CASE 64

Improvement in the Taste of Omelets

Abstract: In this study, to improve the typical physical taste of an omelet, texture, that is, the "mouth feel" when an omelet is chewed, we undertook technological development based on quality engineering by using a mechanical measurement method instead of a sensory test.

1. Taste Measurement Method

The taste of an omelet, which accounts for 70 to 80% of the eating experience, is not chemical but physical. In this study, in order to improve the texture (i.e., the way the mouth feels when an omelet is eaten), we attempted technological development based on quality engineering by using a mechanical measurement method instead of a sensory test.

A typical tasty omelet is a handmade omelet, cooked at home or in a restaurant kitchen. Assuming such an omelet to be ideal and at the same time, targeting popular commercial omelets, we proceeded with our study.

Among major mechanical measurement methods for texture are compression, shearing, cutting, and tension tests. Using these we can evaluate texture from many aspects. In addition, when we eat an omelet, we can perceive deformation, cracks, fragmentation, and so on, in the mouth. We adopted a plunge-type measurement device with a hollow plunger tube (Figure 1).

Primarily, we measured and compared "handmade," "regarded as tasty," and "regarded as worst" omelets (Figure 2). The thickness of the plunger's wall is 0.25 mm. This experiment revealed that for the elastic region (area A), a handmade or regarded-as-tasty omelet has a gentle slope and small rupture load.

On the other hand, for the stage of a plunger's plunge (area B) after the omelet's surface is broken, or after area A, the handmade or regarded-as-tasty omelet has a small plunge load and relatively flat curve. This area is considered to represent textures such as a "feel of chewing" or "feel of crushing."

2. Calculation of SN Ratio and Sensitivity Using Texture Data

For area A in Figure 2 we selected displacement M (0.05, 0.10, ... , 0.25 cm) as a signal factor. For area B, instead of setting up signal factors, we took advantage of a nominal-the-best characteristic. We set cooling time in hours to a noise factor ($N_1 = 24$, $N_2 = 48$), the wall thickness of the plunger in centimeters as a measurement jig was chosen as an indicative factor ($P_1 = 0.25$, $P_2 = 0.50$, $P_3 = 0.75$).

On the basis of the load–displacement curve obtained from the plunge test, for the analysis of area A we read a load value for each signal. For area B we read minimum and maximum loads in the stage of plunge after the surface was broken. As a result, we obtained the data shown in Tables 1 and 2.

Calculation for Area A (Experiment 1)

Since the wall thickness of the plunger is an indicative factor, we did not include it as a noise factor. However, its interaction with the thickness was regarded as noise.

Total variation:

$$S_T = 9194^2 + \cdots + 63{,}439^2 = 60{,}665{,}521{,}314 \qquad (f = 30) \qquad (1)$$

Taguchi's Quality Engineering Handbook. Genichi Taguchi, Subir Chowdhury and Yuin Wu

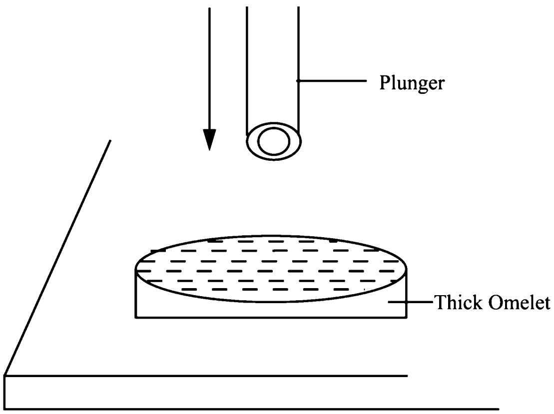


Figure 1
Measurement method for texture of omelet

Effective divider:

$$r = 0.05^2 + \cdots + 0.25^2 = 0.1375 \quad (2)$$

Linear equation:

$$L_1 = (0.05)(9194) + \cdots + (0.25)(68{,}710) = 36{,}384$$

$$\vdots$$

$$L_6 = (0.05)(3371) + \cdots + (0.25)(63{,}439) = 30{,}662 \quad (3)$$

Variation of proportional terms:

$$S_\beta = \frac{(L_1 + L_2 + \cdots + L_6)^2}{6r} = 59{,}129{,}381{,}251 \quad (f = 1) \quad (4)$$

Variation of differences of proportional terms:

$$S_{N\beta} = \frac{(L_1 + L_3 + L_5)^2 + (L_2 + L_4 + L_6)^2}{3r} - S_\beta = 13{,}926{,}068 \quad (f = 1) \quad (5)$$

$$S_{P\beta} = \frac{(L_1 + L_2)^2 + (L_3 + L_4)^2 + (L_5 + L_6)^2}{2r} - S_\beta = 574{,}278{,}389 \quad (f = 2) \quad (6)$$

Error variation:

$$S_e = S_T - S_\beta - S_{N\beta} - S_{P\beta} = 947{,}935{,}606 \quad (f = 26) \quad (7)$$

Error variance:

$$V_e = \frac{S_e}{26} = 36{,}459{,}062 \quad (8)$$

Total error variance:

$$V_N = \frac{S_{N\beta} + S_e}{27} = 35{,}624{,}506 \quad (9)$$

SN ratio:

$$\eta_1 = 10 \log \frac{(1/6r)(S_\beta - V_e)}{V_N} = 33.03 \text{ dB} \quad (10)$$

Sensitivity:

$$S_1 = 10 \log \frac{1}{6r}(S_\beta - V_e) = 108.55 \text{ dB} \quad (11)$$

Calculation for Area B (Experiment 1)

Again for this case, since the variation between each plunger naturally exists, we did not include it as a noise factor.

Total variation:

$$S_T = 102{,}728^2 + \cdots + 150{,}599^2 = 221{,}531{,}535{,}262 \quad (f = 12) \quad (12)$$

Variation of general mean:

$$S_m = \frac{(102{,}728 + \cdots + 150{,}599)^2}{(3)(4)} = 213{,}712{,}627{,}107 \quad (f = 1) \quad (13)$$

y's in Table 2:

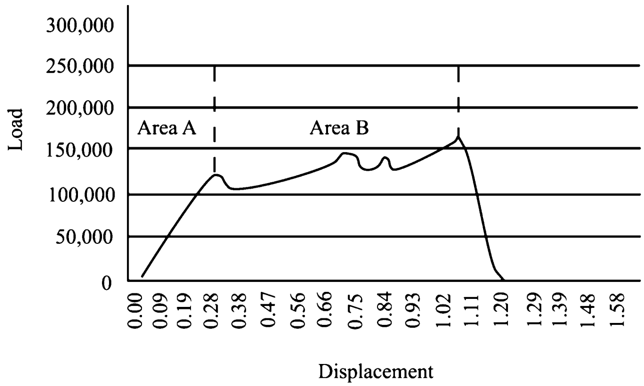
$$y_1 = 102{,}728 + \cdots + 126{,}572 = 451{,}551$$

$$y_2 = 130{,}004 + \cdots + 139{,}750 = 520{,}629$$

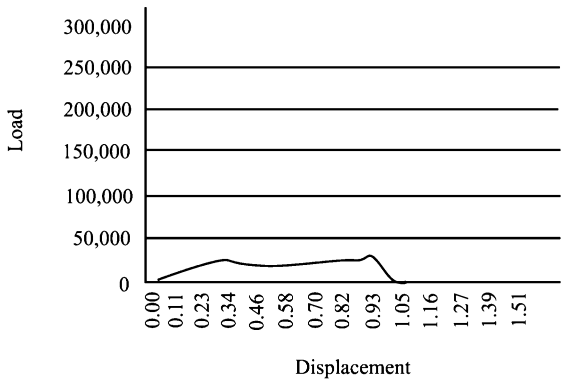
$$y_3 = 159{,}609 + \cdots + 150{,}599 = 629{,}242 \quad (14)$$

Variation between each plunger:

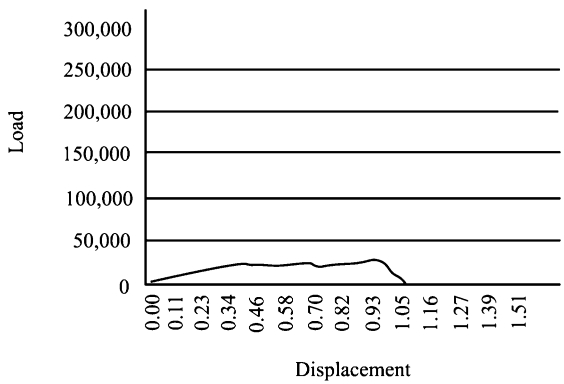
$$S_p = \frac{y_1^2 + y_2^2 + y_3^2}{4} - S_m = 4{,}011{,}867{,}234 \quad (f = 2) \quad (15)$$



(a) Worst (estimation): 0.25 cm (24 hours after made)



(b) Tayaki hondama: 0.25 cm (handmade)



(c) Double omelet by Company A: 0.25 cm (rumored to be tasty)

Figure 2
Comparative measurement of omelet

Table 1
Measured texture data for area A (experiment 1) (dyn)

		M_1	M_2	M_3	M_4	M_5	Linear Equation
P_1	N_1	9,194	23,721	38,309	53,142	68,710	L_1
	N_2	9,133	24,395	38,860	53,080	67,484	L_2
P_2	N_1	7,171	22,066	38,983	55,839	72,572	L_3
	N_2	15,323	33,405	49,893	65,952	81,888	L_4
P_3	N_1	4,107	14,098	32,424	52,038	70,978	L_5
	N_2	3,371	11,830	28,379	45,970	63,439	L_6

Error variation:

$$S_e = S_T - S_m - S_p = 3{,}807{,}040{,}921 \qquad (f = 9) \tag{16}$$

Error variance:

$$V_e = \frac{S_e}{9} = 423{,}004{,}547 \tag{17}$$

SN ratio:

$$\eta_2 = 10 \log \frac{\frac{1}{12}(S_m - V_e)}{V_e} = 16.23 \text{ dB} \tag{18}$$

Sensitivity:

$$S_2 = 10 \log \tfrac{1}{12}(S_m - V_e) = 102.50 \text{ dB} \tag{19}$$

3. Optimal Condition and Confirmatory Experiment

As shown in Table 3, we selected control factors from the mixing, baking, and sterilization processes. Figure 3 shows the response graphs for the SN ratio and sensitivity. Although there exist V-shapes and peaks for some particular factors in the SN ratio response graph for areas A and B, by adding both SN ratios, we evaluated each factor. Similarly, for sensitivity, we added both values.

Table 4 shows estimations and confirmatory experimental results for the SN ratio and sensitivity. In addition, Figure 4 illustrates a part of the load–displacement curve under current (level 2) and optimal conditions. The curve under the optimal condition is similar to that for the handmade omelet. Whereas the reproducibility for the SN ratio was poor, that for sensitivity was fairly good. Although the reason for this tendency is not clear, we note that there exist haphazard causes for the trends related to noise and indicative factors according to the data in Tables 1 and 2. Therefore, for example, an analysis of each categorized data might increase the reliability of error variance.

While we conducted this experiment with a constant baking time because we could not change the

Table 2
Measured texture data for area B (experiment 1) (dyn)

		P_1	P_2	P_3
N_1	min.	102,728	130,004	159,609
	max.	121,484	158,015	181,613
N_2	min.	100,767	92,860	137,421
	max.	126,572	139,750	150,599
Total		y_1	y_2	y_3

Table 3
Control factors and levels

	Control Factor	Level 1	Level 2	Level 3
A:	mixing during baking	Yes	No	—
B:	egg stirring time (min)	0	15	30
C:	ratio of frozen egg (%)	0	50	100
D:	amount of starch (%)	0	3	5
E:	amount of water (%)	0	10	20
F:	initial temperature (pot)	Low	Mid	High
*G**:	flow of gas when F_1	Low	Mid	High
	flow of gas when F_2	Low	Mid	High
	flow of gas when F_3	Low	Mid	High
H:	sterilization time (h)	0	0.5	1

*Sliding-level technique is used for defining levels of *G*.

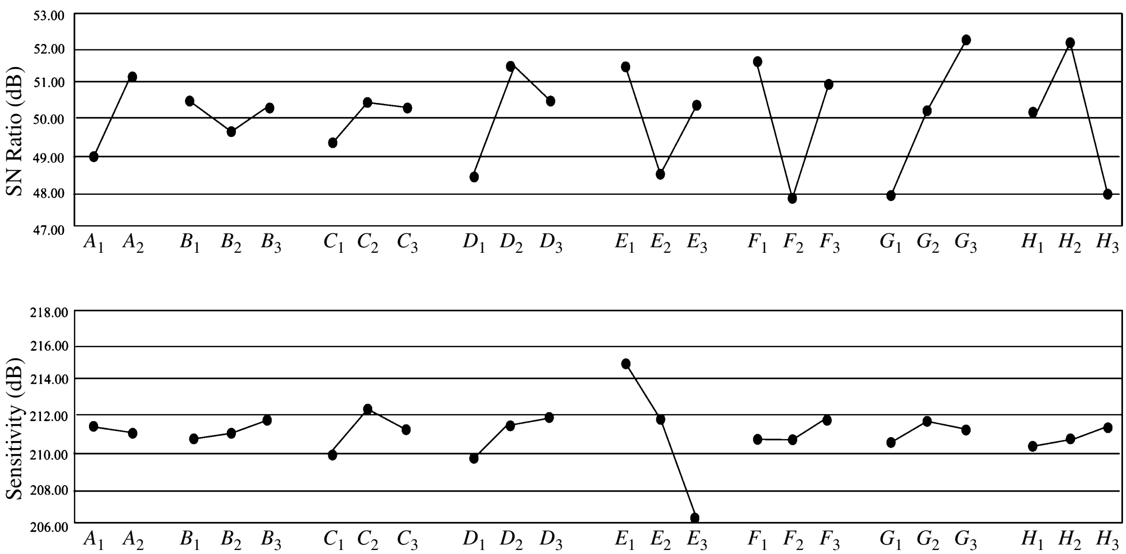
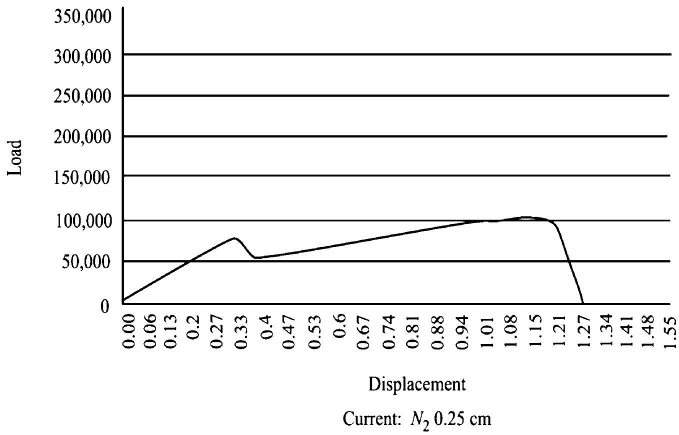


Figure 3
Response graphs

Table 4
Estimation and confirmation of gain (dB)

	SN Ratio		Sensitivity	
Condition	**Estimation**	**Confirmation**	**Estimation**	**Confirmation**
Optimal	51.10	51.90	213.13	212.41
Initial	58.08	54.60	204.84	203.35
Gain	6.98	2.70	−8.29	−9.06



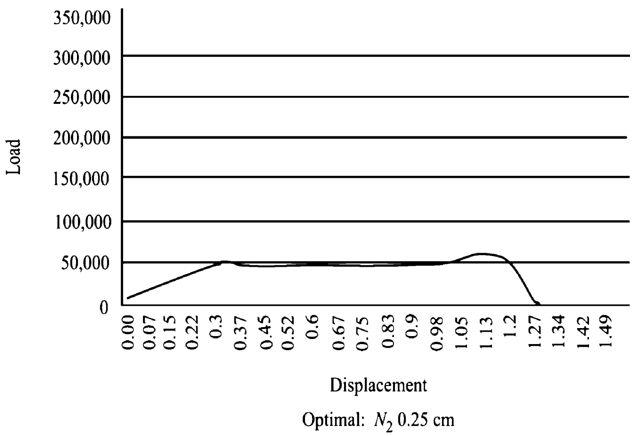


Figure 4
Measured data under current and optimal conditions

production speed materially in our manufacturing process, in the future we intend to attempt to reduce the number of V-shapes and peaks and improve the production speed, regarded as one of the objectives of quality engineering, by implementing an experiment based on heat energy.

Reference

Toshio Kanatsuki, 2000. Improvement of the taste of thick-baked eggs. *Quality Engineering*, Vol. 8, No. 4, pp. 23–30.

This case study is contributed by Toshio Kanetsuki.