장중에 일어나는 조직감 변화를 감지할 수 있었다. 이들 파라메타들은 원료 밀가루의 단백질 함량, 수분흡수력, 발전시간(D.T.), 인장도와 높은 상관관계를 나타 내었으나 비스코그램의 최고 점도와는 상관관계를 나타내지 않았다. 비스코스램의 최고 점도와 층밀림 압출 시험의 최고 압출력을 두 독립 변수로 한 다중회귀분석 결과 관능적 조직감 기호도와의 상관계수는 최고 압출력만을 사용한 단순회귀분석 상관계수보다 크게 증가하지 않았다.

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