# Comparison of the Occlusional Condition and Preference for the Firmness of Cooked Rice between the Elderly and Young

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The occlusional condition and preference for the degree of firmness of cooked rice were compared between ten persons each of the elderly and young. The dental condition of each subject was measured for the number of remaining teeth, Eichner classification and so on. The occlusal area, occlusal force and maximal occlusal force were evaluated by using Dental Prescale. The obtained measurements were summarized for each person by a principal component analysis. The first and the second principal components were set up as axes to provide a plot for all the subjects. The occlusional condition varied widely among the elderly panel members. Numerical values for the preferred cooked rice by each subject were overlaid on the plot. The young were distributed within a small range, while the elderly were distributed in a wider range. The preferred rice was cooked with an average of 1.8 times the amount of water for the elderly and 1.5 times the amount for the young.

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# **INTRODUCTION**

The proportion of elderly people in the total population of Japan was over 14% in 1995. By 2005, this ratio is expected to be over 20%, so the quality of life of the elderly is becoming a social concern. In particular, meals are important not only for nutrient intake but also as an integral part of daily life for the elderly.

The elderly suffer from physical problems resulting from increasing age. Those who do not need nursing care have to adapt to a different sensitivity in the oral cavity from that when younger. It has been reported that the sensitivity to the graininess of food, the required degree of mastication and the mastication time for eating food<sup>11</sup> in addition to the threshold levels for salt, sweet and sour flavors<sup>21</sup> were different between the elderly and the young.

The Japanese diet incorporates cooked rice as the most frequently eaten staple food and hence, the most important. The Japanese preference for cooked rice closely involves its firmness and stickiness.<sup>3)</sup> It is considered that there is a difference in preference for the firmness of cooked rice between the elderly and the young due to their oral cavity condition.4)

Serving the most preferable kind of cooked rice to the elderly thus increases their satisfaction with the daily diet. This present study attempts to identify the difference in oral cavity conditions and the preference for the firmness of cooked rice between the elderly and the young.

The final objective is to identify the most preferable kind of cooked rice for the elderly that reflects their oral cavity condition.

# MATERIALS AND METHODS

#### **Cooked rice**

The rice used was wash-free Koshihikari harvested in Tochigi in 2001. Cooked rice differing in texture was made by varying the amount of water as 1.1, 1.4, 1.7, 2.0, 2.3, and 2.6 times (w/w) for 200 g of raw rice. The water temperature was 20°C, and the rice was cooked by using four or five electric rice cookers at the same time. The cooking time from switching on to switching off for each rice cooker was the same.

After switching off, the cooked rice was gently stirred and served to the evaluating panel members

Table 1. Eichner classification

- 1. No defect or no tooth defect.
- 2. Either upper or lower teeth are perfect.
- 3. 4 sets out of 4 occlusion sets of molar teeth are perfect.
- 3 sets out of 4 occlusion sets of molar teeth are perfect.
- 5. 2 sets out of 4 occlusion sets of molar teeth are perfect.
- 6. 1 set out of 4 occlusion sets of molar teeth remains.
- 7. No molar teeth but other occlusion sets remain.
- 8. No occlusion set remains.
- 9. Either upper or lower teeth are defective.
- 10. No teeth remain.

within one hour. Five kinds of rice cooked with 1. 4– 2. 3 times the water content for the elderly and four kinds of rice cooked with 1. 1–2. 0 times the water content for the young were served to the test panel.

# Physical properties for the cooked rice

Three cooked grains were placed in the testing cup for measurement by a texturometer (GTX-II, Zenken). The testing conditions were as follows: plunger, lucite 18; clearance, 0. 2 mm; voltage, 1 V; bite speed, six time/min.

From the curve obtained, the height of the first peak denotes the firmness, the ratio of the second peak area to the first peak area denotes the cohesiveness, and the peak area under the base line appearing after the first peak denotes the stickiness.

# Sensory panel

The elderly panel was composed of 10 female residents of Niigata Prefecture aged from 66 to 84. The young panel was composed of 10 female students of Ochanomizu University aged around 20.

#### Sensory test

The panel members were first asked to confirm their names and ages, and a dentist surveyed their oral cavity and dental condition. The dental condition was classified into 10 categories according to the Eichner classification.<sup>50</sup> Details of this classification are shown in Table 1. The panel members were then asked to chew a Dental Prescale (Fuji Film Co.) for 3 s. Dental Prescale<sup>60</sup> is a thin film containing microcapsules which rupture under pressure from the teeth, turning red according to the degree of pressure. The intensity of the red color enabled the occlusal area (red-color area in mm<sup>3</sup>), occlusal force (average pressure of red-color area in MPa), and maximal occlusal force (maximal pressure in N) to be evaluated.

The elderly panel members confirmed that they had no disphagia through swallowing water. The sensory tester then handed 5 g of cooked rice in a spoon to each panel member. The panel members assessed the firmness of the cooked rice as either too firm (not preferable), preferable, or too soft (not preferable). One of three testers handed the rice and recorded the answer, and the other two testers counted under the table the number of chews and the mastication period(s) until each panel member had swallowed the rice.

The order of presentation of the cooked rice samples was the rice cooked with 2. 6 times the amount of water, then that cooked with 2. 3 times the amount of water, followed by 2. 0 times, 1. 7 times and finally 1. 4 times the amount of water. The time taken by each panel member for the test was 20 to 30 min. The sensory test took place in an independent small room at a small local community hall for the elderly from 10:00 to 11:00 and from 14:30 to 15:30 in October and December of 2001.

For the sensory test by the young panel members, the tester provided 5 g of each cooked rice sample, and each panel member assessed the firmness. The tester counted the number of chews and the mastication period for eating without notifying the panel member. The sample order presented the rice cooked with 2.0 times the amount of water, this being followed by that with 1.7 times, 1.4 times and finally 1.1 times the amount of water. The sensory test was conducted at a tasting table in a quiet cookery practice room at the university which had a window in the north wall.

## Statistical analyses

Analyses of variance, LSD, probit and principal component were done by SPSS Ver. 10 software.

# **RESULTS AND DISCUSSION**

# Physical properties of the cooked rice

The firmness, cohesiveness and stickiness determined by the texturometer are shown in Table 2. The analyses of variance and LSD revealed that the five kinds of cooked rice were different in their firmness and cohesiveness. In respect of the stickiness, the samples could be divided into two grades, the smaller the amount of water, the firmer and less sticky the cooked rice was. Thus, each cooked rice sample for the sensory analysis was unique in its physical properties. Comparison of the Occlusional Condition and Preference for the Firmness of Cooked Rice between the Elderly and Young

		(r
 	Ratio of water to rice	

Table 2. Physical properties of the cooked rice samples

 $mean \pm S.D.)$ 

	Ratio of water to rice					
	1.1	1.4	1.7	2.0	2.3	2.6
Firmness (kgf)	3.42±0.36 a	2.70±0.17 b	$2.44 \pm 0.19 \mathrm{c}$	$2.20\!\pm\!0.15\mathrm{d}$	1.95±0.21 e	$1.70 \pm 0.21 \ f$
Cohesiveness (TU)	$0.73 \pm 0.02 \text{ a}$	$0.73 \pm 0.02 \text{ a}$	$0.70 \pm 0.04 \text{ b}$	$0.64 \pm 0.05 c$	$0.63 \pm 0.03 \ c$	$0.59 \pm 0.02 \ d$
Stickiness (TU)	$0.47 \pm 0.11$ a	$0.47 \pm 0.10$ a	$0.51 \pm 0.11$ a	$0.79 \pm 0.19 \text{ b}$	$0.88 \pm 0.14$ b	$0.92 \pm 0.14 \text{ b}$

a, b, c, d, e, f: Values with different letters in the same row are significantly different ( $p \le 0.05$ ).

		$(\text{mean}\pm S.D.)$	
	Elderly		Yong
Upper remaining teeth	$3.5 \pm 5.1$	* * *	$13.8 \pm 0.6$
Lower remaining teeth	$5.5 \pm 6.1$	* * *	$13.8 \pm 0.6$
Remaining teeth	$9.0 \pm 10.8$	* * *	$27.6 \pm 1.3$
Occlusal supporting area	$0.7 \pm 1.3$	* * *	$4\pm0$
Eichner classfication	$7.8 \pm 3.0$	* * *	$1\pm0$
Occlusal area (mm <sup>2</sup> )	$16.4 \pm 14.0$	* * *	$20.4 \pm 10.3$
Average occlusal pressure (MPa)	$25.3 \pm 9.9$	* * *	$37.4 \pm 4.1$
Maximal occlusal force (N)	$298.5 \pm 163.0$	* *	$757.3 \pm 376.8$

Table 3. Occlusal condition of the subjects

\*\**p*<0.01, \*\*\**p*<0.001.

# **Occlusional condition of the panelists**

The average and standard deviation of the dental condition for the elderly and young panelists, *i.e.*, upper remaining teeth, lower remaining teeth, occlusal-supporting area, and Eichner-classification<sup>6</sup> as checked by the dentist are shown in Table 3. The occlusal area, average occlusal pressure, and maximal occlusal force determined by the Dental Prescale are also shown in Table 3.

The condition of the elderly teeth varied widely. Some had retained almost a complete set, while others had very few. Food is masticated mainly by the molar teeth, so the absence of one or both of the paired (upper and lower) molar teeth prevents full mastication of food. We thus calculated the occlusalsupporting area which varied from 0 (none) to 4 (full) from person to person.

Values for the other parameters also varied widely. The occlusal area was relatively high when counted from the remaining teeth, because some of the elderly chewed with their gums. Although the number of panelists was small and we cannot identify any correlation, the variation in occlusal condition seemed not to depend on age.

In contrast, none out of the ten young panelists had

a full set of teeth. There were only small variations in the occlusal area, occlusal pressure and maximum occlusal force in comparison with the elderly subjects. The maximal occlusal force of the young members was 2.5 times as much as that of the elderly.

(OD)

All the measured results were significantly different by a *t*-test between the young and the elderly. Kouyama<sup> $\eta$ </sup> has determined the mastication force during mastication by using a multi-point sheet sensor. In our study, we did not determine the change in force during mastication, only one chew being sufficient to identify the occlusional ability to masticate foods.

# **Results of the sensory analysis**

The most preferable (easy to eat) cooked rice for the elderly was that cooked with 1.85 times the amount of water as calculated by the probit<sup>8)</sup> method. The most preferred by the young was the rice cooked with 1.47 times the amount of water. Our results show that the elderly selected the rice with a hardness of about 2.3 kgf, cohesiveness of 0.67 TU, and stickiness of 0.65 TU from the five kinds of cooked rice with different texture. It was also observed that the young selected the rice with a hardness of about 2.5 kgf, cohesiveness of 0.72 TU, and stickiness of 0.48 TU. Rice is usually cooked with 1.5 times the

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			$(\text{mean} \pm 0D)$
	Proportion of water	Elderly	Young
	1.1		51.3±28.5 a
	1.4	56.6±30.7 a *	$40.2 \pm 17.6$ at
Number of charge	1.7	49.0±27.7 a *	$31.1 \pm 10.5$ bc
Number of cnews	2.0	44.7±22.6 a *	$26.2 \pm 10.9$ bo
	2.3	36.5±13.0 a	22.5±13.1 c
	2.6	31.6±12.4 b	
	1.1		30.1±17.2 a
	1.4	$43.8 \pm 40.9$	$23.9 \pm 10.7$ at
Mastication time	1.7	36.7±25.7 *	$17.7 \pm 6.4 \text{ b}$
(s)	2.0	31.7±18.3 *	* 15.8±6.4 b
	2.3	$28.7 \pm 11.9$	$15.6 \pm 11.2 \text{ b}$
	2.6	$25.9\!\pm\!8.7$	
	1.1		1.74±0.0 a
	1.4	$1.50 \pm 0.4$	$1.72\pm0.2$ a
Mastication cycle	1.7	1.42±0.4 *	' 1.77±0.1 a
(no. of chews/time)	2.0	$1.52 \pm 0.4$	$1.65 \pm 0.1  a$
	2.3	$1.36 \pm 0.4$	$1.50\pm0.2~\mathrm{b}$
	2.6	$1.27 \pm 0.3$	

Table 4.Number of chews, mastication time and mastication cycle for<br/>the cooked rice samples by the elderly and the young

\*p < 0.05. a, b, c: different letter(s) within a column show significant difference.

amount of water; this amount of water is suitable for the young, but the resulting cooked rice is often too firm for the elderly.

Both the elderly and the young showed significant differences in the number of chews for each sample of cooked rice with different textures (Table 4). In respect of the mastication time, there was no significant difference for the elderly because of the side variation. There was the tendency that the softer the rice, the fewer chews and shorter mastication time. Some samples of rice cooked with the same amount of water showed a significant difference in the number of chews and mastication time between the young and the elderly. The number of chews was divided by the mastication time to obtain the mastication cycle. The difference in the average cycle between the elderly and the young was clear, the young moving their jaws up and down more quickly than the elderly. It is interesting that the soft rice, i.e. cooked with 2.3 times of water, resulted in the mastication cycle of the young being significantly slow. However, only one rice sample cooked with 1.7 times the amount of water was significantly different, because the standard deviation was relatively large for the

elderly. The standard deviation for the elderly was larger than that for the young.

(moon + SD)

# Occlusional characteristics of the elderly and young by a principal component analysis

Six parametric items of dental measurement, i.e., the remaining upper teeth, remaining lower teeth, total remaining teeth, occlusal-supporting area, average occlusal area, and maximal occlusal force, and the number of chews and mastication time were all applied to a principal component analysis. The obtained component loading, eigenvalue, proportion and cumulative proportion are shown in Table 5. The cumulative proportion of the first and second principal components was 79.6%. We can thus explain about 80% of the variation with these two components. Using these first and second principal components, the data for all the elderly and young were plotted in Fig. 1. The first component is thought to represent the power level for the mastication food, while the second component is thought to represent the degree of dental healthiness.

We can see from this figure that the young are distributed in a relatively small range and the elderly, in a wider range, with one elderly person falling into the Comparison of the Occlusional Condition and Preference for the Firmness of Cooked Rice between the Elderly and Young

	Tuble of Trinopar component analysis of the parametric data				
		Proportion of water	First component	Second component	
	Number of chews	1.4	0.920	0.287	
		1.7	0.886	0.361	
		2.0	0.843	0.437	
	Mastication time	1.4	0.836	0.186	
Component		1.7	0.910	0.242	
loading		2.0	0.864	0.410	
	Upper remaining teeth		-0.792	0.495	
	Lower remaining teeth		-0.796	0.501	
	Remaining teeth		-0.810	0.508	
	Occlusal area		-0.266	0.854	
	Average occlusal pressure		-0.402	-0.141	
	Maximal occlusal force		-0.578	0.538	
Eigen value			7.099	2.457	
Proportion			59.161	20.474	
Cumulative proportion			59.161	79.635	

Table 5. Principal component analysis of the parametric data



Fig. 1. PCA plots for the dental condition of the elderly and the young ■ elderly, ○ young. Numerical values show the proportion of water.

range for the young. The proportion of water for the cooked rice preferred by each person is also shown in Fig. 1. The plots for the young who preferred firmer rice fall in the minus region of the second principal axis, and for those who preferred the softer rice, fall in the plus region. The plots for the elderly, who preferred the softer rice, fall in the plus region of the first principal axis and in the minus region of the second

principal axis. However, no specific trend is apparent for the other panel members. These data indicate a wide variation among the elderly, although we cannot quantify this trend due to the small number of samples. The elderly members were in their sixties to eighties and may therefore have substantially differed in their body condition. A further study should be done with a larger number of subjects and this is J. Home Econ. Jpn. Vol. 54 No. 12 (2003)

now in progress.

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## 高齢者と若年者の口腔内状態と飯の硬さの好みの比較

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口腔内の状態および飯の硬さの好みを高齢者と若年者,各10名のパネルを用いて比較した. パネルの歯の状態は残存歯,アイヒナー指数等を測定した.デンタルプレスケールを用いて咬 合面積,咬合圧,最大咬合圧を測定した.これらの測定値の主成分分析により各パネルメンバー の値を求め,第1軸と第2軸にメンバーの値をプロットした.高齢者の場合,口腔内の状態は 広い範囲に分布した.好ましい飯を重ねてプロットしたところ,若年者は狭い範囲に分布し, 高齢者は広い範囲に分布した.高齢者の飯の好みは加水量平均1.8倍で炊いた飯であり,若年 者は平均1.5倍で炊いた飯であった.

キーワード:高齢者,デンタルプレスケール,口腔内の状態,飯の硬さ.