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# Effects of the Addition of Starch, Salt and Soda Ash on the Mechanical Property of *Naengmyon*

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# 전분, 식염 및 알카리 첨가제가 냉면의 기계적 성질에 미치는 영향

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**Abstract**

The effects of the addition of starch, salt and soda ash to the dough for *Naengmyon* (wheat-sweet potato starch) on the mechanical property of *Naengmyon* noodle were evaluated by using creep test. The strain measurement was made by taking photograph with VTR system. The creep curve of noodle strand could be fitted to the 4 element Burgers model. The instantaneous elasticity and Newtonian viscosity of the noodle strand decreased by the addition of starch. The instantaneous elasticity decreased by the addition of salt up to 4%. The mechamical parameters of the noodle varied inconsistently by the addition of soda ash.

## Introduction

In the previous papers,[1,2,3] the mechanical behaviors of Korean wheat noodle and *Naengmyon* were reported. These noodles showed linear viscoelatic behavior for short time (within 100 sec) of creep. The instantaneous elasticity and retardation time calculated from creep test were significantly related to the sensory hardness of *Naengmyon*. The high instantaneous elasticity or long retardation time represented the high level of sensory hardness. But in these studies, measurements of strain change were made by eye through a magnifier, and inherent error of measurement was unavoidable, especially for the estimation of instantaneous elasticity.

*Naengmyon* is originally made by local manufacturers or at restaurants as wet noodle. This type is made from only potato (or sweet potato) starch. But for dried *Naengmyon*, recently produced by the large scale noodle makers, sweet potato starch is added to wheat flour to make dough which is extruded, and then dried.

In the present study, the effects of starch, salt and sada ash addition on the mehanical properties of *Naengmyon* were studied by creep test. The strain change was photographed by using VTR system, and interpreted from the pictures taken.

## Materials and Methods

### Test Samples

*Naengmyon* (Korean wheat-sweet potato starch noodle) was prepared at a local *Naengmyon* manufacturer. The preparation procedure is as in Fig. 1.

The amount of sweet potato starch added to wheat flour was varied from 0 to 100%. The amounts of NaCl and soda ash ($Na_2CO_3 \cdot NaHCO_3$) added to the mixture of wheat-sweet potato starch (1:9) were varied from 0-5% and 0-3%, respectively. The flour mixture was made into dough by adding boiling water and introduced into piston type extruder, having many cylindrical holes

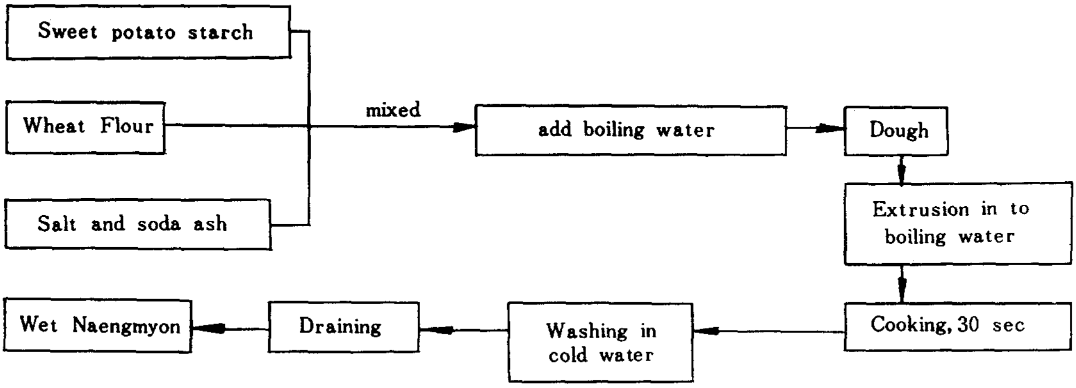


**Fig. 1. Flow diagram of traditional Korean *Naengmyon* preparation**

(2 *mm* in diameter) at the bottom.

The noodle was extruded by hydraulic pressure pump directly into boiling water kettle located in the beneath, and cooked for 30 sec. Cooked noodle was transfered into cold water and washed for cooling and drained. The noodle was subjected to creep test within 2 hrs after extrusion.

### Creep Test

The creep tester built in the laboratory consisted of sampel support and loading assembly with which a noodle strand was stretched vertically[1]. A strand of cooked noodle was clamped to have 15 *cm* length of lower part to be hung and 10 *cm* length of the lower part was used to tie around the pin, so that tension can be aplied to 5 *cm* strand in between. The measurements were made at constant stresses of 141,067 *dyne/cm²* or 98,007 *dyne/cm²*. The creep test was terminated after 60 sec, for which the linear viscoelastic behavior could be assumed[1].

Two fiducial marks were made on each side of the strand. The position of the four fiducial marks were measured as an initial length while the strand was under zero load. The changes in the strain with time was measured by photographing with VTR system. The pictures taken by VTR system were analyzed for the instantaneous deformation of cooked noodles.

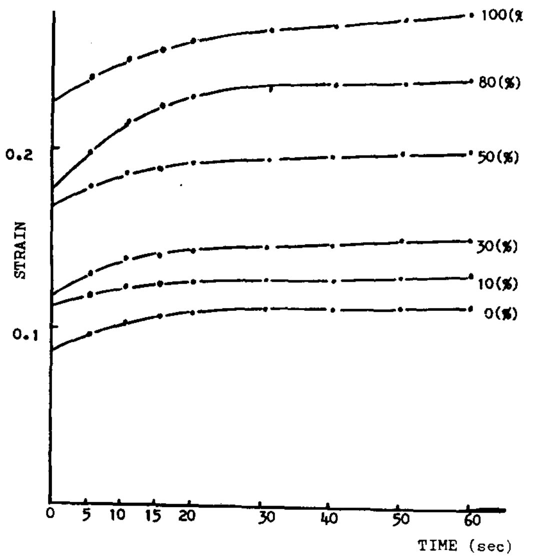


**Fig. 2. The changes in the creep curve of noodle with added potato starch concentration**

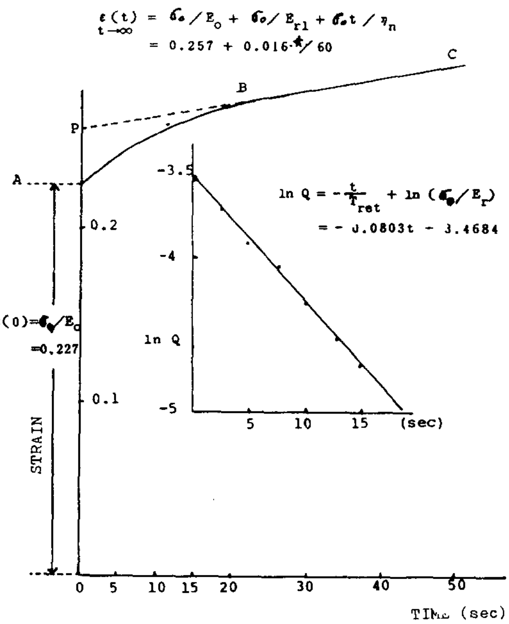


**Fig. 3. Strain-time diagramof 90% starch noodles under constant stress( 141067 *dyne/cm²*)**

**Table 1. Analysis of retarded elastic strain by Inokuchi's method for 90% starch noodle**

| t (sec) | Q | In Q |
|---|---|---|
| 0. | 0.03 | −3.51 |
| 2.5 | 0.026 | −3.61 |
| 5.0 | 0.021 | −3.86 |
| 7.5 | 0.018 | −4.02 |
| 10 | 0.014 | −4.27 |
| 12.5 | 0.0011 | −4.51 |
| 15 | 0.0085 | −4.77 |

The temperature of test cabinet was kept at 25 ± 1 °C and the relative humidity was kept at 99 ± 1% in order to minimize the dehydration of sample surface during measurement.

## Results and Discussion

Fig. 2 shows the changes in the creep curve of noodle strand by the addition of sweet potato starch. The curves showed that the strain increased rapidly during the first 20 sec, and then very slowly for the remaing 40 sec. This result was different from those obtained from the previous study[2]. In the previous study, where strain change was measured by eye, the strain increased gradually for 1-2 min. But more accurate measurement by VTR picture showed that the rapid elongation was occurred for the first 20 sec.

The creep curves could be fitted to the 4 element Burgers model[4]. The equation representing the mechanical behavior is as follows.

$$\varepsilon(t) = \sigma_o/Eo + \sigma_o/Er\,(1 - e^{-t/Tr}) + \frac{\sigma_o \cdot t}{\eta_N} \quad \text{.........} (1)$$

where $\varepsilon(t)$ is strain at time t, $\sigma_o$ constant stress, Eo instantaneous elasticity, Er retarded elasticity, Tr retardation time and $\eta_N$ Newtonian viscosity.

**Table 2. The mechanical model parameters of the noodles made from the dought with varying concentration of starch**

| Starch concn. (%) | Mechanical model parameters $E_o$ (x $10^5$ $dyne/cm^2$) | $E_{rl}$ (x$10^5$ $dyne/cm^2$) | $T_{rl}$ (sec) | $\eta_N$ (x $10^8$ poise) |
|---|---|---|---|---|
| 0 | 15.84 | 6.70 | 9.09 | 24.17 |
| 10 | 13.43 | 11.96 | 9.96 | 16.92 |
| 30 | 11.75 | 6.70 | 7.69 | 9.4 |
| 50 | 8.29 | 6.11 | 7.35 | 9.4 |
| 80 | 7.88 | 2.81 | 8.61 | 7.05 |
| 100 | 6.21 | 4.53 | 12.45 | 5.29 |

**Table 3. The mechanical model parameters of 90 % starch noodle with varying salt concentration**

| Salt concn. (%) | Mechanical model parameters $E_o$ (x$10^5$ $dyne/cm^2$) | $E_{rl}$ (x $10^5$ $dyne/cm^2$) | $T_{rl}$ (sec) | $\eta_N$ (x $10^8$ poise) |
|---|---|---|---|---|
| 0 | 8.10 | 4.67 | 8.61 | 9.80 |
| 1 | 7.15 | 7.26 | 8.20 | 3.92 |
| 2 | 5.90 | 3.29 | 7.12 | 5.88 |
| 3 | 5.30 | 5.29 | 10.86 | 5.88 |
| 4 | 3.61 | 4.26 | 10.29 | 3.46 |
| 5 | 4.62 | 5.03 | 7.67 | 3.80 |

Fig. 3 shows a typical creep curve analysed by Burgers model.

i) From OA, Eo was evaluated.

$$\varepsilon(o) = \sigma_o/Eo = 0.227 \quad \text{........................} (2)$$

$$Eo = 6.21 \times 10^5 \; dyne/cm^2$$

ii) From PBC, $\eta_N$ was calculated.

$$\varepsilon(t)_{t\to\infty} = \sigma_o/Eo = \sigma_o/Er = \sigma_o t/\eta_N \quad \text{........} (3)$$

$$= 0.257 = 0.016\,60\,.t$$

$$\sigma_o/\eta_N = 0.016/60$$

$$\eta_N = 5.20 \times 10^8 \text{ Poise}$$

iii) From AB, retardation time (Tr), retarded elasticity (Er) and retarded viscosity ($\eta_r$) were estimated by successive residual method, which is known as Inoguchi's method[5].

For this calculation$(\sigma_o/Er).e^{-t/Tr}$ term was represented as Q. Table 1 gives the Q values obtained from the plot shown in Fig. 4. This data was again plotted in the form

**Table 4. The mechanical model darameters of 90 % starch noodle with varying soda ash concentration**

| $NaCO_3 \cdot nH_2O$ concn. (%) | Mechanical model parameters $E_o$ (x $10^5$ deny/cm) | $E_{rl}$ (x $10^5$ $dyne/cm^2$) | $T_{rl}$ (sec) | $\eta_N$ (x $10^8$ poise) |
|---|---|---|---|---|
| 0. | 8.10 | 4.67 | 8.61 | 9.80 |
| 0.5 | 4.30 | 2.69 | 6.02 | 5.88 |
| 1.0 | 5.90 | 4.78 | 7.69 | 3.92 |
| 1.5 | 8.31 | 3.44 | 8.13 | 4.52 |
| 2 | 6.58 | 3.50 | 7.94 | 11.76 |
| 3 | 9.16 | 4.45 | 7.35 | 13.07 |

of ln Q versus time. It showed a straight line, which indicates four element Burgers model was applicable.

$$\ln Q = t / TR = \ln(\sigma_o/Er) \quad (4)$$

$$slope = 1/Tr = -0.0803$$

$$Intercept = \ln \sigma_o Er = -3.4684$$

So, $Tr = 12.45$ sec, $Er = 4.53 \times 10^6$ *dyne/cm²* and $\eta_r = Tr.Er. = 5.64 \times 10^7$ Poise.

Table 2 summarizes the changes in the mechanical model parameters of noodle by the addition of sweet potato starch. It shows that the instantaneous elasticity decreased by the addition of starch, which meant that the hardness of noodle decreased. The Newtonian viscosity also decreased by the addition of starch. The reduction of Eo and $\eta_N$, indicating the texture softening effect of starch, may be cause by the dilution of gluten network structure by the addition of starch.

Table 3 shows the changes in the mechanical model parameters of 90% starch noodle by the addition of NaCl. The instantaneous elasticity decreased by the addition of salt, indicating the texture softening effect. Other parameters varied inconsistently. In case of wheat flour dough, addition of salt (up to 4%) generally increases the mechanical strength[6]. However, this effect was not observed for the 90% starch noodle.

In Table 4, the addition of soda ash (up to 3%) did not alter consistently the mechanical behavior of 90% starch noodle. It is generally believed that soda ash increases chewiness of starch noodle. However, this effect was not made conclusive in this experiment.

## 요 약

냉면 국수를 제조함에 있어 전분과 밀가루의 혼합비와 식염및 알카리첨가제의 첨가량에 따른 국수발의 기계적 성질의 변화를 creep test로 측정하였다. Creep test의 초기 변형율을 정확히 측정하기 위하여 VTR시스템으로 사진을 찍어 분석하였다. 국수발의 creep 커브는 Burgers의 4-element모델로 분석될 수 있었다. 반죽에 전분의 비율의 높아질수록 삶은 국수발의 순간탄성치와 뉴우턴 점성치는 감소 하였다. 90% 전분을 포함한 반죽에 식염을 가할 경우 식염농도 4% 수준까지는 순간탄성이 감소하였다. 알카리첨가제 첨가시 국수발의 순간탄성, 지연탄성, 지연시간 및 뉴우턴 점성치들이 불규칙하게 변하였으며 그 효과를 일관성 있게 나타낼 수 없었다.

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