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Studies on Sensory Evaluation of Soy Sauce

(X) Relation between Odor Patterns and Chemical Factors (1)

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Abstract

The authors discussed about linear relation between odor patterns and chemical factors, and linear relation between odor patterns and quality patterns. The odor pattern related to blend ratio of brewed soy sauce to amino acid solution agreed with only the quality pattern related to alcohol fermentation.

The relation between odor patterns and 19 chemical factors was one of most important informations for making up more desirable odor patterns by brewing process on preference (quality) of soy sauce.

The results obtained were as follows:

1. The odor pattern related to blend ratio of brewed soy sauce to amino acid solution (F_1) was contributed at 77.2% by 19 chemical factors. Especially, the direct relation of only alcohol to F_1 was recognized.
2. The odor pattern related to microbial contamination (F_2) was not significantly correlated to 19 chemical factors (contributing proportion: 43.8%). This odor pattern was influenced by alcohol, but not influenced very much by the other chemical factors.
3. The odor pattern related to medicinal dependent on *Asp. oryzae* strains (F_3) was not significantly correlated to 19 chemical factors (contributing proportion: 39.6%).
4. The odor pattern related to degree of ripening (F_4) was not significantly correlated to 19 chemical factors (contributing proportion: 32.7%).
5. The odor pattern related to pasteurization (F_5) was significantly correlated to 19 chemical factors (contributing proportion: 58.0%). The direct relationship of NH_3-nitrogen, alcohol and dulcin to F_5 was recognized.

The soy sauce that contains more alcohol by pure brewing or good fermentation has more perfume, alcoholic odor and acid odor. But the soy sauce containing less alcohol or more amino acid solution (i.e., amino acid soy sauce or bad fermented soy sauce) has more smell of amino acid solution, putrid smell and less perfume, and burnt smell.

Introduction

It is momentous problem to find out the odor components which play an important role or have essential effect on the odor of soy sauce[1~3]. To solve this problem, a systematic study is necessary on the relationship between the odor components and odor judgement by sensory evaluation.

In a previous paper[10], were obtained five odor patterns, which can describe in full the variance on sensory technical terms or the acceptable qualitative factors by the sense of odor. Moreover, the relevancy between odor patterns and the soy sauce brewing process were discussed and odor patterns were independently constructed from each brewing process.

This paper discusses about the linear relation between odor patterns[10] and chemical factors or quality patterns[6], concentrating on the relevancy between odor patterns and brewing process as shown in Fig. 1[4~10].

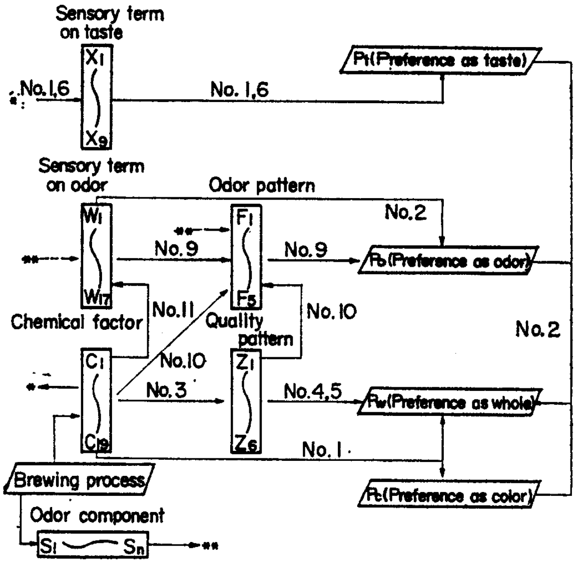

Fig. 1. System of soy sauce quality on the judgement by the sensorium and chemical factor.

Experimental and Analysis Design

1. Experimental Following experiments about 59 samples (brands) were made:

i. Chemical factors (C_k: $k=1, 2, \cdots, 19$)-Analytical data were determined by the

Table 1. Sensory technical terms of odor, chemical factors and symbol.

W_1	Perfume	W_{10}	Butyric acid smell
W_2	Smell of amino-acid solution	W_{11}	Roasting wheat smell
W_3	Alcohol odor	W_{12}	Acid smell
W_4	Acid odor	W_{13}	Decomposed smell
W_5	Abnormal smell	W_{14}	Koji smell
W_6	Natto smell	W_{15}	Warmed brewing smell
W_7	Moldy	W_{16}	Oily smell
W_8	Medicinal	W_{17}	Steamed soybean smell
W_9	Burnt smell		
C_1	Baume	C_{11}	Alcohol
C_2	NaCl	C_{12}	Titratable acid
C_3	Extract	C_{13}	pH
C_4	Total-nitrogen	C_{14}	CD (muddiness)
C_5	Formol-nitrogen	C_{15}	Specific viscosity
C_6	NH_3-nitrogen	C_{16}	Buffer action
C_7	Glutamic acid	C_{17}	Preservative activity
C_8	Glu./T-N.	C_{18}	Levulinic acid
C_9	Reducing sugar	C_{19}	Dulcin
C_{10}	Inverted sugar		

staff of the analytical section.

ii. Sensory technical terms on odor[5,11] (W_j: $j=1, 2, \cdots, 17$)-Experimental data were scored by sensory evaluation according to a certain scale system ("Extremely strong" (5)～, "No detected" (0)). The sensory test panel consisted of 20 members at the Central Research Institute, Kikkoman Shoyu Co., Ltd.

2. Analysis design The abbreviations are shown in Table 1. The analyses of experimental data were carried out by the computer (IBM system 360 Model 40) using the programs of factor analysis[12~15] and multiple regression analysis[16~18] developed by the computer section of Kikkoman Shoyu Co., Ltd.

Results and Discussion

1. Linear relation between odor patterns and quality patterns

In order to discuss linear relation between sensory technical terms on odor (W_j) and chemical factors (C_k) on the same dimension, factor loading and communality were obtained by a factor analysis technique from correlation matrix among 35 factors (Table 2). The meanings of nine patterns, which are referred

Table 2. Orthogonal rotated factor loading matrix, communality.

Factor	I	II	III	IV	V	VI	VII	VIII	IX	Communality
W_1	0.217	0.635	−0.428	−0.439	−0.087	−0.038	0.228	0.013	−0.064	0.891
W_2	−0.148	−0.893	0.009	−0.038	−0.253	−0.003	−0.163	0.154	0.105	0.930
W_3	0.216	0.724	−0.288	−0.242	−0.153	−0.021	0.125	−0.034	0.131	0.771
W_4	0.229	0.639	−0.158	−0.536	−0.040	−0.054	−0.029	−0.028	0.042	0.780
W_5	−0.133	−0.268	0.610	0.388	−0.012	−0.120	−0.461	−0.055	0.088	0.850
W_6	0.139	0.024	0.643	0.224	−0.172	−0.402	−0.063	−0.106	0.209	0.733
W_7	0.116	−0.163	0.488	−0.059	−0.078	−0.367	−0.460	0.021	−0.245	0.695
W_8	−0.027	−0.046	0.120	0.097	0.039	0.101	−0.885	0.003	−0.068	0.827
W_9	0.118	0.165	−0.121	−0.840	−0.107	0.120	0.054	−0.021	0.015	0.791
W_{10}	−0.181	−0.150	0.516	0.353	−0.084	0.007	−0.546	−0.079	−0.010	0.758
W_{11}	−0.017	0.155	−0.137	−0.746	−0.143	−0.253	0.177	0.054	−0.108	0.729
W_{12}	−0.113	−0.202	0.757	−0.153	0.258	−0.082	−0.311	−0.002	−0.017	0.819
W_{13}	−0.128	−0.126	0.867	0.205	−0.129	0.128	0.071	0.126	0.024	0.880
W_{14}	−0.024	0.065	−0.007	−0.127	0.142	−0.835	−0.100	0.071	0.090	0.762
W_{15}	0.040	0.032	0.404	−0.058	0.205	−0.595	0.192	−0.025	−0.184	0.636
W_{16}	0.020	−0.157	0.234	−0.406	−0.291	−0.182	−0.142	−0.169	0.434	0.599
W_{17}	−0.027	0.014	0.013	0.043	−0.270	−0.802	0.077	0.031	−0.053	0.729
C_1	0.931	0.052	0.030	−0.039	−0.056	0.094	0.057	−0.223	−0.033	0.809
C_2	0.087	0.035	0.050	0.050	0.064	0.312	0.023	−0.738	0.102	0.939
C_3	0.913	0.206	−0.020	−0.092	−0.111	−0.066	0.142	−0.002	−0.142	0.671
C_4	0.725	0.077	0.049	−0.131	−0.216	−0.103	0.228	−0.145	−0.458	0.941
C_5	0.520	0.083	0.065	−0.062	−0.537	−0.020	0.154	−0.186	−0.443	0.891
C_6	0.200	0.386	0.048	−0.019	−0.134	−0.238	0.015	−0.620	−0.243	0.816
C_7	0.214	−0.185	−0.080	−0.210	−0.799	−0.161	0.083	−0.055	−0.151	0.710

C_8	−0.436	−0.247	−0.097	−0.107	−0.669	−0.081	−0.125	0.077	0.251	0.827
C_9	0.741	0.395	−0.189	−0.031	0.157	0.052	−0.147	0.223	0.254	0.812
C_{10}	0.773	0.369	−0.145	0.057	0.045	0.114	−0.128	0.217	0.257	0.904
C_{11}	0.352	0.749	−0.239	−0.193	−0.152	0.016	−0.059	−0.009	0.114	0.902
C_{12}	0.856	0.152	−0.041	−0.052	−0.078	−0.032	−0.037	−0.213	−0.183	0.820
C_{13}	−0.439	−0.302	0.288	0.055	−0.223	0.104	0.145	0.591	−0.092	0.848
C_{14}	0.140	−0.014	−0.047	−0.057	−0.179	−0.065	−0.183	0.018	−0.803	0.809
C_{15}	0.841	0.444	−0.010	−0.041	−0.081	0.066	0.082	0.013	−0.015	0.741
C_{16}	−0.755	0.165	0.154	0.138	0.019	0.181	0.063	0.442	0.074	0.923
C_{17}	0.157	0.167	0.147	−0.051	−0.614	0.157	−0.020	0.121	−0.150	0.878
C_{18}	−0.140	−0.886	−0.041	−0.007	−0.152	0.060	−0.059	0.137	0.133	0.516
Value λ_i	6.618	4.701	3.445	2.554	2.477	2.464	2.020	1.865	1.855	0.800
Sum of λ_i	6.618	11.139	14.764	17.318	19.795	22.259	24.279	26.144	27.992	
Cumulative proportion	18.9%	32.3%	42.2%	49.5%	56.6%	63.6%	69.4%	74.7%	80.0%	

Table 3. Meanings of nine factors.

Factor	Meaning	Odor pattern	Quality pattern	Cumulative percentage
I	"Plenty of contents"		Z_1	18.9%
II	"Blend ratio of brewed soy sauce to amino acid solution" "Alcohol fermentation"	F_1	Z_5	32.3
III	"Microbial contamination"	F_2		42.2
IV	"Pasteurization"	F_5		49.5
V	"Amino acid decomposition"		Z_2	56.6
VI	"Degree of ripening"	F_4		63.6
VII	"Medicinal dependent on *Asp. oryzae* strain"	F_3		69.4
VIII	"Organic acid fermentation" "Artificial additions"		Z_3, Z_4	74.7
IX	"Appearance"		Z_6	80.0

from "construction of quality patterns on the chemical factors"[9] and "construction of odor patterns on the odor judgement"[10] in the previous papers, are shown in Table 3. The nine pattterns obtained are considered to have almost the same meanings as quality patterns and odor patterns. The relevancy between nine patterns and each factors is shown in Table 4. These patterns explain about 80% of total variance. Only one out of nine patterns connected with both odor and quality. Four patterns connected with

Table 4. Relevancy between patterns (odor, quality) and chemical factors (sensory terms on odor).

Quality pattern	Chemical factor
Z_1:	C_1, C_3, C_4, C_9, C_{10}, C_{12}, C_{15}, C_{16}.
Z_2:	C_5, C_7, C_8, C_{17}.
Z_3:	C_{13}, C_{16}, C_6.
Z_4:	C_2, C_{17}.
Z_5:	C_{11}, C_{18}.
Z_6:	C_{14}.
Odor pattern	**Sensory term on odor**
F_1:	W_1, W_2, W_3, W_4.
F_2:	W_5, W_6, W_7, W_{12}, W_{13}.
F_3:	W_8, W_{10}.
F_4:	W_{14}, W_{15}, W_{17}.
F_5:	W_9, W_{11}.

only odor, and the other four patterns connected with only quality. Namely, no similarity was observed patterns odor between ($F_{2\alpha}\sim F_{5\alpha}$) and quality patterns ($Z_{1\alpha}\sim Z_{4\alpha}, Z_{6\alpha}$). However, the pattern related to blend ratio of brewed soy sauce to amino acid solution ($F_{1\alpha}$) well correlated to the pattern related to alcohol fermentation ($Z_{5\alpha}$) on the second factor (Fig. 2, Table 3). In other words, the strongest linear relation was observed between $F_{1\alpha}$ and $Z_{5\alpha}$.

The soy sauce that contains more alcohol by pure brewing or good fermentation has more perfume as soy sauce, more alcoholic odor, and acid odor. But the soy sauce containing less alcohol or more amino acid solution (i.e., amino acid soy sauce or bad fermented soy sauce) has more smell of amino acid solution and less perfume.

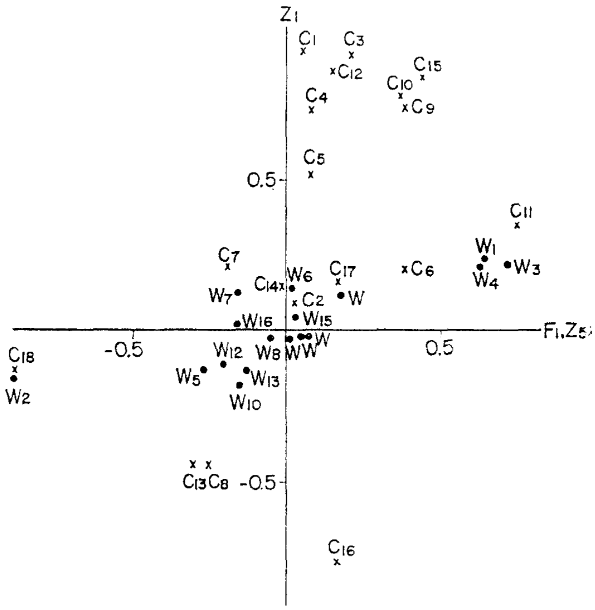

Fig. 2. The relation among factor loading on Factor I (Z_1) and Factor II (Z_5), (F_1).

2. Linear relation between odor patterns and chemical factors

In the above section the strongest linear relation was observed between the odor pattern ($F_{1\alpha}$) and quality pattern ($Z_{5\alpha}$). In this section the authors will describe whether five odor patterns are affected by any of 19 chemical factors or not. To study these relationships will give one of the most important informations for making up more desirable odor patterns by brewing process on preference (quality) of soy sauce.

The following multi-linear regression model was assumed for these relations, and the regression coefficient (β_k), multiple correlation coefficients and other parameters were calculated.

$$F_{i\alpha}=\beta_1 C_{1\alpha}+\beta_2 C_{2\alpha}+\cdots+\beta_{19}C_{19\alpha}+\beta_0$$
$$(i=1,2,\cdots,5;\ k=1,2,\cdots,19;\ \alpha=1,2,\cdots,59)$$

The correlation coefficients and T-values of chemical factors to each odor patterns are shown in Table 5.

i. Linear relation between odor pattern related to blend ratio of brewed soy sauce to amino acid solution ($F_{1\alpha}$) and chemical factors (C_k).

The multi-linear regression model obtained was as follows:

$$F_{1\alpha}=-1.020C_{1\alpha}+0.143C_{2\alpha}+0.512C_{3\alpha}+2.348C_{4\alpha}-3.509C_{5\alpha}$$
$$+6.165C_{6\alpha}-0.261C_{7\alpha}+2.946C_{8\alpha}+0.814C_{9\alpha}-0.676C_{10\alpha}$$
$$+2.277C_{11\alpha}+0.021C_{12\alpha}-1.878C_{13\alpha}+0.057C_{14\alpha}-0.049C_{15\alpha}$$
$$+2.077C_{16\alpha}-0.012C_{17\alpha}-0.685C_{18\alpha}-200.671C_{19\alpha}+14.542$$

(Multiple correlation coefficient: 0.879)

Table 5. Correlation coefficients, T-values and contributing proportion of each chemical factors to odor patterns.

F_i	F_1		F_2		F_3		F_4		F_5	
	Correlation computed		Correlation computed		Correlation computed		Correlation computed		Correlation computed	
C_k	C_k vs F_1	T-value	C_k vs F_2	T-value	C_k vs F_3	T-value	C_k vs F_4	T-value	C_k vs F_5	T-value
C_1	0.289*	−0.817	−0.126	1.360	−0.146	0.651	−0.007	0.103	0.193	−0.153
C_2	0.049	0.148	−0.032	−0.971	0.030	−0.040	−0.194	−0.849	−0.142	−1.132
C_3	0.451**	1.509	−0.219	−0.570	−0.296*	−1.073	0.117	1.161	0.383**	0.776
C_4	0.345**	0.182	−0.143	−0.107	−0.254*	0.855	0.154	−0.138	0.340**	0.177
C_5	0.240	−1.085	−0.074	0.495	−0.126	0.522	0.089	−0.933	0.189	−1.514
C_6	0.359**	0.671	−0.037	0.769	−0.120	0.299	0.219	1.084	0.312*	2.323**
C_7	0.075	−0.019	−0.072	−0.543	−0.136	−1.209	0.167	−0.384	0.161	−0.125
C_8	−0.232	0.162	0.076	0.545	0.102	1.100	0.052	0.575	−0.141	0.219
C_9	0.495**	1.656	−0.300*	−0.650	−0.233	−1.199	−0.063	0.160	0.292*	1.635
C_{10}	0.426**	−1.084	−0.261*	−0.592	−0.190	1.173	−0.104	−1.565	0.216	−1.803
C_{11}	0.774**	3.137**	−0.479**	−2.036*	−0.418**	−0.556	0.027	−0.060	0.497**	2.211**
C_{12}	0.376**	0.016	−0.152	0.679	−0.152	1.035	0.066	0.171	0.218	−1.263
C_{13}	−0.453**	−0.613	0.276	0.552	0.221	0.805	−0.030	0.542	−0.203	−0.191
C_{14}	0.063	0.603	0.004	−0.378	0.015	0.598	0.115	0.242	0.087	0.773
C_{15}	0.554**	−0.020	−0.265*	0.485	−0.307*	−0.841	0.025	1.087	0.356**	1.111
C_{16}	−0.195	0.720	0.116	−0.023	0.111	−0.358	−0.153	−0.839	−0.203	0.273
C_{17}	0.101	−0.071	−0.005	−0.077	−0.031	−0.309	−0.000	−0.861	0.000	−0.775
C_{18}	−0.678**	−0.535	0.222	−1.310	0.310*	−0.299	−0.080	−0.727	−0.300*	1.578
C_{19}	−0.466**	−1.913	0.327**	1.093	0.301*	0.788	0.061	0.233	−0.293*	−1.976*
Total	0.879**	☆77.2%	0.662−	☆43.8%	0.629−	☆39.6%	0.572−	☆32.7%	0.762	☆58.0%

*: Significant at 5% level, **: Significant at 1% level, −: No significant.
☆: Contributing proportion.

The contributing proportion of this model was about 77.2% and the correlation of odor patterns ($F_{1\alpha}$) to 19 chemical factors was significant at 1% level. Especially, the direct relationship of only alcohol to the odor pattern was significantly recognized. As shown in Figs. 3, 4 and Table 5, levulinic acid, reducing sugar, specific viscosity and other chemical factors but alcohol superficially related to the odor pattern ($F_{1\alpha}$). However, more alcohol brewed in soy sauce seems to be the

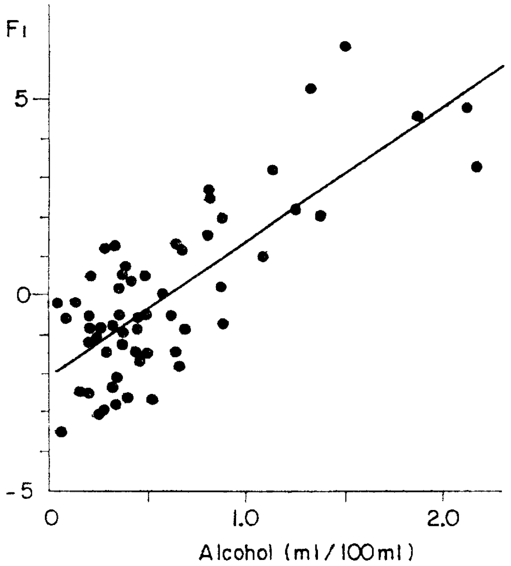

Fig. 3. Linear regression estimator between odor pattern related to blend ratio of brewed soy sauce to amino acid solution (F_1) and alcohol (C_{11}).
$F_{1\alpha}=3.448\times C_{11\alpha}-2.091$ (r=0.774)

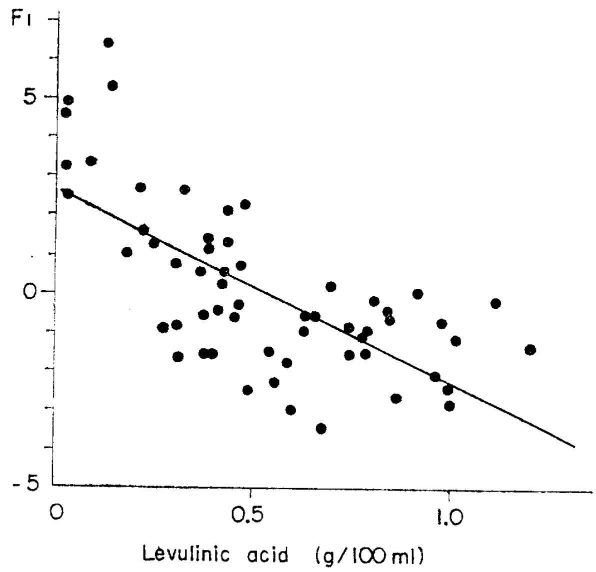

Fig. 4. Linear regression estimator between odor pattern related to blend ratio of brewed soy sauce to amino acid solution (F_1) and levulinic acid (C_{18}).
$F_{1\alpha}=-4.845\times C_{18\alpha}+2.449$ (r=−0.678)

most important factor to make up higher odor pattern ($F_{1\alpha}$).

ii. Linear relation between odor pattern related to microbial contamination ($F_{2\alpha}$) and chemical factors (C_k).

The multi-linear regression model obtained was as follows:

$$F_{2\alpha}=2.638F_{1\alpha}-1.450F_{2\alpha}-0.300F_{3\alpha}-2.145F_{4\alpha}+2.487F_{5\alpha}+10.971F_{6\alpha}$$
$$-11.418F_{7\alpha}+15.366F_{8\alpha}-0.496F_{9\alpha}-0.573F_{10\alpha}-2.296F_{11\alpha}$$
$$+1.357F_{12\alpha}+2.628F_{13\alpha}-0.056F_{14\alpha}+1.813F_{15\alpha}-0.104F_{16\alpha}$$
$$-0.021F_{17\alpha}-2.606F_{18\alpha}+178.213F_{19\alpha}-41.497$$

(Multiple correlation coefficient: 0.662)

The contributing proportion of this model was about 43.8% and this odor pattern was not significantly related to 19 chemical factors. The direct relation of only alcohol to $F_{2\alpha}$ was significantly recognized. As shown in Figs. 5, 6 and Table 5, reducing sugar, pH, and dulcin superficially related to the odor pattern, but the direct relations of these factors to $F_{2\alpha}$ were not recognized. Namely, the odor pattern related to microbial contamination ($F_{2\alpha}$) was influenced by a alcohol, but the other chemical factors did not influence very much to $F_{2\alpha}$.

iii. Linear relation between odor pattern related to medicinal ($F_{3\alpha}$) and chemical factors (C_k).

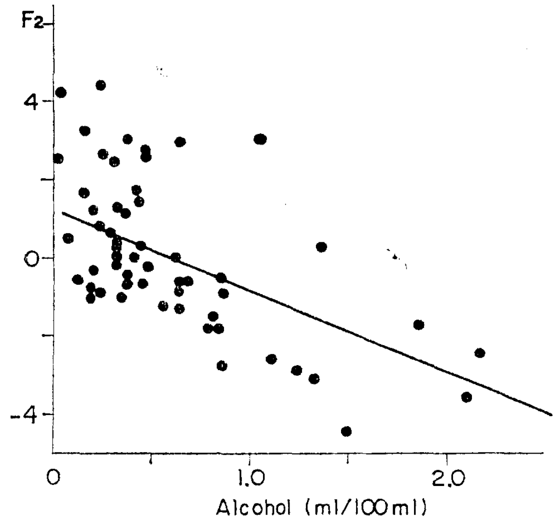

Fig. 5. Linear regression estimator between odor pattern related to miccrobial contamination (F_2) and alcohol (C_{11}).
$F_{2\alpha}=-2.111\times C_{11\alpha}+1.250$
($r=-0.479$)

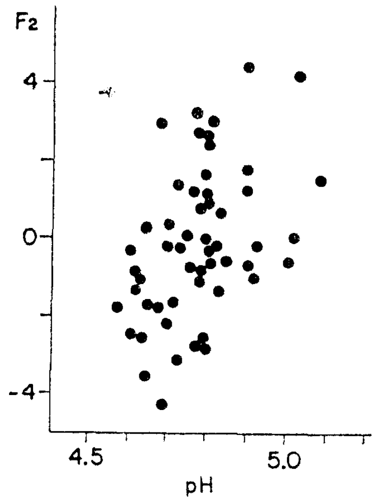

Fig. 6. Linear regression estimator between odor pattern related to microbial contamination (F_2) and pH (C_{13}).
$F_{2\alpha}=3.590\times C_{13\alpha}-17.194$
($r=0.276$)

The multi-linear regression model obtained was as follows:

$$F_{3\alpha}=1.182C_{1\alpha}-0.055C_{2\alpha}-0.529C_{3\alpha}+16.089C_{4\alpha}+2.456C_{5\alpha}+3.992C_{6\alpha}$$
$$-23.827C_{7\alpha}+29.034C_{8\alpha}-0.857C_{9\alpha}+1.063C_{10\alpha}+0.587C_{11\alpha}$$
$$+1.936C_{12\alpha}+3.589C_{13\alpha}+0.082C_{14\alpha}-2.943C_{15\alpha}-1.504C_{16\alpha}$$
$$-0.079C_{17\alpha}-0.556C_{18\alpha}+120.268C_{19\alpha}-51.663$$

(Multiple correlation coefficient: 0.662)

The contributing proportion of this model was about 39.6% and this odor pattern ($F_{3\alpha}$) was not significantly correlated to 19 chemical factors. As shown in Fig. 7 and Table 5, soy sauce containing more alcohol had little medicinal, but the direct relations of all chemical factors to $F_{3\alpha}$ were significantly recognized.

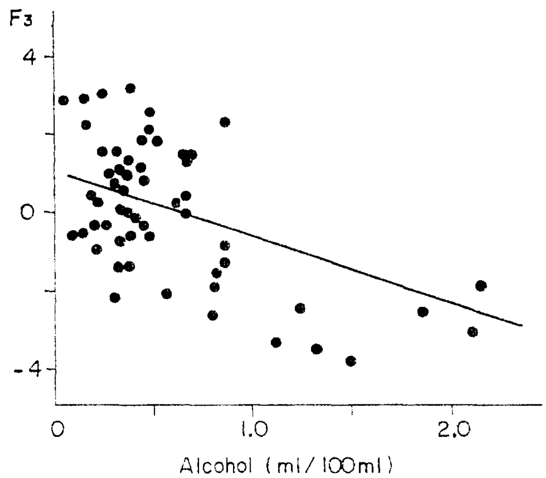

Fig. 7. Linear regression estimator between odor pattern related to medicinal dependent on *Asp. oryzae* strain (F_3) and alcohol (C_{11}).
$F_{3\alpha}=-1.665\times C_{11\alpha}+0.985$ ($r=-0.418$)

iv. Linear relation between odor pattern related to degree of ripening ($F_{4\alpha}$) and chemical factors (C_k).

The multi-linear regression model obtained was as follows:

$$F_{4\alpha}=0.160C_{1\alpha}-1.017C_{2\alpha}+0.490C_{3\alpha}-2.218C_{4\alpha}-3.755C_{5\alpha}+12.397C_{6\alpha}$$
$$-6.472C_{7\alpha}+12.992C_{8\alpha}+0.098C_{9\alpha}-1.214C_{10\alpha}-0.054C_{11\alpha}$$

$$+0.274C_{12\alpha}+2.069C_{13\alpha}+0.028C_{14\alpha}+3.260C_{15\alpha}-3.012C_{16\alpha}$$
$$-0.187C_{17\alpha}-1.159C_{18\alpha}+30.406C_{19\alpha}-3.201$$

(Multiple correlation coefficient: 0.512)

The contributing proportion of this model was about 32.7% and this odor pattern was not significantly correlated to these chemical factors. Moreover, the direct and essential relation of each chemical factor to $F_{4\alpha}$ was not recognized. It can be considered that there is no effect of these chemical factors on $F_{4\alpha}$.

v. Linear relation between odor pattern related to pasteurization ($F_{5\alpha}$) and chemical factors (C_k).

The multi-linear regression model obtained was as follows:

$$F_{5\alpha}=-0.195C_{1\alpha}-1.112C_{2\alpha}+0.269C_{3\alpha}+2.341C_{4\alpha}-4.998C_{5\alpha}+21.790C_{6\alpha}$$
$$-1.736C_{7\alpha}+4.061C_{8\alpha}+0.821C_{9\alpha}-1.148C_{10\alpha}+1.639C_{11\alpha}$$
$$-1.659C_{12\alpha}-0.598C_{13\alpha}+0.075C_{14\alpha}+2.734C_{15\alpha}+0.805C_{16\alpha}$$
$$-0.138C_{17\alpha}+2.064_{18\alpha}-211.745C_{19\alpha}+14.873$$

(Multiple correlation coefficient: 0.762)

The contributing proportion of this model was about 58.0% and correlation of the odor pattern ($F_{5\alpha}$) to 19 chemical factors was significant at 1% level. Especially, the direct relation of NH_3-nitrogen, alcohol or dulcin to $F_{5\alpha}$ was recognized as shown in Figs. 8, 9 or Table 5. Fig. 11 illustrates the above relation concerning the production process of soy sauce[19]. The odor patterns of $F_{1\alpha}$ and $F_{5\alpha}$ were significantly (1% level) correlated to 19 chemical factors. The strongest correlation was observed between odor patterns and alcohol. To produce more alcohol by brewing in soy sauce gave higher $F_{1\alpha}$ and $F_{5\alpha}$ and lower $F_{2\alpha}$ and $F_{3\alpha}$, and seems

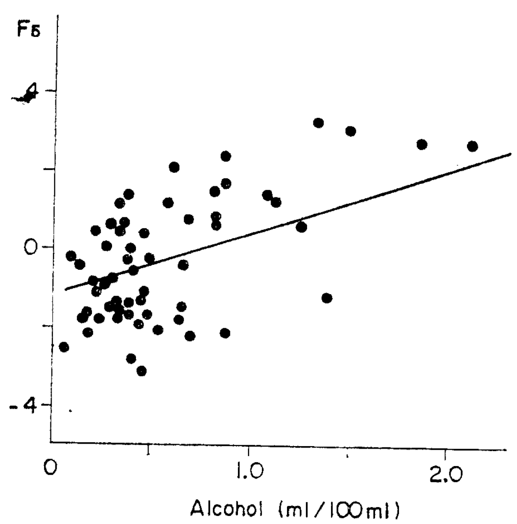

Fig. 8. Linear regression estimator between odor pattern related to pasteurization (F_5) and alcohol (C_{11}).

$F_{5\alpha}=1.665\times C_{11\alpha}-1.190$

($r=0.497$)

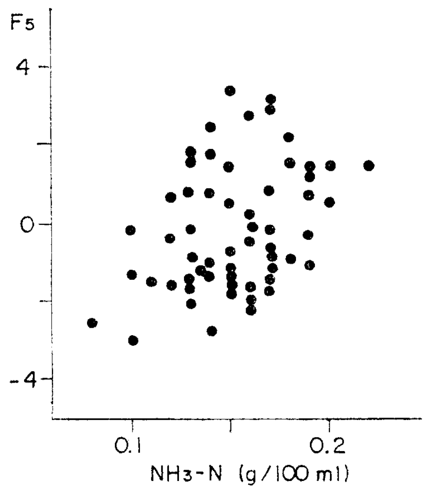

Fig. 9. Linear regression estimator between odor pattern related to pasteurization (F_5) and NH_3-nitrogen (C_6).

$F_{5\alpha}=17.821\times C_{6\alpha}-2.923$

($r=0.311$)

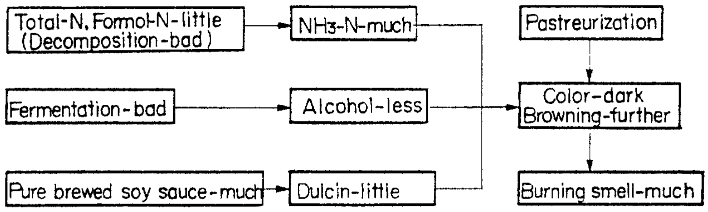

Fig. 10. Direct relation of NH_3-nitrogen, alcohol and dulcin to burning smell.

to be the most important condition to make soy sauce of highly preferable quality.

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