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Analyses of Flavor Qualities of Vegetable Oils by Gas Chromatography

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가스크로마토그래피에 의한 식물성 기름의 향미품질의 분석

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Abstract

Soybean, hydrogenated soybean and corn oils, which were exposed to fluorescent light for different periods of time, were evaluated for sensory qualities by subjective sensory evaluation and instrumental gas chromatographic analysis. Sensory evaluation was conducted in 8 laboratories using a 10-point hedonic scale with a total of 95 panel members. The correlation coefficients between sensory scores and predicted sensory scores by gas chromatographic analysis for the 8 laboratories varied from 0.10 to 0.99. However, most laboratories had better than 0.90, which was considered excellent. The correlation coefficients between sensory scores of the 95 panel members and predicted sensory scores using the amount of 2, 4-decadienal isomers in oil determined by a gas chromatographic method for soybean, hydrogenated soybean, and corn oils, were r=0.96, r=0.97, and r=0.97, respectively. The correlation study suggests that it is possible to obtain realistic results of oil flavor qualities from the instrumental evaluation by combining improved gas chromatographic analysis, sensory evaluation, and statistical analysis for practical purposes.

Introduction

With the remarkable advancements in analytical instruments used in food science during the last 20 years, numerous papers have been published on the instrumental analyses of flavor qualities for many foods.[1-5] The application of instrumental methods to evaluate the sensory qualities of oil has been reported[6-11] and summarized by Min and Kim.[12] These papers reported a good correlation coefficient of better than 0.90 between sensory scores and predicted sensory scores by a gas chromatographic method for soybean oils where more than 20 samples were analyzed. However, most of the sensory evaluations used for the development of correlation coefficients between instrumental and sensory methods were performed with a limited number of about 12 panel members in a laboratory.[7-10] The scientific validity of excellent correlation coefficients reported in these studies has been questioned by some scientists due to the limited number of sensory panel members. Another question has been raised as to whether a gas chromatographic analysis done by one laboratory would have a good correlation coefficient with the sensory scores obtained by other laboratories.

The objectives of this investigation were to study (1) the correlation coefficients between sensory scores from 95 panel members at the 8 different laboratories and predicted sensory scores by gas chromatographic analysis from a specific laboratory and (2) the correlation coefficients between sensory scores of individual laboratories and predicted sensory scores by gas chromatographic analysis from a specific laboratory for

soybean oil, hydrogenated soybean oil and corn oil.

Materials and Methods

Flavor isolation, gas chromatographic analysis and identification of flavor compounds

The procedures for the preparation of the flavor isolation apparatus, flavor compounds isolation from oils, gas chromatographic analysis of flavor compounds isolated, and identification of flavor compounds by mass spectrometry were essentially the same as described by Min.[11] Compounds identified by mass spectrometry were confirmed by comparing the gas chromatographic retention times with those of authentic compounds.

Sample preparation and sensory analysis

Soybean oil (I.V. 135), hydrogenated soybean oil (I.V. 110), and corn oil (I.V. 125) were exposed to 700 ft.-candle light of fluorescence by the method of Moser, *et al*[13] for different periods of time as shown in Tables 1, 2 and 3.

Sensory analysis was essentially the same as described by Min.[11] Sensory qualities of different oils were evaluated using a hedonic scale of 1 to 10, where 1 indicated the poorest flavor quality and 10 the highest flavor quality.

Results and Discussion

The sample description, sensory scores, content of 2,4-decadienals, predicted sensory scores by gas chromatography and correlation coefficients between sensory scores and predicted sensory scores by gas chromatography for soybean oils, hydrogenated soybean oils and corn oils, are shown in Tables 1, 2 and 3, respectively.

THe participating laboratories were university, industry and government laboratories, and the panel size in each laboratory ranged from 7 to 24 members.

The soybean oil was exposed to 700 foot-candle light for 0, 1, 8, and 45 hrs., to obtain a wide range of sensory qualities. The sensory sco-

Table 1. Sample Description, Sensory Scores, Content of 2, 4-Decadienals, Predicted Sensory Scores by Gas Chromatography and Correlation Coefficients Between Actual and Predicted Sensory Scores for Each Individual Laboratory and Total Panel for Soybean Oils

LABORATORIES	1	2	3	4	5	6	7	8	Total	Content of
PANEL MEMBERS	9	16	24	7	10	11	10	8	Panel95	2,4-Decadienal[a]
Control Sample (0-Hr.)[b]										
Sensory Score	8.33	7.88	7.83	8.14	7.50	8.27	7.20	7.38	7.82	102
Predicted Score	8.33	7.53	7.91	8.11	7.45	8.27	7.62	7.59	7.78	
Lightly-Abused Sample (1-Hr.)[b]										
Sensory Score	8.22	7.50	7.88	8.29	7.45	8.91	8.10	7.88	7.98	164
Predicted Score	8.22	7.39	7.79	8.05	7.34	7.90	7.60	7.45	7.68	
Moderately-Abused Sample (8-Hrs.)[b]										
Sensory Score	7.56	5.94	·····	7.29	6.50	5.41	7.40	6.38	6.53	520
Predicted Score	7.56	6.58	·····	7.66	6.67	7.10	7.46	6.65	7.07	
Heavily-Abused Sample (45-Hrs.)[b]										
Sensory Score	5.78	4.56	5.29	6.71	4.90	5.36	7.10	4.50	5.41	1498
Predicted Score	5.77	4.37	5.29	6.61	4.85	4.89	7.10	4.43	5.41	
Correlation Coefficient	0.99	0.96	0.99	0.93	0.99	0.78	0.54	0.98	0.96	

[a] Peak Area of 2,4-Decadienals which was Calculated by Electronic Integrator in the Gas Chromatograph

[b] Light-exposure Hours to 700 foot-Candle Light of Fluorescence

Table 2. Sample Description, Sensory Scores, Content of 2,4-Decadienals, Predicted Sensory Scores by Gas Chromatography and Correlation Coefficients Between Actual and Predicted Sensory Scores for Each Individual Laboratory and Total Panel for Hydrogenated Soybean Oils

LABORATORIES	1	2	3	4	5	6	7	8	Total	Content of
PANEL MEMBERS	9	16	24	7	10	11	10	8	Panel 95	2,4-Decadienals[a]
Control Sample (0-Hr.)[b]										
Sensory Score	7.78	8.38	8.13	8.43	7.67	8.91	8.30	3.50	7.83	157
Predicted Score	7.76	7.77	7.89	8.28	7.76	8.10	8.37	3.44	7.58	
Lightly-Abused Sample (1-Hr.)[b]										
Sensory Score	7.78	7.44	7.83	8.14	8.00	7.59	8.40	3.50	7.46	112
Predicted Score	7.91	7.97	8.08	8.43	7.97	8.29	8.52	3.46	7.74	
Moderately-Abused Sample (4-Hrs.)[b]										
Sensory Score	7.00	6.00	6.50	7.57	6.22	6.27	7.85	3.50	6.38	528
Predicted Score	6.56	6.10	6.32	6.98	5.99	6.41	7.13	3.69	6.21	
Heavily-Abused Sample (44-Hrs.)[b]										
Sensory Score	5.75	5.44	5.54	6.00	5.11	5.77	6.10	3.88	5.48	681
Predicted Score	6.06	5.41	5.68	6.44	5.26	5.72	6.62	3.75	5.63	
Correlation Coefficient	0.94	0.88	0.98	0.90	0.99	0.89	0.87	0.74	0.97	

[a] Peak Area of 2,4-Decadienals which was Calculated by Electronic Integrator in the Gas Chromatograph

[b] Light-exposure Hours to 700 foot-Candle Light of Fluorescence

Table 3. Sample Description, Sensory Scores, Content of 2,4-Decadienals, Predicted Sensory Scores by Gas Chromatography and Correlation Coefficients Between Actual and Predicted Sensory Scores for Each Individual Laboratory and Total Panel for Corn Oils

LABORATORIES	1	2	3	4	5	6	7	8	Total	Content of
PANEL MEMBERS									Panel 95	2,4-Decadienals[a]
Control Sample (0-Hr.)[b]										
Sensory Score	6.00	6.38	6.79	6.57	7.10	6.27	6.56	6.50	6.55	494
Predicted Score	6.00	6.43	6.85	6.62	7.10	6.59	6.61	5.79	6.65	
Lightly-Abused Sample (1-Hr.)[b]										
Sensory Score	5.67	6.25	6.21	6.29	6.50	6.14	6.44	6.00	6.20	879
Predicted Score	6.05	6.00	5.91	6.38	6.30	5.70	6.39	5.27	6.15	
Moderately-Abused Sample (8-Hrs.)[b]										
Sensory Score	6.67	5.69	5.42	6.64	5.80	5.86	6.44	6.13	5.93	989
Predicted Score	6.06	5.87	5.64	6.31	6.07	5.44	6.33	5.12	6.00	
Heavily-Abused Sample (27-Hrs.)[b]										
Sensory Score	5.89	5.63	·····	6.00	5.70	4.41	6.11	5.25	5.54	1210
Predicted Score	6.09	5.63	(5.10)	6.17	5.61	4.93	6.20	4.82	5.63	
Correlation Coefficient	0.10	0.88	0.92	0.65	0.95	0.81	0.88	0.90	0.97	

[a] Peak Area of 2,4-Decadienals which was Calculated by Electronic Integrator in the Gas Chromatograph

[b] Light-exposure Hours to 700 foot-Candle Light of Fluorescence

res of the control soybean oil from each of 8 laboratories ranged from 7.20 to 8.33, and the average sensory score of the 95 panel members was 7.82. The sensory scores of the soybean oil decreased as the light exposure increased from 0 to 45 hrs., as was expected.

The gas chromatograms of soybean oils having differnet fluorescent light exposure at 700 foot-candle light are shown in Fig. 1. As the light exposure increased from 0 to 45, the area of peaks 3 and 4, which are isomers of 2,4-decadienal, increased from 102 to 1498 electronic counts.

Since the amount of isomers of 2,4-decadienal in soybean oil increased and the sensory scores decreased, a linear regression equation for predicting sensory scores by gas chromatography was developed from the sensory scores of the total 95 panel members and the content of 2,4-decadienals in the different soybean oils. The linear regression equation was $y=7.96-0.0018x$, where y is the predicted sensory score, and x is the content of 2,4-decadienal isomers in soybean oil.

Using the linear regression equation, the sensory scores for soybean oils have been calculated and the results are shown in Table 1. A comparison of sensory scores obtained by the subjective sensory panel and an instrumental gas chromatographic method indicates that the scores obtained by the 2 methods were in good agreement for soybean oils. The correlation coefficients between instrumental gas chromatographic analysis and sensory analysis of the total 95 panel members for soybean oil was $r=0.96$.

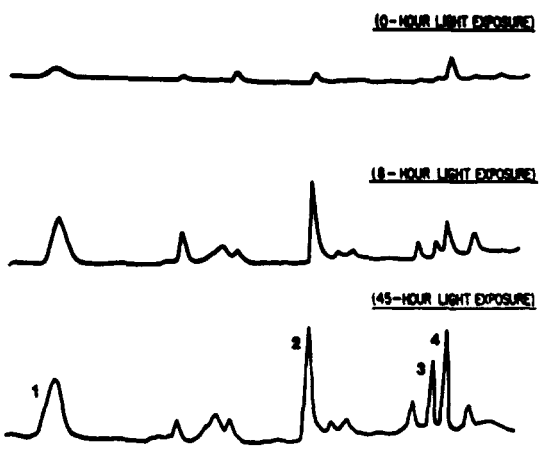

Fig. 1. Gas chromatograms of volatile compounds in soybean oils: (1) pentane; (2) 2-heptenal; (3) Trans, cis 2, 4-decadienal; and (4) Trans, trans 2, 4-decadienal

Similarly, a linear regression equation was developed to determine the predicted sensory scores for soybean oils using the content of 2,4-decadienals in the soybean oil and the sensory scores of individual laboratories. The predicted sensory scores calculated from the linear regression equations listed in Table 1 were in good agreement in 7 out of 8 laboratories.

The correlation coefficients betwen sensory scores and predicted sensory scores for each of the 8 laboratories are shown in Table 1 and anged from $r=0.54$ to $r=0.99$. Laboratory 7 with only $r=0.54$ evaluated the sensory quality of the moderately abused sample (8-hr. light exposure) higher than the control sample of 0-hr. light exposure, and the sensory scores of the control sample and heavily-abused sample were evaluated almost equally. All 7 other laboratories with good correlation coefficients consistently evaluated the control sample better than the moderately-abused sample or the heavily-abused sample. This result may indicate that the sensory panel of Laboratory 7 did not have good discriminating power of sensory judgment to distinguish between the 2 samples of control and heavily-abused oils which were quite different in flavor quality according to the sensory scores of the other 7 laboratories.

The linear regression equation for predicting sensory scores by gas chromatography for hydrogenated soybean oils was developed from the sensory scores of 95 panel members and the content of 2,4-decadienals in the hydrogenated soybean oils. The equation was $y=8.17-0.0037x$, where y is the predicted sensory score, and x is the content of 2,4-decadienals in hydrogenated soybean oils. the calculated predicted sensory scores using the above linear regression equation for differnet hydrogenated soybean oils listed in Table 2, were in very good agreement with the sensory scores of the 95 panel members. The correlation coefficient was $r=0.97$, which is excellent.

The predicted sensory scores using the linear regression equations developed from the sensory scores of individual laboratories and the content of 2,4-decadienals in hydrogenated soybean oils shown in Table 2, were also in good agreement with the sensory scores of participating individual laboratories. The correlation coefficients between sensory scores and predicted sensory scores by gas chromatography for 8 individual laboratories ranged from r=0.74 to r=0.99.

Similarly, the linear regression equation for predicting sensory scores for corn oils developed from the sensory scores of 95 panel members of 8 laboratories and the content of 2,4-decadienals in corn oil was $y=7.30-0.0013x$, where y is the predicted sensory score and x is the content of 2,4-decadienals in corn oil. The correlation coefficient was r=0.97, which was excellent.

The excellent correlations between sensory scores and predicted sensory scores by instrumental gas chromatographic analyses for soybean oil, hydrogenated soybean oil and corn oil indicate that instrumental G.C. analysis can predict sensory scores which are in good agreement with the sensory scores of panel members.

Individual laboratories which evaluated the sensory qualities according to the degree of light exposure to soybean oil, hydrogenated soybean oil or corn oil had good correlation coefficients between sensory scores and predicted sensory scores by gas chromatography.

The correlation coefficients between sensory scores and predicted sensory scores by gas chromatography can be generally improved by either increasing the number of sensory panel members and/or by improving the sensitivity to discriminate sensory differences among different oils according to the degree of light abuse treatment applied.

This extensive correlation study between an instrumental gas chromatographic analysis and sensory evaluations of 3 different types of vegetable oils from 8 laboratories suggests that it is possible to obtain some realistic and good results in the search for instrumental evaluations of sensory quality of oils by combining improved sample preparation methods, gas chromatographic analysis, sensory evaluation, and statistical analysis.

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요 약

콩기름, 경화콩기름 및 옥수수기름을 형광하에서 산화시켜, 향미품질을 관능검사및 가스크로마토 그라피(GC)로 분석하였다. 관능검사의 경우, 10점 Hedonic scale을 사용하여 8개의 각기 다른 연구소에서 시행하였는데, 총 평가원의 수는 95명이었다. 관능검사에 의한 기름의 향미 품질값과 GC에 의한 계산된 향미품질값 사이의 상관계수는 0.10~0.99사이에 나타났으나, 대부분의 경우 상관계수 0.9이상의 높은 상관관계를 보였다. 총평가원의 관능검사에 의한 향미품질값과 GC에 의한 향미품질값과의 상관계수는 콩기름 0.96, 경화콩기름 0.97 및 옥수수기름 0.97이었다. 가스크로마토그래피에 의한 향미품질값의 계산은 2,4-decadienal이성체의 합계를 근거로 하였다. 이 상관관계 연구는, 식용유의 향미성분에 의한 품질검사가 GC분석, 관능검사 및 통계처리가 적합할 경우, 실제 공정에 필요한, 유용한 방법으로 쓰일 수 있음을 시사하였다.

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