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Application News

EZTest™ Texture Analyzer

Prediction of Sensory Evaluation Values of Cookies by Multivariate Analysis

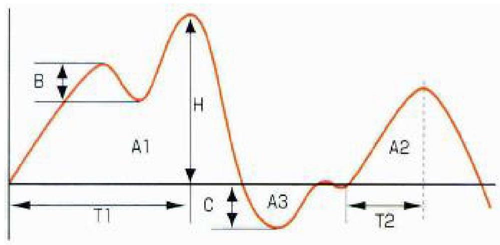
F. Yano, N. Koike

User Benefits

- Texture testing is possible by using EZTest.
- Jigs can be exchanged easily by the jig platform.
- Prediction of approximate sensory evaluation values from the measurement values in texture testing is possible.

■ Introduction

The factors experienced as the deliciousness of food consist of factors related to the food itself (e.g., taste, aroma, food texture) and human factors (physiological and psychological factors, eating habits, external factors), but because texture may account for a large part of the perception of deliciousness depending on the food, texture has become an important item in evaluations of food products. Methods for evaluating texture can be divided into sensory evaluation, in which human subjects evaluate the "mouthfeel" of the food when eaten, and evaluation of mechanical properties, in which instruments are used to evaluate the hardness and other properties of the food. Mouthfeel is normally evaluated by sensory tests, but the difficulty of reproducing evaluation results due to individual differences in the human senses, the physical condition of the subjects, and similar factors is a problem in sensory testing. For this reason, measurements are being conducted using instruments in order to obtain objective results. As example of the representative mechanical properties of texture, Fig. 1 shows the Szczesniak texture profile [1]. Although the basic mouthfeel of foods can be evaluated by the texture profile, measurement of more complex mouthfeel characteristics is difficult. Therefore, in this experiment, a multivariate analysis was carried out referring to the literature [2, 3], and the sensory evaluation values of the hardness, crispness, and moistness of various sample cookies were predicted. The optimum evaluation method was also examined by conducting tests with three types of measurement methods (compression test, piercing test, and 3-point bending test).



Hardness	: H	Maximum force (N)
Brittleness	: B	Force required to break food in the mouth (N)
Adhesiveness	: A3	Force required to remove food adhering to the teeth, tongue, or oral cavity (N)
Cohesiveness	: A2/A1	Ratio of 1st and 2nd load areas (energy)
Springiness	: T2/T1	Ratio of time (displacement) to return to peak
Gumminess	: H × A2/A1	Hardness × Cohesiveness
Chewiness	: H × A2/A1 × T2/T1	Hardness × Springiness × Cohesiveness

Fig. 1 Szczesniak Texture Profile

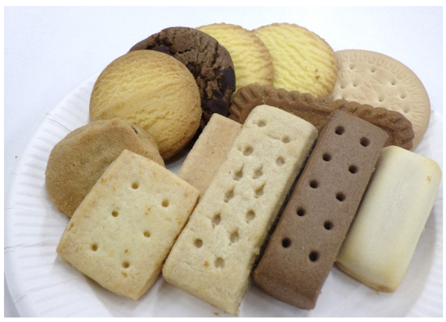


Fig. 2 Measurement Samples (11 Types of Cookies)

■ Sensory Evaluation

Eleven types of cookies were used as the test samples in this study. Table 1 shows the results of a sensory evaluation. The sensory evaluation was carried out referring to a statistical scoring method [2]. The sensory evaluations were provided by 16 subjects, and the data for 10 subjects were evaluated, after excluding 3 subjects each who reported the largest and smallest values.

Table 1 Results of Sensory Evaluation (Statistical Results for 10 Central Subjects)

Sample name	Hardness			Crispness			Moistness		
	Average	Standard deviation	Coefficient of variation	Average	Standard deviation	Coefficient of variation	Average	Standard deviation	Coefficient of variation
A	54.30	7.85	14.45	72.10	5.07	7.03	44.90	8.57	19.09
B	66.10	4.58	6.93	80.20	5.90	7.36	20.30	8.08	39.82
C	20.40	4.70	23.02	25.50	4.28	16.77	79.00	6.99	8.85
D	88.60	3.10	3.50	78.80	6.14	7.80	22.50	7.55	33.54
E	60.20	9.44	15.68	67.60	6.22	9.20	42.10	13.11	31.14
F	52.50	7.23	13.77	70.90	5.20	7.33	40.00	9.43	23.57
G	72.20	4.13	5.72	65.80	4.44	6.75	37.65	5.52	14.66
H	40.30	7.87	19.54	40.10	7.23	18.04	55.70	14.58	26.18
I	54.70	8.21	15.00	68.20	6.43	9.42	37.10	6.21	16.73
J	75.60	5.50	7.28	83.40	3.53	4.24	24.60	7.59	30.85
K	34.50	4.38	12.69	31.30	3.80	12.15	70.00	11.55	16.50

■ Texture Tests

A Shimadzu EZTest texture analyzer was used in the measurements. In this experiment, a compression test, piercing test, and 3-point bending test were conducted. Table 2 shows the instrument configuration, including the jigs used, and Fig. 3 shows the condition of the respective tests.

Table 2 Instrument Configuration

Texture analyzer	:	EZTest
Load cell	:	100 N
Test jigs	:	φ3 circular cylindrical press jig (compression test)
		30° circular cone pressing jig (piercing test)
		R2.5 mm 3-point bending test jig (3-point bending test)
Software	:	TRAPEZIUM™-X texture

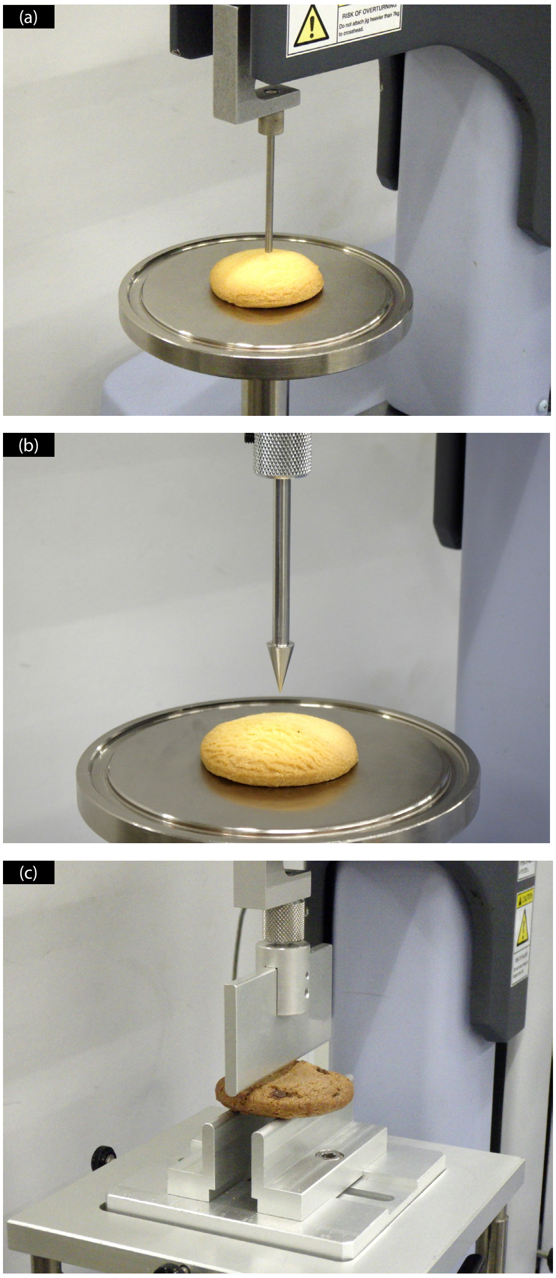


Fig. 3 Condition of Tests
(a) Compression Test, (b) Piercing Test, (c) 3-Point Bending Test

The test speed in the compression test was set to 10 mm/s. Fig. 4 shows representative force-strain curves. Because the samples were not uniform, large variations occurred in each of the samples, but general tendencies were nevertheless apparent with each sample type. For example, with Sample A, some variations in the force were observed as the test proceeded, the test of Sample C proceeded smoothly with little variation, and large variations in the force occurred with Sample D.

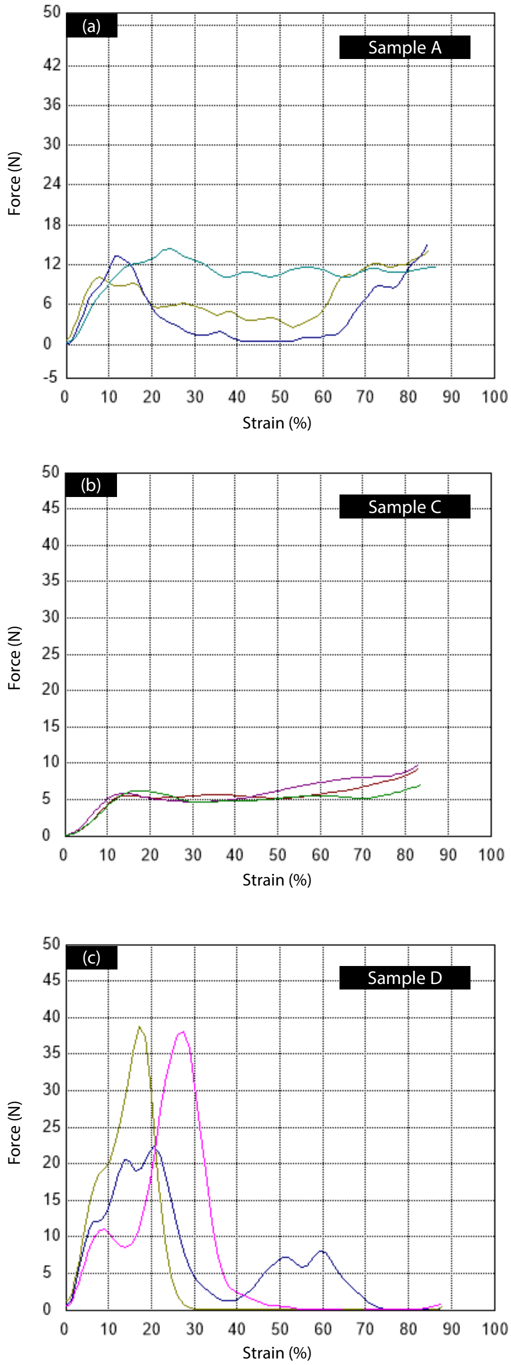


Fig. 4 Examples of Compression Test Results (Force-Strain Curves)
Results for (a) Sample A, (b) Sample C, (c) Sample D

As in the compression test, the test speed in the piercing test was set to 10 mm/s. Fig. 5 shows the force-strain curves of Samples A, C, and D as examples of the piercing test. As in the compression test results, there were large variations in the respective samples, but each of the samples displayed a certain tendency.

The test speed in the 3-point bending test was set to 1 mm/s, and the distance between supports was set to approximately 2 times the sample thickness for each sample. Fig. 6 shows the stress-strain curves as examples of the 3-point bending test. While there were samples with comparatively good reproducibility, as can be seen in Sample C, there were also samples with large variations, as shown by Sample A and Sample D. However, as an overall tendency, tendencies could be seen in each sample.

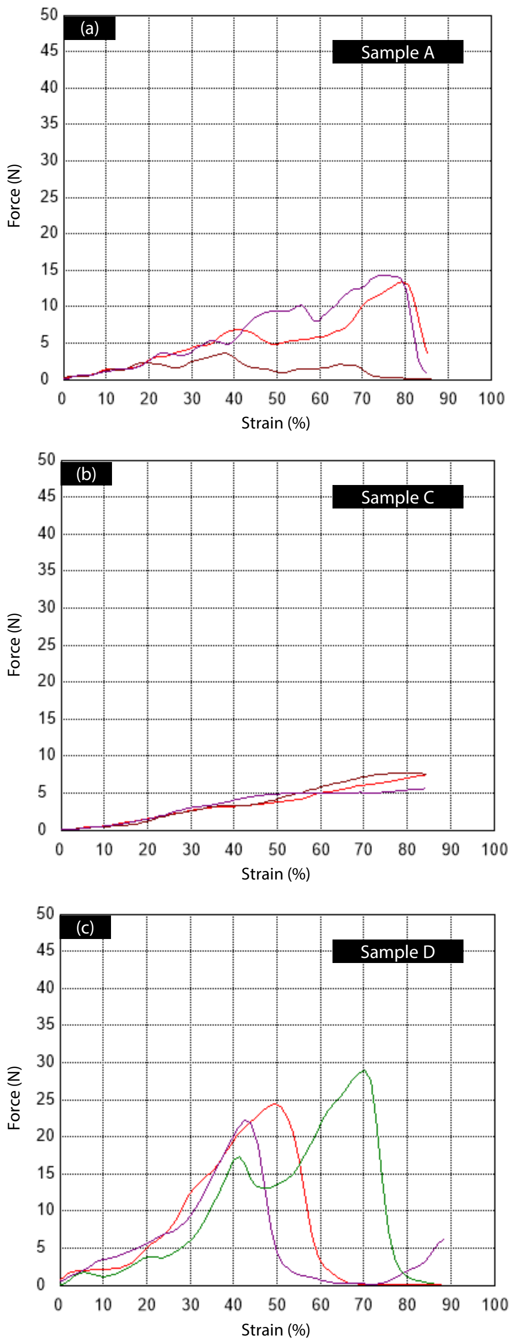


Fig. 5 Examples of Piercing Test Results (Force-Strain Curves)
Results for (a) Sample A, (b) Sample C, (c) Sample D

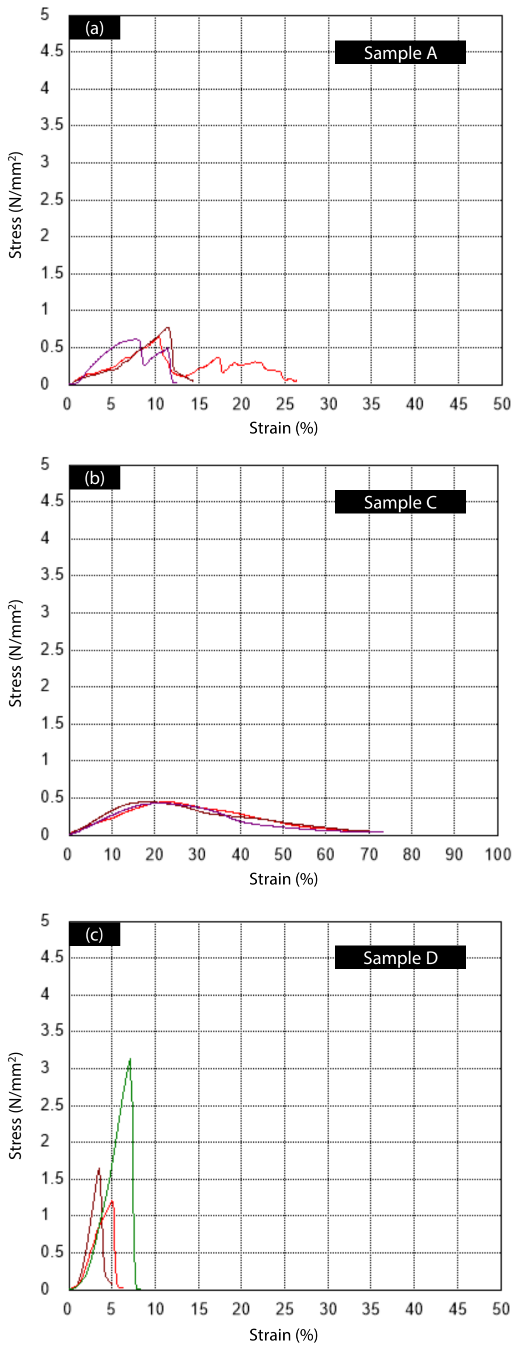


Fig. 6 Examples of 3-Point Bending Test Results (Stress-Strain Curves)
Results for (a) Sample A, (b) Sample C, (c) Sample D

Here, in the respective texture tests, six items (hardness, strain at maximum force, initial inclination, energy, number of convex points, and sample thickness) were measured, and the results were compared with the sensory evaluations of three items. For example, Fig. 7 shows the comparison of the texture tests results of the compression, piercing, and 3-point bending tests and the results of the sensory evaluation for hardness. The correlation coefficients for the three tests were 0.77 (compression test), 0.52 (piercing test), and 0.67 (3-point bending test). From these results, hardness in the Szczesniak texture profile displays as certain degree of correlation, but in these tests, the results do not necessarily agree with the results of the sensory evaluation. When the results of the texture tests were compared with sensory evaluation items other than hardness, the correlation coefficients for the compression test were excellent. Therefore, among the test methods used in this experiment, the compression test was considered to show the closest agreement with the sensory evaluation.

Since the results described above showed that the compression test is a suitable test method, study was narrowed to the compression test in the following. However, even in the compression test, it was not possible to obtain a strong correlation coefficient of 0.9 or higher when the sensory evaluation items were compared with only one texture test. Moreover, as shown in Fig. 8, it was inherently difficult to identify any evaluation item in the texture test which displayed a correlation with moistness. Therefore, the sensory evaluation values were predicted by a multiple regression analysis. In this analysis, among the eleven types of samples, a regression formula was obtained by using the characteristic values of Samples A to I, and the sensory evaluation values of Samples J and K were then predicted and compared with the actual sensory evaluation values.

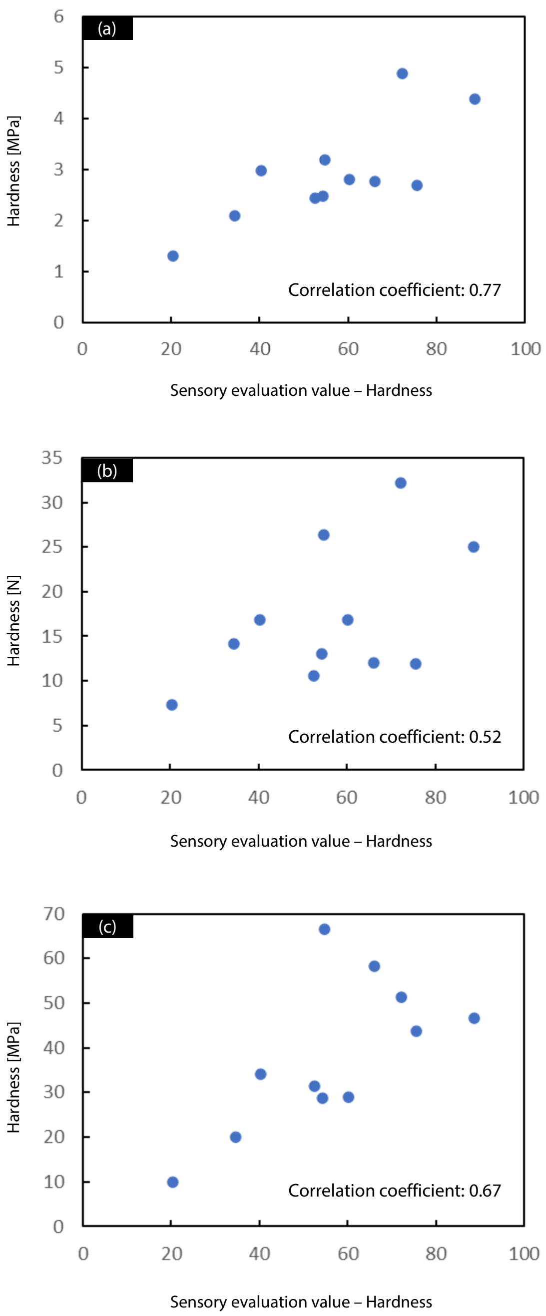


Fig. 7 Examples of Comparison of Hardness Results in Texture Tests and Sensory Evaluation
Hardness in (a) Compression Test, (b) Piercing Test, and (c) 3-Point Bending Test

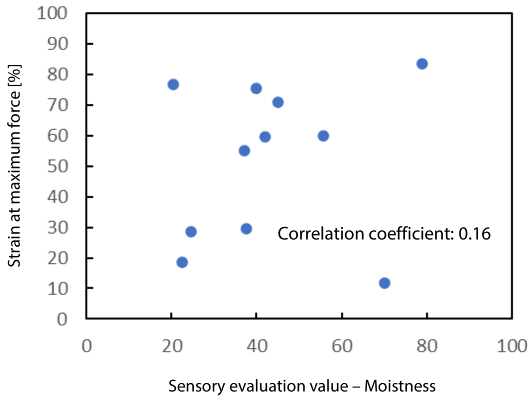


Fig. 8 Comparison of Strain at Maximum Force and Moistness

Fig. 9 shows the results of the multiple regression analysis. Here, hardness, strain at maximum force, initial inclination, energy, number of convex points, and sample thickness were selected here as the explanatory variables [(2), (3)]. In the results shown in Fig. 9, the values of Samples J and K predicted by the regression formula are shown in orange. From Fig. 9, rough agreement was obtained between the prediction values and the sensory evaluation values, suggesting that it is possible to predict sensory evaluation values.

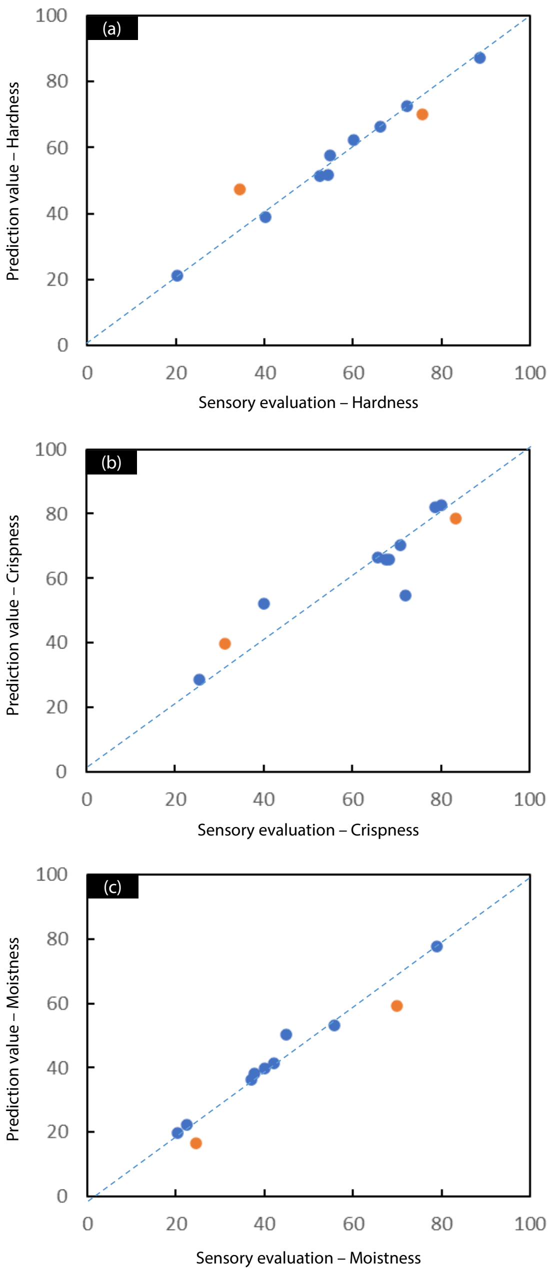


Fig. 9 Sensory Evaluation Values Predicted by Multiple Regression Analysis
(a) Hardness, (b) Crispness, (c) Moistness

■ Conclusion

The sensory evaluation values of eleven types of cookies were predicted using the Shimadzu EZTest texture analyzer. Among the three types of test methods used in this experiment, the results revealed that the compression test is the most suitable. Even when a correlation with sensory evaluation items cannot be obtained from the results of one type of texture test, as in the case of crispness and moistness, a rough prediction of the sensory evaluation value was possible by conducting a multiple regression analysis using the results of various texture tests as explanatory values.

<Reference>
(1) Yoshimasa Yamano, Evolving Research on Food Texture, Taste Science Research Institute (Social Corporation) (2011).
(2) Hideko Furukawa and Reiko Ueda, Measuring Deliciousness (Cont'd), Saiwaishobo (2012).
(3) Shinya Nagasawa and Satoshi Kawae, Statistical Sensory Evaluation Method Possible with Excel, Union of Japanese Scientists and Engineers (2008).

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