최 종
연구보고서

국내산 주요 식물소재의 향기성분 분석에 관한 연구

Studies on Volatile Flavor Components in Domestic Plant Materials

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요 약 문

Ⅰ. 제 목

국내산 주요 식물소재의 향기성분 분석에 관한 연구

Ⅱ. 연구개발의 목적 및 중요성

식품산업에서 향료는 식품에 대한 소비자의 기호나 선택을 좌우 할 수 있는 결정적인 가치를 지니고 있으며, 그 중 천연향은 인공향이나 인공합성향에 대한 안전성 문제가 제기되면서 수요가 크게 증가하고 있어 국내에서도 이에 대한 관심이 필요하다.

천연향에 대한 높은 부가가치를 인정한 선진 각국에서는 천연향의 소재 개발이나 천연향 생산 및 생합성에 관한 연구가 매우 활발히 진행되고 있는 실정을 감안할 때 국내 주요 식품소재에 함유되어 있는 유용 천연향의 파악과 이를 기초로 한 천연향료의 생산기술이나 효과적인 이용방안을 위해 국내산 식물소재의 향기성분에 관한 자료 구축이 우선되어야 한다.

본 연구는 국내산 주요 과일이나 과채류 및 향신료의 향기성분을 분석하여 각 식물 소재에 함유된 독특한 향기성분을 규명함으로써 천연향 활용 및 생산연구를 위하여 국내에서 이용 가능한 향기성분 데이터 구축의 토대를 마련하고자 하였다.

Ⅲ. 연구개발의 내용 및 범위

국내산 주요 식물소재의 향기성분 분석을 위하여 국내산 과일류와 과채류 및

향신료를 선정하여 국내산 과일로는 각 품종별로 배 5종, 사과 5종, 포도 4종, 감 2종, 복숭아 5종, 자두 2종, 살구 1종, 매실 1종, 모과 1종, 감귤류 6종, 키위 1종과 과채류로는 메론 3종, 토마토 3종, 딸기 2종, 수박 1종, 참외 1종, 그리고 향신료는 산초의 잎과 열매, 방아잎과 부추 등 총 47종의 국내산 식물소재를 분석 대상으로 하였다.

향기성분 분석을 위한 GC-FID 및 GC/MS의 최적조건을 수립하기 위하여 적절한 capillary column의 선택과 분석시간 및 최적 분리를 위한 다양한 온도 program과 flow rate를 설정하였으며, 향기성분 동정을 위한 mass spectrum의 명확한 data를 얻기 위해 최적 GC/MS 조건을 수립하고자 하였다. 최적 분석 조건하에서 n-alkane계 표준물질을 조제하여 각 화합물의 보정된 머무름시간을 구한 후, 향기성분 분석에 필수요소인 각 성분들의 머무름지표값(retention index, RI)을 구하기 위한 basic program을 작성하였다. 식물소재로부터 휘발성 향기성분을 추출하기 위한 추출용매의 제조와 최적 추출방법을 수립하여 정유성분을 얻은 후, 이를 분석기기의 최적 분석조건에서 RI와 표준물질 및 library의 mass spectrum을 비교하여 휘발성 향기성분들을 동정하고, 동정된 성분들의 함유량을 정량하고자 하였다.

Ⅳ. 연구개발 결과 및 활용에 대한 건의

국내산 식물소재에 함유된 휘발성 향기성분을 분석하기 위하여 분석기기의 최적 분석조건과 향기성분의 추출용매 및 추출방법을 수립하였다.

과일, 과채류 및 향신료와 같은 국내산 식물소재를 선택하여 휘발성 향기성분을 분석하였다. 과일로는 모과 1종에서 총 138종, 황금배, 이마무라, 신고, 장십랑, 만삼길 등 5종의 배에서 각각 107종, 61종, 102종, 109종, 47종의 화합물이 확인되었다. 사과의 품종중 후지, 쓰가루, 홍옥(조나단), 홍로, 하향의 향기성분

을 분석한 결과 각각 98종, 67종, 99종, 82종, 66종의 화합물이 분리 동정되었다. 네오머스캇, 블랙올림피아, 캠벨, 델라웨어 포도등 4품종의 포도에서 각각 94종, 77종, 73종, 74종의 향기성분이 확인되었다. 부유와 대봉 등 2종의 감을 시료로 추출한 향기성분은 각각 69종, 99종의 화합물이 분리 동정되었다. 국내산 감귤류 중 유자, 금귤, 조생, 향상조생 그리고 껍질을 제거한 조생과육, 향상조생과육의 향기성분으로 각각 77종, 83종, 89종, 90종, 98종, 86종의 화합물이 분리 동정되었다. 백도, 천도, 유명도, 대구보, 황도 등 5종의 복숭아에 각각 86, 85종, 70종, 74종, 67종의 향기성분이 확인되었으며, 뷰티와 포모사 자두의 향기성분으로 99종, 96종의 화합물이 분리 동정되었다. 살구의 휘발성 향기성분은 79종이, 매실에서 81종의 향기성분이, 헤이워드 키위의 향기성분으로 91종이 분리 동정되었다.

과채류중 빼빼, 꼬꼬, 도태랑 토마토의 향기성분으로 85종, 77종, 68종이 분리동정되었으며, 수홍과 보교 등 2종의 딸기에서 각각 143종, 133종의 향기성분이 확인정되었다. 별똥별, 파파이야, 머스크 메론의 휘발성 향기성분으로 각각 121종, 106종이, 그리고 참외와 수박에서 총 97종, 66종의 향기성분이 분리 동정되었다.

향신료중 산초의 잎과 열매에서 각각 144종, 92종이, 방아잎에서 86종, 부추에서 65종의 향기성분이 확인되었다.

본 연구를 통하여 축적된 국내산 과일 및 과채류와 향신료의 향기성분 데이터는 다양한 분야의 기초자료, 즉 식품가공산업에서 식물소재에 함유되어 있는 향기성분의 손실 및 변화를 추적하는 자료로 이용하여 제품의 고급화에 활용 될 수 있으며, 국내산 과일 및 과채류의 맛과 향기가 뛰어난 품종 개발을 위한 자료로 활용될 수 있으며, 미생물을 이용한 천연향 (bioflavor) 생산의 연구개발 및 식물소재에 다량 존재하는 천연향 전구물질(flavor precursor)의 이용 연구, 식물소재에 함유되어 있는 천연향에서 고부가가치 chiral성 향기성분의 연구자료로 활용할 수 있다. 또한, 본 연구결과는 수입 농산물과의 품질비교를 위한 기초자료로 이용하

고 농산물의 경쟁력 확보를 위한 홍보자료로 활용할 수 있으며, 과잉 생산된 과일이나 낙과, 폐과를 이용하여 고부가가치 천연향 소재로 활용하므로써 농민의 소득 증대를 기여할 수 있다.

SUMMARY

I. Project Title

Studies on the Volatile Flavor Components in Domestic Plant Materials

II. Objective and Importance of the Project

In food industry, flavors have an important influence on consumer decision making system. With occurrence the safety problem about artificial or synthetic flavors, the demand of bioflavor is increasing. Currently in Korea, there is a lack of interest of bioflavors. Therefore, Korea must understand and show high interest in bioflavors. The developed countries that understood the importance of bioflavors, are researching for development of bioflavors and production of bioflavors. The data of flavor components of plant materials should be constructed to understand bioflavor included in the food material in Korea and effectively use application method and production technology.

This study was conducted to construct the data of flavor components for application and production research of bioflavors, identifying the characteristics of flavor components in plant materials.

III. Scope and Contents of the Project

To analyze the flavor component of domestic plant materials, we

experimented total of 47 types of plant materials. The following are the experimented plant materials: five types of pears, five types of apples, four types of grapes, two types of persimmons, five types of peaches, two types of plums, one type of apricot, one type of Japanese apricot, one type of Chinese quince, six types of citrus fruit, one type of kiwi, three types of melons, three types of tomatoes, three types of strawberries, one type of watermelon, one type of oriental melon. Spices include Sanchoo leaves and seeds, Bangah herb and leek.

In order to establish the optimal conditions of GC-FID and GC/MS, conditioned temperature program and flow rate separation and analysis of time, selection of capillary column and the corrective conditions of GC/MS were used. After finding the retention time of compounds by analysis the mixture of n-alkane standards under the optimal conditions, we made basic program for calculating the retention index(RI) of individual component as a necessary factor in flavor analysis. Essential oil extracted by the optimal extraction method with organic solvent were analyzed under the optimal conditions. Volatile flavor components in plant materials were identified by comparison with RI, mass spectrum of standard and library.

IV. Results and Applications

To analyze the volatile flavor components of domestic plant materials, the optimal analysis condition and the extraction solvent and method of flavor components were used.

By selecting domestic fruits, vegetables, spices and plant materials, we

identified flavor components. The following fruits were analyzed for fragrant components of volatility: five types of pears (Mansamgil, Immamura, Shingo, Whangkeum, Jangshiplang), five types of apples (Fuji, Tsugaru, Jonathon, Honglo, Hahyang), four types of grapes (Neomuscat, Blackolympia, Campbell, Delaware), two types of persimmons (Buyu, Daebong), five types of peaches (Bekdo, Chundo, Yumungdo, Daegubo, Whangdo), two types of plums(Beauty, Pomosa), one type of apricot, type of Japanese apricot, and one type of Chinese quince. Six types of Citrus fruits(Yuzu, Kumquats, Hyangsanchosaeng, Josaeng, peeled Hyangsanchosaeng, peeled Josaeng), one type of Hayward kiwi fruit. In fruit-vegetables, three types of melons (Byultongbyul, Papaiya, Musk), three types of tomatoes (Paepae, Koko, Dotaerang), two types of strawberries(Suhong, Bokyu), and one type of watermelon and oriental melon. Also for spices, Sanchoo leaves and seeds, bangah herb and leek were analyzed.

The accumulated data of volatile flavor components in plant materials can be contributed to basic data in various field. That is, this data will be applied as follows: to quality improvement of product by monitoring the loss and changes of volatile flavor components in plant materials in food industry, to studies on production and development bioflavor using a microorganism, to studies on using flavor precursors, and to studies on high value of volatile components in bioflavor.

Farmers can use this data to compare with import agriculture and marketing data to secure competitive power. And these data can increase income of farmers by using overproduced fruits and damaged fruits to produce bioflavor or natural flavor.

C O N T E N T S

목 차

표 목 차

그 림 목 차

제 1 장 서 론

식품산업에서 향료는 다른 주요 성분에 비하여 미량으로 식품의 색이나 조직감과 더불어 제품의 품질을 평가하고, 식품에 대한 기호나 소비자의 선택을 좌우할 수 있는 결정적인 가치를 부여하고 있으며1), 현재 가공식품 80%이상이 제조생산시 향료를 첨가하거나 강화하고 있는 추세이다2,3).

식품제조나 공업용에 첨가되는 향료는 자연에 전혀 존재하지 않는 구조를 가진 화합물의 인공향(artificial flavor), 자연에 존재하는 화합물을 인공적으로 합성한 인공 합성향(natural identified flavor), 그리고 자연에서 직접 추출한 천연향(natural flavor)3)등이 동시에 사용되고 있다.

그러나 세계적으로 건강에 대한 관심이 높아짐에 따라 인위적 조작에 의해 생산된 인공 향이나 인공합성향은 이들의 합성시 동반 생성되는 부산물이나 특히 자연에 전혀 존재하지 않는 이성질체(stereoisomer 혹은 enantiomeric antiphode 등)의 생성으로 인하여 이들의 안전성 문제가 제기됨에 따라 선진각국에서는 몇몇 인공향(예, ethylvanillin등)을 제외하고는 인공합성향의 식품첨가에 대한 엄격한 규제나 제한4,5)을 하고 있다.

따라서 최근 천연향의 수요가 폭발적으로 증가됨에 따라 구미 각국에서는 천연향의 소재개발과 천연향의 생산 및 생합성에 대한 연구가 매우 활발히 진행되고 있으며6-8) 천연향에 대한 부가가치가 새롭게 인식되고 있어 국내에서도 이에 대한 관심이 절실히 필요한 실정이다.

1970년부터 분석기기의 발달로 천연소재로부터 원래있던 향의 character 성분 및 impact compound 분석이 가능해지면서 이들 성분의 추출과 분리에 대해 여러 실험방법 및 조건들이 개선되고 이에 따른 일차적 향생산에 많은 발전과 더불어 이를 응용한 인공합성향(natural identified flavor)의 개발이 그간 향 연구분야의 주종이었

다.

최근엔 천연향의 급격한 수요 증가에 따라 천연향 생산개발 연구에 박차를 가하게 되었으며 여러가지 새로운 방법의 천연향 생산 확대의 방안이 제기되고 있다.

Ionone류나 lactone류등 향기역가(aroma threshold)가 높고 경제적 가치가 좋은 몇몇 향기 성분들은 박테리아, 곰팡이 등 미생물을 이용한 생물공학적 방법[7]이나 세포조직배양[9]등의 방법으로 천연향(bioflavor)의 대량 생산을 위한 연구가 시도되고 있으며 고부가가치 chiral성 향기성분에 대한 연구가 보고되고 있다.

사람에게 인지되는 향기성분이나 곤충등의 pheromon등에서 chiral성 화합물들은 각각 enantiomer의 향기[10,11]가 판이하게 다를뿐만 아니라 곤충에서는 특정 enantiomer에만 감응[12] 할 수 있고 이에 대한 antiphode에는 전혀 반응하지 않는 특성을 가지고 있다. 천연향에서의 chiral성 향기성분은 향 생성의 mechanism에 관여하는 효소들의 입체 특이성 반응에 의해 생성되기 때문에 대부분의 경우 한 형태의 enantiomer만이 존재하거나 일부 chiral성 화합물등은 각각의 거울상 이성질체들이 혼합된 채로 존재할 수 있으나 그들의 혼합비(ee-value)가 일정하게 구성[13,14]되어 있어 인공으로 합성한 향은 자연에서 생성된 천연향과 매우 다른 관능적 상이함을 나타낸다. 따라서 천연 소재로부터 광학적으로 순수한 chiral성 화합물의 분리와 수득 은 고부가가치 천연향으로써 새롭게 인식되고 있다.

또한 Francis[15]등이 geraniol-β-D-glucoside등 배당체 형태의 몇몇 monoterpene을 발표한 이후 향 전구물질(flavor precursor)에 관한 연구가 1980년대 이후 매우 활발히 연구되는 바 이는 사람의 감각기관에 인지되는 향기성분들은 그 소재에 잠재해 있는 극히 일부분이고 많은 다른 volatile 성분들이 배당체 형태(glucoside bound flavor)로 존재하기 때문에 천연소재로부터 향을 추출 또는 식품가공시 효소(glucosidase류)를 이용 배당체를 가수분해하여 향 이용율을 극대화하는 연구[16-19]가 시도되고 있다.

국내에서는 식품 및 생활용품(화장품 등) 제조에 이용되는 향료가 국내 향료 산

업에서 생산되는 것은 거의 없는 상태로 대부분 수입에 의존하고 있어 향료에 대한 연구가 시급한 실정이다.

WTO 출범 이후 선진각국들은 자국의 자원량 확보 및 보존에 깊은 관심을 보이고 있으며 그 중요성은 국가 경제와 직결시킬 만큼 부각되고 있다. 자국의 값싼 식물자원을 이용하여 부가가치가 높은 향료 물질을 탐색하고 천연향료로서 사용할 수 있는 소재를 개발하므로써 지금까지 1차적 가공만으로 사용되었던 국내산 농산물에 부가가치가 높은 기능성 물질을 탐색하고 이의 대량 생산 방법에 대한 연구가 필요하다. 따라서 본 연구는 가용 가능한 천연향기성분의 탐색을 위하여 일차적으로 과채류 및 향신료와 같은 국내산 식물소재의 휘발성 향기성분을 분석하였다. 과일류로는 황금배, 이마무라, 신고, 만삼길, 장십랑 등 5종의 배, 후지, 쓰가루, 홍옥(조나단), 홍로, 하향 등 5종의 사과, 네오머스캇, 캠벨, 델라웨어, 블랙올림피아 등 4종의 포도, 부유, 대봉 등의 2종의 감, 백도, 황도, 대구보, 유명도, 천도복숭아 등 5종의 복숭아, 뷰티, 포모사 등 2종의 자두, 1종의 살구, 1종의 매실, 1종의 모과, 감귤류는 유자, 금귤, 조생, 향상조생, 껍질을 제거한 조생, 껍질을 제거한 향상조생 등 6종, 헤이워드의 키위 1종의 휘발성 향기성분을 분석하였고, 과채류로는 머스크, 파파이야, 별똥별 등 3종의 메론 및 토마토는 도태랑, 빼빼, 꼬꼬 등 3종, 딸기는 보교, 수홍 등 2종, 1종의 수박과 참외의 향기성분을 동정하였다. 그리고 향신료는 산초의 잎과 열매, 방아잎과 부추의 휘발성 향기성분을 분석하였다.

제 2 장 국내산 식물소재의 향기분석

제 1 절 연구내용 및 방법

1. 최적 분석조건 수립

향기성분 분석을 위한 적절한 GC column을 선택하기 위해 Carbowax 20M(J&W, USA), DB-1 및 DB-5(J&W, USA) column을 사용하여 GC chromatogram에 나타난 분리도를 비교하였으며, 적당한 분석 시간 및 최적 분리를 위해 GC 분석 temperature program과 flow rate를 바꿔가며 실험하였으며, GC/MS(Shimadzu QP-5000, Japan) 분석 기기의 최적 EI 조건과 명확하고 깔끔한 mass spectrum의 data를 얻기 위해 여러 조건을 변화시켜 실험하였다.

2. 머무름 지표값(Retention idnex,RI) 수립

향기성분의 정확한 분석에 필수조건인 각각 성분들의 머무름지표값(retention index, RI)을 구하기 위해 탄소수 7개부터 30개까지의 n-alkane 표준물질(Sigma, USA)을 구입하여 각 10 μL을 wire packed column distillation 장치에서 재증류된 10 mL의 n-hexane으로 희석하여 C7-C30 혼합액을 조제하였으며 이를 위의 분석 기기조건에서 분석하여 각 화합물의 보정된 머무름 시간(exact retention time, RT)을 구하였으며, 머무름 지표값(RI)을 얻기 위해 basic program을 작성하여 GC-chromatogram에서 확인된 n-alkane 표준물질의 머무름 시간(RT)을 programable Chromatopak 6A GC-integrator에 입력하였다.

3. 휘발성 향기성분의 추출 및 분획분리

가. 국내산 식물소재 선택

국내산 식물소재로부터 향기성분을 분석하기 위하여 과일, 과채류 및 향신료를 실험재료로 선택하였다. 본 실험에 사용한 과일로는 황금배, 이마무라, 신고, 만삼길, 장십랑 등 5종의 배 및 후지, 쓰가루, 홍옥(조나단), 홍로, 하향 등 5종의 사과, 네오머스캇, 캠벨, 델라웨어, 블랙올림피아 등 4종의 포도, 부유, 대봉 등 2종의 감, 백도, 황도, 대구보, 유명도, 천도복숭아 등 5종의 복숭아, 뷰티, 포모사 등 2종의 자두, 1종의 살구, 1종의 매실, 1종의 모과, 감귤류는 유자, 금귤, 조생, 향상조생, 껍질을 제거한 조생, 껍질을 제거한 향상조생 등 6종, 헤이워드의 키위 1종을 광주근교의 농산물 직매장에서 구입하여 사용하였다.

본 실험에 사용한 과채류로는 머스크, 파파이야, 별똥별 등 3종의 메론 및 토마토는 도태랑, 빼빼, 꼬꼬 등 3종, 딸기는 보교, 수홍 등 2종, 1종의 수박과 참외를 광주근교의 농산물 직매장에서 구입하여 사용하였다.

본 실험에 사용한 향신료는 산초의 잎과 열매 등 2종, 1종의 방아잎과 부추를 선정하였다.

나. 휘발성 향기성분의 추출

본 실험에 사용한 모든 식물소재는 씨와 껍질 등을 제거한 과육을 추출시료로 하였다. 향기성분의 추출용매로는 wire spiral packed double distilling 장치로 재증류한 n-pentane : diethylether (1:1, v/v) 혼합용매를 사용하였고, 휘발성 향기성분의 추출은 시료 종류에 따라 액체액체추출 (liquid liquid extraction & perforation, LLEP, Normschliff, Germany) 장치 및 연속수증기증류추출 (simultaneous steam distillation and extraction, SDE, Normschliff, Germany) 장치를 이용하여 추출하였다. 보다 간편한 휘발성 향기성분의 분석을 위하여

SPME (solid phase micro extraction, Supelco, USA) 추출방법을 시도하였으나 회수율이 낮아 본 연구에 도입하지 않았다.

1) 액체 액체 추출법 (LLEP)에 의한 휘발성 향기 성분의 추출

각 품종별로 씨와 껍질을 제거한 과육 1 kg을 Milli Q water 200 mL와 혼합하여 Waring blender로 3분간 분쇄하고 이를 4℃에서 10,000×g의 속도로 20분 동안 원심분리하여 상층액을 여과한 후, 이 여액에 1 N NaOH 용액을 첨가하여 pH 6.5로 조정하고 이를 휘발성 향기성분의 추출용 시료로 사용하였다. 휘발성 향기성분의 추출은 LLEP 장치로 상압하에서 24시간 동안 추출하였으며, 추출용매는 n-pentane과 diethylether (1:1, v/v) 300 mL를 사용하였다. 추출 후 추출용매에 무수 Na2SO4를 첨가하여 4℃에서 하룻밤 동안 방치하여 수분을 제거하였다. 정량분석을 위해 내부표준물질로서 butylbenzene 1 μL를 추출용 시료에 첨가하였다.

2) 연속증류추출법 (SDE)에 의한 휘발성 향기성분의 추출

시료 각각 300g과 증류수 1 L를 혼합하여 Waring blender로 분쇄하고 pH의 보정을 위해 1 N NaOH 용액을 가하여 약 pH 6.5로 조정한 후 이를 휘발성 향기성분의 추출용 시료로 사용하였다. 휘발성 향기성분의 추출은 SDE 장치로 상압에서 2시간 동안 추출하였고, 추출용매는 n-pentane과 diethylether 혼합용매 (1:1, v/v) 200 mL를 사용하였다. 추출 후 추출용매에 무수 Na2SO4를 첨가하여 4℃에서 하룻밤 동안 방치하여 수분을 제거하였다. 정량분석을 위해 butylbenzene 1 μL를 내부표준물질로서 첨가하였다.

다. 휘발성 향기성분의 분획분리

LLEP 및 SDE 방법에 의하여 얻은 향기 추출액은 분액 깔대기에 넣고 5% acid fraction을 분리하고 중성분획분을 농축하여 이를 silicagel로 충전된

chromatograph에 주입한 후 polar index를 달리한 용리용매(n-pentane 100%, n-pentane : diethylether = 9 : 1 v/v, diethylether 100%)를 순차적으로 분리하여 이를 Vigreux column 농축하여 분석시료로 사용하였다.

1) 향기추출물의 neutral fraction과 acid fraction의 분리

LLEP 및 SDE방법에 의해서 얻은 향기 추출물을 분액 깔대기에 넣고 5% NaHCO3 수용액 50 mL를 가한 후 acid fraction을 NaHCO3 수용액층으로 유출시키는 조작을 2회 반복하여, NaHCO3 수용액층을 분리해 낸 neutral fraction에 무수 Na2SO4를 첨가한 후 하룻동안 방치하여 수분을 제거하였다.

2) 분리된 neutral fraction의 농축

Acid fraction을 분리해 낸 향기성분의 neutral fraction을 Vigreux column을 사용하여 약 1 mL까지 농축하고 GC용 vial에 옮긴 후 질소가스 기류 하에서 0.1 mL까지 농축하여 GC와 GC/MS의 분석시료로 하였다.

3) Silicagel chromatography에 의한 neutral fraction의 분리

과일에서 추출한 향기성분에서 acid fraction을 분리한 중성분획구 향기농축액을 Silicagel로 충전된 chromatography관(2×50)에 주입한 후 Polar index를 달리한 용리용매(Fraction I n-pentane 100%, Fraction II n-pentane: diethylether = 9 : 1 v/v, Fraction III diethylether 100%)를 각각 300 mL로 순차적으로 분리하여 이를 Vigreux column 농축장치에서 농축하여 GC-FID 및 GC/MS의 시료로 사용하였다.

4) Acid fraction의 산성화 및 methylation

수분이 제거된 acid fraction은 1N HCl 용액을 이용하여 pH 2까지 산성화시킨

후 n-pentane : diethylether (1:1, v/v) 50 mL를 가한 후 유기산을 유기용매층으로 유출시키는 조작을 2회 반복하였다. Acid fraction에 무수 Na2SO4를 첨가한 후 방치하여 수분을 제거하였다. 위의 방법으로 획득된 acid fraction을 Vigreux column을 사용하여 약 10 mL까지 농축하고, methylester화하기 위해 이 농축액에 15% BF3-Methanol 용액 3 mL를 가하고 환류냉각기를 부착하여 65℃로 10분동안 가열하고 방냉한 후 여기에 NaCl 포화용액 20 mL와 diethylether 20 mL를 첨가하여 상층액만을 분리해낸 후, 무수 Na2SO4를 첨가 하룻동안 방치하여 수분을 제거하였다. 수분을 제거한 상층액을 농축하여 GC/MS 분석을 위한 시료로 사용하였다.

4. 휘발성 향기성분의 분석, 동정 및 정량

가. 휘발성 향기성분 분석 및 동정

분획분리에 의하여 얻어진 각 분획구는 Gas chromatography (GC)와 Gas chromatography /mass spectrometry (GC/MS)에 의하여 분석하였다. GC는 FID가 부착된 Hewlett-Packard 5890 II Plus(Hewlett Packard, USA)를 사용하였으며, column은 극성을 달리한 DB-1, DB-5 및 Carbowax 20M column을 이용하여 분석하였으나, 본 휘발성 향기성분의 분석에 Carbowax 20M (J&W, 60 m × 0.25 mm i.d., 0.25 μm film thickness)이 적절하였다. 많은 예비실험을 거쳐 온도 program은 40℃에서 3 min간 유지한 후, 150℃까지 2℃/min 속도로, 220℃까지 4℃/min 속도로 승온시켜 10 min간 유지하여 온도 program을 선정하였다. Injector와 detector의 온도는 각각 250℃, 300℃이며, 운반기체는 helium을 사용하여 유속은 1.0 mL/min으로 하고 시료는 1 μL를 주입하였고 split ratio는 20:1로 하였다. GC chromatogram에서 확인된 탄소수 7개부터 30개까지 n-alkane 표준물질의 머무름 시간을 basic program에 입력하여, integrator로부터 각 화합물의 retention index를 구하여 화합물의 동정에 필요한 자료로 사용하였다. 화합물 동정에 사용

한 GC/MS는 QP-5000 (Shimadzu, Japan), JMS-DX 300 (Jeol, Japan)을 이용하였으며 시료의 이온화는 electron impact ionization (EI) 방법과 메탄을 이용한 chemical impact ionization (CI) 방법을 병행하여 행하였다. GC/MS 분석조건은 위에서 설명된 것과 같은 column과 분석조건으로 설정하여, ion source temperature는 230℃, ionization voltage를 70 eV 그리고 분석할 분자량의 범위(m/z)는 31 400으로 하여 분석하였다. Total ion chromatogram (TIC)에 분리된 각 peak의 동정은 mass spectrum library (Wiley 139와 Nist 62)와 mass spectral data book[20,21]의 spectrum과의 일치 및 GC-FID의 분석에 의한 RI 그리고 표준물질의 분석 data를 비교하여 확인하였다.

나. 휘발성 향기성분의 정량

동정된 휘발성 향기성분의 상대적 정량을 위하여 내부 표준물질로 첨가한 butylbenzene과 각 화합물의 peak area%를 비교하여 성분들의 함유량을 계산하였다. 각 식물소재로부터 추출한 향기성분의 정량은 각각 시료의 재배조건, 토양, 기후, 숙성도 등의 biofactor 등을 고려하지 않았고, 또한 정량을 위해 사용한 내부 표준물질과 동정된 성분들과의 검출기내에서의 감응정도(response factor) 등은 무시하였다.

$$\text{Component content(mg/kg of samples)} = \frac{B\% \times 1000g}{A\% \times \text{시료}g} \times SG$$

SG : Butylbenzene의 비중 (0.86(20/20℃))

A% : 각 sample에서 butylbenzene의 peak area%

B% : 각 sample에서 각 성분의 peak area%

제 2 절 연구결과 및 고찰

1. 분석기기의 최적 분석조건 수립

향기성분 분석을 위하여 GC column의 선택을 위해 Carbowax 20M(HP, USA), DB-1 및 DB-5(J&W, USA) column을 사용하여 GC chromatogram에 나타난 분리도를 비교하였으며, 적당한 분석 시간 및 최적 분리를 위해 GC 분석 temperature program 과 flow rate를 바꿔가며 실험한 결과 Table 1과 같은 최적 분석조건을 확립하였으며. GC/MS(Shimadzu QP-5000, Japan) 분석 기기의 최적 EI 조건과 명확하고 깔끔한 mass spectrum의 data를 얻기 위해 여러 조건을 변화시켜 실험한 결과 GC/MS의 최적 분석 조건을 Table 2와 같이 정립하였다.

2. 머무름 지표값(Retention idnex,RI)

분석기기조건에서 분석하여 구한 각 화합물의 보정된 머무름 시간(exact retention time, RT)을 구한 후, 머무름 지표값(RI)을 얻기 위해 GC-chromatogram은 Fig. 1에 나타내었고, 여기에서 확인된 n-alkane 표준물질의 머무름 시간(RT)을 입력한 basic program은 Appendix 1에 나타내었다.

3. 국내산 식물소재로부터의 향기성분 분석

가. 국내산 과일의 향기성분 분석

1) 모과의 향기성분 분석

국내산 모과의 휘발성 향기성분을 SDE 방법으로 추출하여 분석한 chromatogram

Table 1. GC condition for analysis of volatile flavor components

GC	Hewlett - Packard 5890 II Plus
Column	Carbowax 20M (J&W, 60 m × 0.25 mm i.d., 0.25 μm film thickness)
Detector	FID
Carrier gas	Helium (1.0 mL/min)
Make up gas	N2 (30 mL/min)
Temp. program	40℃(3 min) - 2℃/min - 150℃ - 4℃/min - 220℃ (10 min)
Detector temp.	300℃
Injector temp.	250℃
Split ratio	1:20
Injection volume	1 μL

Table 2. GC/MS conditions for identification of volatile flavor components

GC/MS	Shimadzu GC/MS QP-5000
Column	Carbowax 20M (J&W, 60 m × 0.25 mm i.d., 0.25 μm film thickness)
Carrier gas	Helium (1.0 mL/min)
Temp. program	40℃(3 min) - 2℃/min - 150℃ - 4℃/min - 220℃ (10 min)
Injector	250℃, split ratio 1:20
Temperature	ion source and interface 230℃
Ionization	electron impact ionization (EI)
Ionization voltage	70 eV
Cathod strom	0.8 ma
Mass range (m/z)	41 450
Injection volume	1 μL

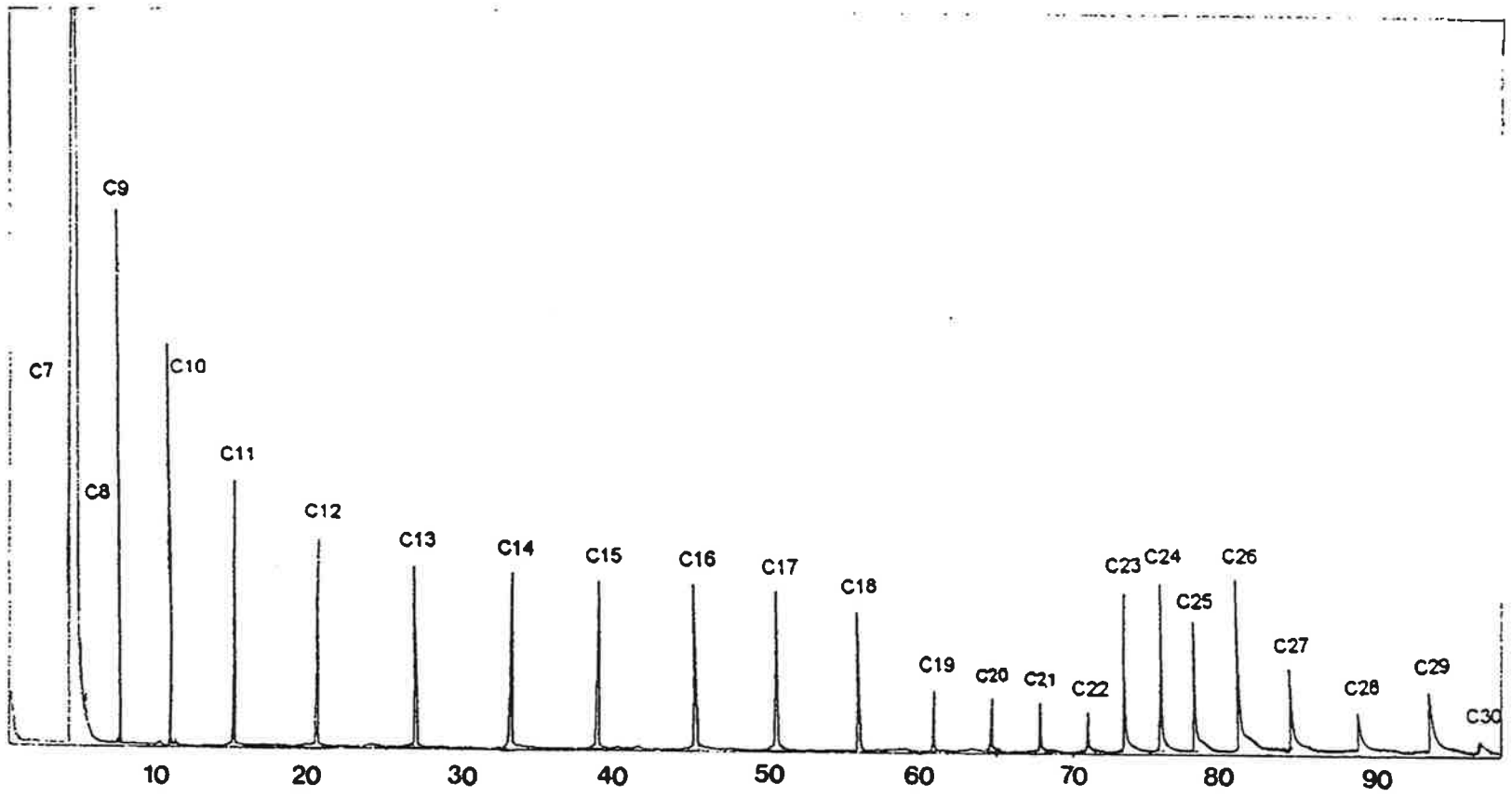

Fig. 1. GC chromatogram of n-alkane standards

DB-Wax 60m×0.25mm i.d. 0.25μm film thickness
40℃(3min)- 2℃/min-150℃-4℃/min-220℃(10min)-5℃/min-230(5min)

은 Fig. 2와 같고, GC의 RI 및 GC/MS에 의해 동정된 휘발성 향기성분과 상대농도는 Table 3에 나타내었다. 모과의 과즙에서 동정된 성분은 총 138종으로, 74종의 ester류가 39.51%, 21종의 alcohol류가 34.24%, 18종의 aldehyde류가 7.15%, 6종의 acid류가 4.76%, 6종의 ketone류가 1.80%, 1종의 ether류가 0.04%, 기타 9종의 화합물이 1.21%로 확인되었다(Table 4). 이 동정된 성분들 중 ester류와 alcohol류가 다량 확인되었으며, 주요 향기성분으로는 hexanol, 2-methylpropanol, hexyl 2-methylpropanoate, hexyl hexanoate, tridecanal, ethylpropyl octanoate, butanol이 13.45%, 8.57%, 5.28%, 4.79%, 4.38%, 4.06%, 3.47% 확인되었으며, 그 외에 (*E*)-2-hexen-1-ol, hexyl octanoate, hexyl butanoate, hexanoic acid, (*E*)-2-hexenal, hexyl 2-methylbutanoate, butyl octanoate가 2.74%, 2.08%, 2.06%, 2.04%, 1.36%, 1.32%, 1.32%가 동정되었다.

모과의 휘발성향기 성분의 함량은 89.8mg/kg으로 확인되었으며 특히 많은 종류의 ester 화합물이 동정되어 이들이 모과의 주요향기성분인 것으로 생각되며 또한 C6 화합물 등은 모과의 풋 냄새의 주성분으로 생각된다.

2) 배의 품종별 향기성분 분석

황금배, 이마무라, 신고, 장십랑, 만삼길 등 5품종의 배로부터 휘발성 향기성분을 LLEP 방법과 SDE 방법으로 추출하여 분석한 chromatogram은 Fig.3-7과 같고 GC의 RI와 GC/MS 분석에 의하여 동정한 향기성분은 Table 5-9에, 관능기별 함량비교는 Table 10에 나타내었다. 황금배, 이마무라, 신고, 장십랑, 만삼길에서 107종, 61종, 102종, 109종, 47종의 화합물이 분리 동정되었다.

황금배에서 분리동정된 향기성분으로 36종의 ester류가 36.34%, 21종의 aldehyde류가 8.95%, 19종의 alcohol류가 6.78%, 5종의 acid류가 4.36%, 14종의 ketone류가 1.44%, 2종의 ether류가 0.48%, 1종의 terpene류가 0.06%, 기타 8종의 화합물이 0.48% 확인되었다. 이중에서 ethyl 3-hydroxynonanoate, ethyl

acetate, hexanal, ethyl butanoate가 12.61%, 12.10%, 6.65%, 4.60%로 다량 동정되었고, 그외 acetic acid, ethyl hexanoate, hexanol이 3.74%, 1.94%, 1.85%로 주요향기성분으로 확인되었다.

이마무라에서 동정된 향기성분으로 alcohol류 10종, acid류 3종, ester류 12종, terpene류 1종, aldehyde류 10종, ketone류 7종이 동정되었다. 이 중에서 ethyl acetate, acetaldehyde, 2-methylbutanal가 20.69%, 14.57%, 1.22% 확인되었고, 그 외에 2-pentanol, *(Z)*-3-hexen-1-ol, propyl acetate가 이마무라의 향기에 기여하는 것으로 확인되었으며 많은 종류의 alcohol이 확인되었다.

신고의 향기성분으로 alcohol류 27종, ester류 27종, aldehyde류 21종, acid류 3종, ketone류 8종, ether류 3종, terpene류 1종, 기타 7종의 화합물이 16.41%, 12.70%, 17.16%, 3.46%, 1.92%, 1.30%, 0.01%, 1.85% 확인되었다. 이 중에서 hexanal, 1,2-propanediol, ethyl acetate, hexanol, (*E*)-2-hexenal, hexanoic acid, ethyl butanoate가 11.05%, 7.81%, 6.88%, 3.99%, 3.03%, 1.88%, 1.74%로 신고의 주요 향기성분이며, C6 화합물이 많은 부분을 차지하였다.

장십랑에서 동정된 향기성분으로 33종의 ester류가 29.47%, 24종의 alcohol류가 13.52%, 20종의 aldehyde류가 11.28%, 10종의 ketone류가 1.87%, 4종의 acid류가 1.81%, 4종의 terpene류가 0.24%, 기타 9종의 화합물이 0.45%를 나타내었다. 주요 향기성분으로 ethyl butanoate와 ethyl acetate가 11.91%, 10.86%로 다량 확인되었으며, acetaldehyde 6.44%, hexanal 2.28%, hexyl acetate 1.96% 함유되어 있다.

만삼길에서 분리 동정된 향기성분으로 alcohol류 23종, acid류 8종, ester류 5종, terpene류 5종, aldehyde류 4종, ketone류 2종이 동정되었다. 이 중에서 hexanal, ethyl 2-hydroxypropanoate, methyleugenol, ethyl acetate가 11.20%, 6.18%, 5.81%, 4.34% 확인되었고, 그 외에 2-pentanol, *(Z)*-3-hexen-1-ol, propyl acetate가 만삼길의 향기에 기여하는 것으로 여겨졌다.

3) 사과의 품종별 향기성분 분석

사과는 장미과의 *Malus*속에 속하는 과실로서 주성분이 탄수화물이고, 단백질과 지방은 비교적 적으며, vitamin C와 무기염류의 함량이 높다[22]. 또한 소화변비에 좋고 피부를 아름답게 하는 효과가 있으며 혈압을 내리게 하는 칼륨이 함유되어 있어 고혈압 환자에게 좋은 식품으로 알려져 있다[23]. 우리나라에서는 후지, 쓰가루, 홍옥(조나단), 홍로, 하향 등의 품종이 주로 재배되고 있으며, 이들은 주로 생과일로 소비되지만, 일부는 주스류, 넥타, 사과주, 잼, 젤리 등의 원료로 이용되고 있다.

후지, 쓰가루, 홍옥(조나단), 홍로, 하향의 향기성분을 SDE 방법으로 추출하여 분석한 chromatogram은 Fig. 8-12와 같고, GC의 RI와 GC/MS 분석에 의하여 동정된 휘발성 향기성분과 상대농도는 Table 11-15에, 관능기별 함량비교는 Table 16에 나타내었다. 후지, 쓰가루, 홍옥(조나단), 홍로, 하향에서 각각 98종, 67종, 82종, 99종, 66종의 화합물이 분리 동정되었다.

후지에서 분리 동정된 휘발성 향기성분 중 butanol과 hexanol을 포함한 15종의 alcohol류가 48.10%로 가장 높은 함유율을 보였으며, ethyl 2-methylbutanoate를 포함한 36종의 ester류와 hexanal, (*E*)-2-hexenal을 포함한 15종의 aldehyde류가 각각 21.29%, 8.75%를 차지하였다. 그밖에 8종의 ketone류, 3종의 terpene류, 2종의 ether류, 3종의 acid류가 1.28% 1.32%, 1.05%, 1.12%를 나타내었다. Alcohol류로는 butanol, hexanol, 3-methyl-1-butanol, 2-methylpropanol이 각각 15.36%, 12.15%, 12.41%, 2.26%로 많은 부분을 차지하고 있었으며, butanol과 hexanol은 로얄 갈라 사과의 주요 향기성분으로 확인되었다[24]. 다량 확인된 3-methyl-1-butanol과 소량 확인된 acetaldehyde, ethanol, 3-methylbutanal, 2-methylbutanal은 과일 내에 있는 측쇄 아미노산의 대사에 의해 생성되며, 특히 3-methyl-1-butanol은 leucine으로부터 생성된다[25]. Ester류 중 ethyl butanoate는 4.99%로 가장 많이 포함되어 있었으나 다른품종에서는 확인되지 않았다.

2-Methylbutyl acetate, hexyl acetate, butyl acetate, ethyl acetate는 3.12%, 2.52%, 2.44%, 1.59%를 나타내었으며, 이 화합물들 또한 로얄 갈라 사과의 중요한 향기성분으로 보고되었다[24]. SPME에 의한 골든 델리셔스 사과[26]의 향기성분으로써 확인된 hexyl 2-methylbutanoate는 후지에서 소량 확인되었지만 홍로와 홍옥(조나단)에서는 다량 확인되었다. 델리셔스 사과[27]에서 주요 향기성분으로 보고된 ethyl 2-methylbutanoate는 0.56%로 소량 확인되었지만 향기역가[28]가 0.3ppb로 관능적 향기특성에 기여한다고 볼수있으며 다른품종에서는 확인되지 않았다. Aldehyde류 중 hexanal은 4.98%, 그리고 (*E*)-2-hexenal은 1.69%로 다량 함유되어 있었으며, 델리셔스와 로얄 갈라 사과에 다량 함유되어 있는 hexanol, hexanal, (*E*)-2-hexenal과 더불어 소량 확인된 (*E*)-2-hexen-1-ol은 풀내음을 내는 C6화합물로써 사과 분쇄시 세포벽 파괴로 인하여 불포화 지방산인 linoleic acid 또는 linolenic acid가 유리되어 lipoxygenase와 hydroperoxide lyase에 의해 분해, 생성된다[25]. Butanol, hexanol, 3-methyl-1-butanol, hexanal, ethyl butanoate, 2-methylbutyl acetate, (*E*)-2-hexenal이 후지의 주요향기성분으로 확인되었으며, 델리셔스와 골든 델리셔스, 로얄 갈라 사과의 향기성분들과 유사한 결과를 보였다.

쓰가루에서 분리동정된 향기성분중 (*E*)-2-hxenal과 hexanal을 포함한 20종의 aldehyde가 60.61%로 가장 높은 함유율을 보였으며, hexanol과 butanol을 포함한 17종의 alcohol류가 3.81%, hexyl acetate를 포함한 9종의 ester류가 2.11%를 차지하였다. 그외 5종의 ketone류, 3종의 acid류, 3종의 ether류, 기타 9종의 화합물이 0.11%, 0.39%, 0.52%, 1.31%를 나타내었다. Aldehyde류중 (*E*)-2-hexenal과 hexanal은 각각 29.36%, 29.10%로 후지와 비교하여 월등히 높은 햐량을 나타내었으며, 쓰가루의 중요 향기성분으로 확인되었다. Ester류중 후지에 상당량 함유되어 있는 butyl acetate는 소량확인되었으며, hexyl acetate는 0.92%로 함량이 낮지만 향기역가[28]가 2ppb로 낮아서 쓰가루의 향기특성에 기여하는 것으로 간주된

다. Alcohol류중 다른 품종의 사과에서 다량 확인된 3-methyl-1-butanol은 0.16%로 매우 적은양을 나타내고 있으며, hexanol과 butanol은 1.06%, 1.03%를 차지하고 있다. 풀내음을 내는 C6 화합물인 (*Z*)-3-hexen-1-ol, (*E*)-2-hexen-1-ol이 소량 확인되었다. (*E*)-2-hexenal, hexanal, hexanol, butanol, hexyl acetate가 쓰가루의 향기에 기여하는 것으로 여겨졌다.

홍옥에서 분리 동정된 휘발성 향기성분은 25종의 alcohol류가 47.50%, 18종의 aldehyde류가 18.75%, 28종의 ester류가 6.70%, 4종의 terpene류가 3.09%, 2종의 acid류가 1.33%, 12종의 ketone류가 0.79%, 2종의 ether류가 0.3%, 기타 2종의 화합물이 0.46%가 확인되었다. 홍옥의 주요 향기성분으로는 alcohol류인 3-methyl-1-butanol, hexanol, butanol이 18.43%, 13.57%, 9.67%를 차지하였고, aldehyde류인 (*E*)-2-hexenal과 hexanal이 9.04%, 7.74%를 함유하고 있었다. Ester류인 ethyl acetate와 hexyl 2-methylbutanoate가 2.59%, 1.98%로 다른 품종에 비하여 높은 함유율을 보였으며, terpene류 중 (*E,E*)-α-farnesene이 3.01%로 상당량 함유되어 있으며, SPME에 의한 골든델리셔스 사과의 향기성분으로 확인되었다[26].

홍로에서 분리 동정된 휘발성 향기성분은 24종의 alcohol류가 52.88%, 16종의 aldehyde류가 20.02%, 21종의 ester류가 5.22%, 2종의 acid류가 1.47%, 3종의 ether류가 1.09%, 2종의 terpene류가 0.49%, 7종의 ketone류가 0.2%, 기타 5종의 화합물이 0.54%를 나타내었다. 주요 향기성분으로 alcohol류인 3-methyl-1-butanol, butanol과 hexanol이 20.98%, 13.36%, 12.80%함유되어 있으며, 쓰가루의 중요 향기성분인 (*E*)-2-hexenal과 hexanal이 9.74%, 9.21%를 차지하였다. 그 외에 ethyl acetate, (*E*)-2-hexen-1-ol가 각각 2.43%, 1.00% 그리고 골든델리셔스 사과[26]의 향기성분으로 확인된 hexyl 2-methylbutanoate가 1.07% 동정되었다.

하향에서 분리 동정된 66종의 향기성분 중 15종의 alcohol류가 40.91%, 14종의 aldehyde류가 28.80%, 18종의 ester류가 18.38%, 2종의 terpene류가 2.73%, 2종의

acid류가 0.51%, 3종의 ether류가 0.48%, 9종의 ketone류가 0.30%, 기타 3종의 화합물이 0.05%로 확인되었다. 주요 향기성분중 alcohol류인 butanol, hexanol, 3-methyl-1-butanol이 23.42%, 7.04%, 6.45%를 차지하였고, aldehyde류인 hexanal, (*E*)-2-hexenal이 14.69%, 13.09%, ester류인 butyl acetate, 2-methylbutyl acetate가 8.61%, 4.65%를 함유하고 있었으며, hexyl acetate, ethyl acetate가 2.23%, 1.06%를 나타내었다. Terpene류인 (*E*,*E*)-α-farnesene이 2.62% 확인되었다. 후지, 쓰가루, 홍로, 홍옥, 하향에서 추출된 휘발성 향기성분의 함량은 17.5mg/kg, 7.9mg/kg, 16.9mg/kg, 16.2mg/kg, 46.4mg/kg으로 하향의 정유 회수율이 높았다.

4) 포도의 품종별 향기성분 분석

SDE 방법으로 추출한 네오머스캇, 블랙올림피아, 캠벨, 델라웨어의 향기성분을 분석하여 얻은 chromatogram은 Fig. 13-16과 같고, GC의 RI와 GC/MS 분석에 의하여 동정된 휘발성 향기성분들과 이들의 상대적 농도는 Table 17-20에, 관능기별 함량비교는 Table 21에 나타내었다. 네오머스캇, 블랙올림피아, 켐벨, 델라웨어에서 각각 94종, 77종, 73종, 74종의 휘발성 향기성분이 분리 동정되었다.

네오머스캇에서 분리 동정된 성분들은 34종의 ester류가 26.11%, 24종의 alcohol류가 23.84%, 15종의 aldehyde류가 19.35%, 3종의 ether류가 1.14%, 3종의 acid류가 0.54%, 5종의 ketone류가 0.50%, 1종의 terpene류가 0.03%, 기타 8종의 화합물이 0.29% 확인되었다. 이 중에서 (*E*)-2-hexenal, ethyl acetate, (*E*)-2-hexen-1-ol, (*Z*)-3-hexene-1-ol, hexanol이 14.84%, 11.33%, 8.04%, 5.88%, 5.04%를 함유하고 있으며, 그 외 ethyl (*E*,*Z*)-2,4-decadienoate, hexanal, ethyl 3-hydroxybutanoate, ethyl hexanoate, ethyl 2-butenoate가 3.72%, 2.68%, 1.97%, 1.70%, 1.68%로 네오머스캇의 주요 향기성분으로 여겨졌다.

블랙올림피아에서 동정된 향기성분으로 28종의 ester류가 25.73%, 23종의

alcohol류가 9.73%, 15종의 aldehyde류가 44.21%, 3종의 acid류가 1.01%, 3종의 ether류가 0.67%, 1종의 ketone류가 0.07%, 1종의 terpene류가 0.04%, 기타 3종의 화합물이 0.35%로 확인되었다. 블랙올림피아의 주요 향기성분으로 (*E*)-2-hexenal, diethylacetal, hexanal, ethyl acetate가 20.36%, 18.03%, 13.24%, 9.02%를 다량 함유하고 있었으며, 그 외에 ethyl butanoate, (*E*)-2-hexen-1-ol이 각각 2.19%, 1.49%로 소량 확인되었다.

캠벨에서 분리 동정된 성분들은 24종의 ester류가 47.08%, 14종의 aldehyde류가 23.24%, 25종의 alcohol류가 17.77%, 3종의 ketone류가 0.52%, 3종의 terpene류가 0.11%, 1종의 ether류가 0.01%, 기타 3종의 화합물이 0.31% 함유되어 있다. 주요 향기성분은 ester류로써 30.81%를 나타낸 ethyl acetate가 가장 높은 함유율을 보였으며, ethyl (*E*,*E*)-2,4-decadienoate와 ethyl butanoate가 각각 7.96%, 2.59% 차지하였다. Alcohol류와 aldehyde류는 주로 C6 화합물이 다량 함유되었다. 즉, (*E*)-2-hexenal이 16.08%, hexanal이 4.86%, (*E*)-2-hexen-1-ol이 4.61%, hexanol이 2.72%를 나타내었다.

델라웨어에서 분리 동정된 성분들로는 33종의 alcohol류가 49.31%, 20종의 aldehyde류가 27.75%, 4종의 terpene류가 0.43%, 3종의 ester류가 1.94%, 3종의 acid류가 0.24%, 3종의 ketone류가 0.03%, 2종의 ether류가 1.18%, 기타 6종의 화합물이 0.46% 동정되었으며, 네오머스캇, 블랙올림피아, 켐벨과는 달리 alcohol류가 높은 함량을 나타내었다. 델라웨어의 주요향기성분으로 (*E*)-2-hexenal과 (*E*)-2-hexen-1-ol이 21.07%, 19.43%로 많은 부분을 차지하고 있었으며, 1,2-ethanediol, hexanol, (*Z*)-3-hexen-1-ol, hexanal, ethyl acetate도 각각 10.48%, 9.78%, 5.64%, 5.34%, 1.22%로 다량 함유되어 있었다.

포도의 주요 향기성분으로는 모든 품종에서 공통적으로 hexanal, (*E*)-2-hexenal, hexanol, (*E*)-2-hexen-1-ol, ethyl acetate 등이 다량 확인되어 C6 화합물이 포도의 주된 향기성분으로 확인되었다.

포도의 품종별 휘발성 향기성분의 함량으로 네오머스캇, 블랙올림피아, 캠벨, 델라웨어에서는 12.1mg/kg, 13.7mg/kg, 48.5mg/kg, 15.3mg/kg가 정량되었으며, 전체의 상대적 함량비교에서 블랙올림피아는 aldehyde 화합물이 44.21%, 캠벨은 ester 화합물이 47.08%, 델라웨어는 alcohol 화합물이 49.31%로 다른 화합물에 비하여 높은 비율을 차지하였으며, 네오머스캇은 alcohol류와 ester류가 23.84%와 26.11%로 비슷한 함량을 나타내었다.

5) 감의 품종별 향기성분 분석

부유와 대봉을 시료로 하여 SDE 방법으로 추출하여 향기성분을 분석한 chromatogram은 Fig. 17-18과 같고, GC의 RI 및 GC/MS에 의해 동정한 향기성분과 상대농도는 Table 22-23에, 관능기별 함량비교는 Table 24에 나타내었다. 부유와 대봉의 과즙에서 각각 69종, 99종의 화합물이 분리 동정되었다.

부유에서는 분리동정된 22종의 alcohol류가 전체 동정 성분 중 15.08%로서 가장 많은 향기성분으로 동정되었으며 이어서 11종의 ester류가 9.61%, 14종의 aldehyde류 5.83%, 11종의 ketone류 2.08%, 2종의 ether류 1.89%, acid 류가 1종인데 반하여 3.86%가 확인되어 부유 휘발성 성분중 상당 부분을 구성하고 있는 것으로 나타났다. 부유에서는 ethyl acetate, ethanol, acetic acid, tolualdehyde 그리고 2-methylpropanol이 가장 많은 함량을 차지하였으며 이들은 부유의 휘발성분의 주요 화합물로 여겨진다.

대봉에서 분리 동정된 향기성분으로 28종의 alcohol류가 17.25%, 21종의 aldehyde류가 12.19%, 17종의 ester류가 17.49%, 4종의 acid류가 6.04%, 3종의 ether류가 0.44%, 2종의 terpene류가 0.08%, 기타 13종의 화합물이 3.50%로 확인되었다. 대봉의 주요 향기성분으로 3-methyl-1-butanol, acetic acid, acetaldehyde, ethyl acetate가 각각 7.52%, 5.73%, 4.65%, 3.66%를 나타내었고, 그외 4-terpineol, 2-methylpropanol, (*E*)-sabinene hydrate가 2.56%, 2.39%,

2.31%가 차지하였다. 감류의 향기 성분을 분리 동정한 결과 부유에서는 2.1mg/kg, 대봉에서는 4.6mg/kg이 정량되었다.

6) 감귤류의 품종별 향기성분 분석

국내산 감귤류의 품종별 휘발성 향기성분을 분석하기 위하여 유자, 금귤, 조생, 향상조생 그리고 껍질을 제거한 조생 과육, 향상조생과육을 시료로 하여 SDE 방법으로 향기성분을 추출하여 분석한 chromatogram은 Fig. 19-24과 같고, GC의 RI 및 GC/MS에 의해 동정한 휘발성 향기성분과 상대농도는 Table 25-30에, 관능기별 함량비교는 Table 31에 나타내었다. 유자, 금귤, 향상조생, 조생 그리고 껍질을 제거한 조생과육, 향상조생과육에서 각각 77종, 83종, 89종, 90종, 98종, 86종의 화합물이 분리 동정되었다.

유자에서 분리동정된 향기성분은 32종의 terpene류가 94.04%를 보였으며, 그외 24종의 alcohol류가 2.98%, 8종의 ester류가 0.14%, 7종의 aldehyde류가 0.12%, 1종의 ketone류가 0.01%, 기타 4종의 화합물이 1.04% 확인되었다. Terpene류가 유자의 주요 향기성분으로 여겨지며, 이 중에서 α-limonene과 γ-terpinene이 68.11%, 11.96%를 나타내며, β-phellandrene, β-myrcene, α-pinene, 2-β-pinene, linalool, (*E*)-β-farnesene도 상당량 확인되었다.

금귤에서 동정된 향기성분은 25종의 terpene류가 91.32%로 가장 높은 함량을 나타내었으며, 23종의 alcohol류가 2.25%, 13종의 ester류가 2.49%, 7종의 aldehyde류가 0.36%, 5종의 ketone류가 0.39%, 기타 8종의 화합물이 0.91% 확인되었다. 금귤의 중요 향기성분은 α-limonene으로 79.09% 함유되어 있으며, 그외에 α-pinene, geranyl acetate가 각각 1.72%, 1.32%로 소량 확인되었다.

껍질을 제거하지 않은 향상조생에서 분리 동정된 향기성분으로 α-limonene을 포함한 25종의 terpene류가 95.13%를 나타내었으며, 21종의 alcohol류가 1.76%, 12종의 ester류가 0.69%, 14종의 aldehyde류가 0.58%, 6종의 ketone류가 0.09%, 1

종의 ether류가 0.01%, 1종의 acid류가 0.01%, 기타 9종의 화합물이 0.30%로 확인되었다. 이 중에서 α-limonene이 65.93%로 가장 높은 함유율을 보였으며, 그 외에 α-pinene, (*E,E*)-α-farnesene, 2-β-pinene, β-elemene이 2.64%, 1.92%, 1.12%, 1.04%를 차지하였다.

껍질을 제거하지 않은 조생에서 분리 동정된 향기성분은 63.92%로 가장 높은 함유율을 보이는 α-limonene을 포함하여 29종의 terpene류가 93.17%로 조생의 향기에 중요하다. 그외 18종의 alcohol류, 13종의 ester류, 10종의 aldehyde류, 8종의 ketone류, 1종의 acid류, 1종의 ether류, 기타 8종의 화합물이 각각 0.93%, 0.75%, 0.39%, 0.17%, 0.01%, 0.01%, 2.0%를 나타내었다. α-Limonene이 조생의 중요 향기성분이며, 그 외 γ-terpinene이 8.93%, β-myrcene이 5.01%, β-elemene이 3.39%, (*E,E*)-α-farnesene이 2.47%, α-pinene이 1.46%, α-thujene이 1.26% 확인되었다.

껍질을 제거한 향상조생과육에서 동정된 향기성분으로 28종의 alcohol류가 15.66%, 16종의 terpene류가 23.93%, 10종의 aldehyde류가 2.61%, 9종의 ester류가 5.52%, 9종의 ketone류가 1.24%, 3종의 ether류가 0.78%, 1종의 acid류가 2.14%, 기타 10종의 화합물이 1.30%로 확인되었다. 주요 향기성분으로 α-limonene이 20.18%를 차지하고 있었으며, 그 외에 3-methyl-1-butanol, ethanol, ethyl acetate, acetic acid, ethyl formate, valencene이 4.46%, 3.59%, 3.27%, 2.14%, 1.59%, 1.45%로 소량 함유되어 있었다. 유자, 금귤, 조생, 향상조생 그리고 껍질을 제거한 조생과육, 향상조생과육에서 동정된 향기성분의 함량은 4730.9, 783.0, 474.1, 807.4, 57.482, 3.723mg/kg 정량되었으며, 유자의 향기 함량이 가장 높았다.

껍질을 제거한 조생 meat에서 동정된 향기성분으로 18종의 terpene류가 49.39%, 39종의 aldehyde류가 19.08%, 8종의 ester류가 7.26%, 1종의 acid류가 4.79%, 11종의 aldehyde류가 3.32%, 10종의 keone류가 2.54%, 3종의 ether류가

1.12%, 기타 8종의 화합물이 2.88%를 나타내었다. Terpene류가 주요 향기성분으로 여겨지며, 이중에서 α-limonene이 39.0%로 가장 높은 함유율을 보였으며, valencene과 γ-terpiene도 2.97%, 2.55%를 차지하였다.

껍질을 제거하지 않은 4종의 시료 즉 유자, 금귤, 향상조생 그리고 조생에서는 terpene류가 모두 약 90% 이상을 나타내었는데 이러한 terpene류의 대부분은 C10과 C15인 monoterpene과 sesquiterpene류였다. 그 외에 1-3%를 차지하는 alcohol류와 ester류가 확인되었다. 이에 반하여 껍질을 제거한 시료 조생과육과 향상조생과육에서 terpene류는 각각 49.39%와 23.93%만을 차지하여 껍질을 제거하지 않은 4가지 시료와 큰 차이점을 보였다. 이는 휘발성 향기성분의 대부분을 차지한 C10과 C15인 monoterpene과 sesquiterpene류의 상당한 양이 대부분 껍질에서 유래되었음을 알 수 있었다. 6종류의 모든 시료에 α-limonene이 가장 많이 함유되어 있었으며, 그 다음으로 껍질을 제거하지 않은 4가지 시료에서는 γ-terpinene, β-myrcene, (*E*,*E*)-α-farnesene, α-pinene 등 terpene류가 많은 함량으로 확인되었다. 반면, 껍질을 제거한 시료 조생과육과 향상조생과육에서는 acetic acid, ethyl acetate, 3-methyl-1-butanol, ethanol, ethyl formate 등이 주요 성분으로 확인되어 껍질을 분리하지 않는 시료와의 차이점을 보여주고 있다.

7) 복숭아의 향기성분 분석

백도, 천도, 유명도, 대구보, 황도복숭아의 향기성분을 SDE 방법으로 추출하여 분석한 chromatogram은 Fig. 25-29과 같고, GC의 RI 와 GC/MS 분석에 의하여 동정한 휘발성 향기성분과 상대농도는 Table 32-36에, 관능기별 함량비교는 Table 37에 나타내었다. 백도, 천도, 유명도, 대구보, 황도복숭아에서 각각 86종, 85종, 70종, 74종, 67종의 화합물이 분리 동정되었다.

백도에서 확인된 성분은 26종의 alcohol류가 12.82%, 15종의 aldehyde류가 32.3%, 14종의 ketone류가 7.65%, 6종의 ester류가 1.32%, 4종의 ether류가

0.69%, 1종의 acid류가 0.12%, 2종의 terpene류가 0.06%, 기타 17종의 화합물이 1.95% 확인되었다. 백도의 주요 향기성분으로 (*E*)-2-hexenal, hexanal이 19.10%, 10.49%로 다량 함유되어 있으며, hexanol, γ-dodecalactone, (*E*)-2-hexen-1-ol, γ-decalactone, benzaldehyde도 각각 4.03%, 3.75%, 3.15%, 1.98%, 1.54%를 나타내었다.

천도에서 확인된 성분은 24종의 alcohol류가 23.27%, 18종의 ketone류가 15.82%, 15종의 aldehyde류가 23.99%, 7종의 ester류가 4.73%, 5종의 ether류가 4.04%, 2종의 acid류가 0.18%, 1종의 terpene류가 0.03%, 기타 12종의 향기 성분이 9.5% 확인되었다. 천도에서는 (*E*)-2-hexenal, (*E*)-2-hexen-1-ol, γ-decalactone, hexanal, γ-dodecalatone이 각각 16.42%, 8.77%, 8.77%, 8.38%, 1.90% 동정되어 이들이 주요한 향기성분으로 확인되었으며 복숭아의 특징적인 향기성분으로 알려져 있는 γ-hexalactone, γ-octalactone, γ-nonalactone, γ-decalactone, γ-dedecalactone, δ-undecalactone 등이 동정되었다.

유명도에서 확인된 성분으로 가장 높은 함유율을 보인 (*E*)-2-hexenal을 포함한 15종의 aldehyde류가 46.97%, 22종의 alcohol류가 6.24%, 4종의 ether류가 1.61%, 5종의 ester류가 1.14%, 8종의 ketone류가 0.35%, 1종의 acid류가 0.01%, 기타 15종의 화합물이 11.12%를 차지하였다. 유명도의 주요 향기성분은 (*E*)-2-hexenal, hexanal이 31.87%, 12.54%를 보였으며, 2-methyl-1-pentene, (*E*)-2-hexen-1-ol, hexanol, (*Z*)-3-hexenal, (*Z*)-3-hexen-1-ol이 3.81%, 1.35%, 1.23%, 1.07%, 1.06% 함유되어 있다. 풀내음을 나타내는 C6 화합물들이 서로 다른 함량을 보이면서 유명도의 주된 향기에 기여하는 것으로 간주된다.

대구보에서 분리 동정된 향기성분은 14종의 aldehyde류가 24.50%, 14종의 ketone류가 8.83%, 18종의 alcohol류가 7.02%, 7종의 ester류가 2.64%, ether류가 1.46%, 기타 16종의 화합물이 15.41%로 확인되었다. 대구보의 주요 휘발성 향기성분으로 (*E*)-2-hexenal, hexanal, 2-methyl-1-pentene, γ-decalactone이

16.15%, 5.64%, 5.51%,, 5.47%로 다량 확인되었고, 그 외에 ethyl acetate, hexanol, benzaldehyde, (*E*)-2-hexen-1-ol이 2.10%, 1.70%, 1.30%, 1.09% 함유되어 있었다.

황도에서 확인된 향기 성분은 9종의 aldehyde류가 26.07%, 20종의 alcohol류가 8.5%와 12종의 ketone류가 2.99%, 기타 14종의 화합물이 22.57% 동정되었다. 또한 hexanal, (*Z*)-3-hexenal, (*E*)-2-hexenal이 8.98%, 0.49%, 15.10% 등 C6와 C9 화합물이 동정되어 이들이 황도 복숭아의 향기성분에 기여하는 것으로 확인되었으며 여러 가지 γ-lactone류도 확인되었다. 백도, 천도, 유명도, 대구보, 황도복숭아에서 동정된 향기성분의 함량은 4.8mg/kg, 18.8mg/kg, 6.7mg/kg, 5.4mg/kg, 6.5mg/kg 정량되었다.

복숭아에서 동정된 향기성분 중 aldehyde류가 백도, 천도, 대구보, 유명도, 백도에서 각각 총 향기성분의 32.30%, 23.99%, 24.5%, 46.97%, 26.07%로서 그 중 (*E*)-2-hexenal,(*Z*)-3-hexenal, hexanal, benzaldehyde 등이 다량 함유 되어있는 것으로 확인되었으며, lactone류가 확인되었는데 이들 중 복숭아의 특징적인 향기성분으로 알려진[29] γ-decalactone과 γ-dodecalactone은 유명도를 제외한 4종의 복숭아에서 모두 상당량 동정되었지고, γ-hexalactone, γ-octalactone, γ-nonalactone, δ-undecalactone 등이 복숭아에서 미량으로 확인되었다. 향기 역가가 낮고 향그러운 과실향을 나타내는 lactone류가 다량 동정되어 복숭아 향기특성에 기여하는 것으로 보이며, 이들 중 복숭아의 핵부위에 존재하는 amygdalin의 효소적 가수분해에 의해 생성된 것[30]으로 보이는 benzaldehyde와 benzyl alcohol이 동정되었다. Alcohol류로는 ethanol, 2-methylpropanol, (*E*)-2-penten-1-ol, 3-pentanol, (*Z*)-3-hexen-1-ol, (*E*)-2-hexen-1-ol 등이 확인되었으며, 이들 중 불포화 C6의 alcohol류가 다량 존재하였다. Ester류는 ethyl acetate, (*Z*)-3-hexenyl acetate, (*Z*)-2-hexenyl acetate 등이 확인되었다.

8) 자두의 품종별 향기성분 분석

국내에서 주로 재배되는 자두중, 뷰티와 포모사의 향기성분을 SDE 방법으로 추출하여 분석한 chromatogram은 Fig. 30-31과 같고, GC-FID와 GC/MS를 사용하여 동정된 향기성분은 Table 38-39에, 관능기별 함량비교는 Table 40에 나타내었다. 뷰티, 포모사 자두에서 99종, 96종의 화합물이 분리 동정되었고, 뷰티의 향기성분으로 ester류 38종, alcohol류 26종, aldehyde류 12종, ketone류 11종, ether류 2종, terpene류 1종, acid류 1종과 그 외 8종의 화합물이 각각 32.63%, 19.29%, 17.14%, 5.57%, 0.92%, 0.01%, 0.37%, 4.65% 확인되었다. 이 중에서 butyl acetate, hexanol, (*E*)-2-hexenal, hexanal, ethyl acetate, hexyl acetate, γ-decalactone이 주요 화합물로 간주되었다.

포모사 자두에서 분리 동정된 향기성분으로 16종의 aldehyde류가 36.36%, 31종의 alcohol류가 17.95%, 6종의 ketone류가 11.83%, 27종의 ester류가 6.24%, 3종의 ether류가 0.63%, 1종의 acid류가 0.07%, 기타 11종의 화합물이 1.30% 확인되었다. 주요 향기성분으로 hexanal, (*E*)-2-hexenal, γ-dodecalactone, hexanol, nonanal, (*Z*)-3-hexen-1-ol, γ-decalactone 등이 16.05%, 15.67%, 9.06%, 4.24%, 2.91%, 2.51%, 2.36%를 함유하고 있었으며, 그외 ester류인 hexyl acetate, butyl acetate가 1.42%,1.27%를 차지하고 있었다. 뷰티와 포모사 자두 모두에서 lactone류가 많은 함량을 차지하고 있으며, 이들이 향기특성에 영향을 미치는 것으로 여겨졌다. 자두의 향기성분을 정량한 결과 뷰티에서는 16.2mg/kg, 포모사에서는 11.3mg/kg이 함유되어 있었다.

9) 살구의 향기성분 분석

살구의 휘발성 향기성분을 SDE 방법으로 추출하여 분석한 chromatogram은 Fig. 32과 같고, 동정된 휘발성 향기성분과 상대농도는 Talbe 41에, 관능기별 함량비교는 Table 42에 나타내었다. 살구의 향기성분은 79종의 화합물이 분리 동정되었

고, 20종의 aldehyde류가 28.9%, 23종의 alcohol류가 12.58%, 5종의 ether류가 2.75%, 8종의 ketone류가 2.52%, 7종의 ester류가 1.43%, 2종의 terpene류가 1.40%, 기타 12종의 화합물이 6.90%를 나타내었다. 이 중에서 (*E*)-2-hexenal, 2-methyl-1-pentene, hexanal, (*E*)-2-hexen-1-ol, hexanol, β-ionone, geranyl acetone, (*Z*)-3-hexen-1-ol이 19.60%, 5.60%, 4.91%, 3.48%, 2.72%, 1.33%, 1.25%, 1.05%를 차지하고 있고 주요 화합물로 간주되었으며, 살구에서 동정된 향기성분의 함량은 4.6mg/kg 정량되었다.

10) 매실의 향기성분 분석

국내에서 재배되어 사용되는 매실은 매실절임, 매실주등으로 우리 식생활에서 이용되며 건조한 것은 오매라고하여 한방에서 사용되고 있다. 이러한 매실의 향기성분을 pentane 과 diethylether 혼합용매를 추출용매로하여 휘발성 향기 성분을 추출하고 이를 GC-FID와 GC/MS를 사용하여 분석, 동정하여 Fig. 33과 table 43에 나타내었으며, 향기성분의 관능기별 함량비교는 Table 44와 같다. 매실에서 81종의 화합물이 분리 동정되었고, alcohol류 26종, aldehyde류 19종, ester류 17종, acid류 4종, ketone류 5종, terpene류 2종과 그 외 6종의 화합물이 동정되었다. 이 중에서 (*E*)-3-hexenal, (*E*)-2-hexen-1-ol, hexanol, hexanal, (*E*)-2-hexenyl acetate, (*Z*)-3-hexen-1-ol, ethyl acetate가 주요 화합물로 확인되었다. 또한 ethanol, 1-penten-3-ol, (*Z*)-2-penten-1-ol 등 전체 함량의 36.27%로 확인된 alcohol류가 매실의 주요한 정유성분 화합물로 간주되었으며, 매실의 정유성분의 함량은 15.6mg/kg 으로 정량되었다.

11) 키위의 향기성분 분석

국내 해남지방에서 생산되는 헤이워드 키위의 향기성분을 SDE방법으로 추출하였고 GC의 RI와 GC/MS 분석에 의하여 확인동정하여 이 chromatogram을 Fig. 34

에, 확인된 성분과 상대농도는 Table 45에, 관능기별 함량비교는 Table 46에 나타내었다. 헤이워드 키위에서는 91종의 휘발성 향기성분이 분리 동정되었다. 이중 aldehyde류가 19종이 동정되어 전체 화합물중 32.85%로 나타나 대부분을 차지하였고 alcohol류가 23종이 확인되어 6.29%, ester류가 18종 동정되어 0.24%, ketone류가 12종 동정되어 1.31%, acid류가 6종이 동정되어 21.04%, 기타 11종의 화합물이 3.6%를 나타내었다. 헤이워드 키위에서 2-hexenoic acid, ethyl acetate, hexanoic acid 등이 많은 함량을 나타내었고 lipoxygenase에 의해 생성되는 C6 화합물중 다량 동정된 (*E*)-2-hexenal, hexanal 이외에도 hexanol, (*E*)-2-hexen-1-ol 등이 확인되어 키위의 주요 향기성분임을 나타내었다. 헤이워드 키위에서 분리 동정된 휘발성 향기성분을 정량한 결과 9.5㎎/㎏이 함유되어 있었다.

나. 국내산 과채류의 향기성분 분석

1) 토마토의 품종별 향기성분 분석

SDE 방법으로 추출한 빼빼, 꼬꼬, 도태랑 토마토의 향기성분을 분석한 chromatogram은 Fig. 35-37과 같고, GC의 RI와 GC/MS 분석에 의하여 동정한 휘발성 향기성분와 상대농도는 Table 47-49에, 관능기별 함량비교는 Table 50에 나타내었다. 빼빼, 꼬꼬, 도태랑 토마토에서 85종, 77종, 68종의 휘발성 향기성분이 분리 동정되었다.

빼빼의 향기 성분으로 aldehyde류 30종이 34.17%, alcohol류 23종이 20.25%, ketone류 14종이 11.49%, ester류 6종이 5.54%, ether류 3종이 0.22%, acid류 3종이 0.50%, terpene류 1종이 0.04%, 기타 5종의 화합물이 0.28% 확인되었다. 이중 *(E)*-2-hexenal는 18.48%, hexanl은 10.55%, 2-methyl-1-butanol는 3.71%가 동정되어 이들이 빼빼의 주요한 향기성분으로 여겨졌다.

꼬꼬에서 분리 동정된 향기성분으로 30종의 alcohol류가 44.63%, 5종의 ester

류가 6.9%, 19종의 aldehyde류가 6.02%, 12종의 ketone류가 5.85%, 3종의 ether류가 2.4%, 2종의 acid류가 0.89%, 2종의 terpene류가 0.02%, 기타 4종의 화합물이 0.6%가 확인되었다. 꼬꼬의 전체적인 상대농도의 대부분을 차지한 alcohol류로 2-methyl-1-butanol, 3-methyl-1-butanol, phenethyl alcohol, 1,2-propanediol이 7.13%, 4.53%, 4.21%, 3.20%를 함유하고 있었으며, ester류로 ethyl acetate가 5.52%를 차지하고 있었다. Aldehyde류로 풀내음을 내는 C6 화합물인 hexanal과 (*E*)-2-hexenal이 1.03%, 1.28%를 함유하고 있었으며, ketone류에는 (*Z*)-geranyl acetone과 farnesylacetone가 2.05%, 1.76%를 나타내었다. 2-Methyl-1-butanol, ethyl acetate, 3-methyl-1-butanol, phenethyl alcohol 등이 꼬꼬의 향기에 기여하는 것으로 여겨졌다.

도태랑에서 분리 동정된 향기성분으로 18종의 aldehyde류가 26.93%, 26종의 alcohol류가 16.03%, 9종의 ketone류가 10.44%, 3종의 ether류가 1.31%, 1종의 terpene류가 0.14%, 기타 9종의 화합물이 12.02%로 확인되었다. 이 중에서 (*E*)-2-hexenal, 2-methyl-1-pentene, hexanal, farnesylacetone, 2-methyl-1-butanol, (*Z*)-geranylacetone, 2-methylpropanol, 2-butanol 등이 각각 14.89%, 10.35%, 8.42%, 5.81%, 5.34%, 3.15%로 확인되었으며, 도태랑의 주요 향기성분으로 간주되었다.

전체의 상대적 함량비교에서 빼빼와 도태랑은 aldehyde 화합물이 각각 34.17%, 26.93%로, 꼬꼬에서는 alcohol류 화합물이 44.63%로 나타나 다른 화합물에 비하여 높은 비율을 차지하였다. 토마토의 품종별 분리동정된 휘발성 향기성분을 정량한 결과 빼빼에서는 7.2mg/kg, 꼬꼬에서는 7.1mg/kg, 도태랑에서는 7.7mg/kg이 함유되어 있었다.

2) 딸기의 품종별 향기성분 분석

국내산 딸기중 수홍과 보교의 휘발성 향기성분을 SDE 방법으로 추출하여 분석

한 chromatogram은 Fig. 38-39와 같고, GC의 RI와 GC/MS 분석에 의하여 동정한 휘발성 향기성분과 상대농도는 Table 51-52에, 관능기별 함량비교는 Table 53에 나타내었다.

수홍에서 분리동정된 143종의 향기성분중 63종의 ester류가 29.96%, 26종의 alcohol류가 22.39%, 12종의 aldehyde류가 3.86%, 21종의 ketone류가 8.57%, 4종의 acid류가 2.95%, 3종의 terpene류가 0.21%, 기타 7종의 화합물이 3.41% 확인되었다. 주요향기성분으로 nerolidol이 13.75%로 가장 높은 함유율을 보였으며, 그외 ethyl butanoate, methyl butanoate, ethyl hexanoate, 3-penten-2-one, ethyl acetate, linalool, methyl hexanoate, (*E*)-2-hexenyl acetate, acetic acid가 각각 5.16%, 4.14%, 3.83%, 3.58%, 3.29%, 3.25%, 2.25%, 2.20%, 2.11%로 다량 차지하였다.

보교에서 분리동정된 133종의 향기성분중 42종의 ester류가 23.22%, 31종의 alcohol류는 15.91%, 23종의 aldehyde류는 10.13%, 4종의 acid류는 6.09%, 17종의 ketone류는 5.69%, 3종의 ether류는 0.31%, 1종의 terpene류는 0.08%, 기타 8종의 화합물이 확인되었다. (*E*)-2-Hexenyl acetate, acetic acid, nerolidol, (*E*)-2-hexenal, hexyl acetate가 각각 5.54%, 4.89%, 4.46%, 3.84%, 3.14%로 다량 확인되었고, 그외 hexanal, ethyl acetate, (*E*)-2-hexen-1-ol, hexanol도 보교의 주요 향기성분으로 여겨졌다. 수홍과 보교에서 정량된 향기성분의 함량은 12.6mg/kg, 46.1mg/kg으로 보교의 회수율이 더 높았다.

3) 메론의 품종별 향기성분 분석

별똥별, 파파이야, 머스크 메론의 휘발성 향기성분을 SDE 방법으로 추출하여 분석한 chromatogram은 Fig. 40-42와 같고, GC의 RI와 GC/MS 분석에 의하여 동정된 휘발성 향기성분과 상대농도는 Table 54-56에, 관능기별 함량비교는 Table 57에 나타내었다. 별똥별, 파파이야, 머스크 메론에서 87종, 121종, 106종의 화합

물이 분리 동정되었다.

별똥별 메론의 향기성분으로 32종의 ester류가 51.89%, 26종의 alcohol류가 24.28%, 2종의 ether류가 1.50%, 13종의 aldehyde류가 1.20%, 1종의 acid류가 0.07%, 6종의 ketone류가 0.49%, 기타 6종의 화합물이 0.20% 동정되었다. 주요 향기성분으로 ester류인 ethyl acetate가 전체 상대농도의 24.28%로 가장 높은 함유율을 보였으며, benzyl acetate, 2-methylbutyl acetate, 2-methylpropyl acetate, butyl acetate도 각각 9.14%, 3.40%, 2.96%, 2.00%로 다량 함유되어있다. Alcohol류에는 미량으로도 메론향을 발휘하는것으로 보고[32]된 (*Z*,*Z*)-3,6-nonadien-1-ol이 5.28%, (*Z*)-3-nonen-1-ol이 4.58%를 차지하였으며 오이의 impact 화합물인 (*E*,*Z*)-2,6-nonadienal이 소량 확인되었다. 메론의 전체적인 aroma profile을 결정하는데 중요한 역할을 하는 황함유 화합물은 Yabumoto 등[33]이 메론 추출물에서 dimethyl disulfide를 분리한 것이 최초였으며, 자신의 향기역가보다 높은 농도로 존재 할 때 메론의 향기 특성에 큰 영향을 미치는 것으로 알려져 있다. 별똥별 메론에서는 ethyl (methylthio)acetate, ethyl 3-(methylthio)propanoate, dimethyl trisulfide, 3-(methylthio)propanal과 같은 황함유 ester 화합물이 소량으로 존재하였다.

파파이야 메론에서 분리 동정된 향기성분으로 51종의 ester류가 47.04%, 31종의 alcohol류가 9.98%, 16종의 aldehyde류가 1.57%, 2종의 acid류가 1.01%, 2종의 ether류가 1.00%, 12종의 ketone류가 0.69%, 기타 5종의 화합물이 0.34% 확인되었다. 이 중에서 ethyl acetate, 2-methylbutyl acetate, 2-methylpropyl acetate, ethyl butanoate, benzyl acetate가 16.52%, 3.61%, 3.29%, 3.24%, 3.14%로 높은 함유율을 보였으며, 파파이야 메론의 향기에 기여하는 것으로 여겨졌다. 그외 (*Z*)-3-nonen-1-ol, ethyl propanoate, (*Z*,*Z*)-3,6-nonadien-1-ol, ethyl 2-methylbutanoate, butyl acetate, propyl acetate가 2.35%, 1.96%, 1.95%, 1.63%, 1.37%, 1.28%를 차지하였으며, 메론의 특징적 향기를 내는 황함유 ester

화합물인 methylthioacetate, ethyl (methylthio)acetate, ethyl 3-(methylthio) propanoate가 소량 확인되었다. 이들 황화합물들은 숙성 호르몬인 ethylene이 발생되는 동안 methionine의 탈아미노반응과 α-keto-(methylthio)butanoic acid의 탈탄산화반응을 포함한 생합성 경로를 거쳐 생성되거나, 또는 thioglucosinate로부터 생성된다[25]. 다량 함유되어 있는 2,3-butanediol diacetate는 향기역가[34]가 높아서 향기 기여도가 낮다.

머스크 메론에서 분리 동정된 향기성분으로 55종의 ester류가 59.40%, 21종의 alcohol류가 8.75%, 11종의 aldehyde류가 1.16%, 3종의 acid류가 3.03%, 2종의 terpene류가 0.48%, 6종의 ketone류가 0.19%, 기타 6종의 화합물이 0.41%를 차지하였다. 이 중에서 ethyl acetate, 2-methylbutyl acetate, ethyl butanoate, benzyl acetate, butyl acetate, 2-methylpropyl acetate, ethyl 2-methylbutanoate, propyl acetate가 9.56%, 7.80%, 6.95%, 5.68%, 3.59%, 3.33%, 3.05%, 2.96%로 머스크 메론의 주요 향기성분으로 여겨졌으며, 황함유 ester 화합물인 methylthioacetate 또한 메론의 향기특성에 중요한 역할을 하는 것으로 간주된다. 2,3-Butandiol에서 유도되어 생성된 diester[34]인 meso-2,3-butanediol diacetate은 2.75%로 상당량 함유되어 있었지만 향기역가가 높기때문에 머스크 메론의 중요향기에 크게 기여하지 않는다. Horvat 등[35]에 의해 머스크메론의 향기성분으로 확인된 benzyl alcohol은 0.65%로 소량 확인되었다.

메론의 향기특성에 기여하는 것으로 보고된[36] 황함유 ester 화합물이 각각의 품종에서 확인되었는데, 별똥별, 파파이야 메론에서는 ethyl 2-(methylthio) acetate, ethyl 3-(methylthio)propanoate, methyl thioacetate가 서로 다른 함량으로 존재하였으며 파파이야 메론에서 더 많은 부분을 차지하였고, 머스크 메론에서는 methyl thioacetate만이 확인되었다.

별똥별, 파파이야, 머스크 메론에서 추출된 휘발성 향기성분의 함량은 19.9mg/kg, 7.5mg/kg, 11.0mg/kg이었으며, 전체의 상대적 함량비교에서 각각

ester 화합물이 51.89%, 47.04%, 59.4%로 매우 높은 비율을 차지하였으며, C9 화합물이 상당량 함유되어 있는 alcohol류도 메론의 주요 향기 성분으로 간주되었으며, 소량 확인된 황함유 화합물 또한 중요한 역할을 하는 것으로 여겨졌다.

4) 참외와 수박의 향기성분 분석

*Cucurbitaceae*과에 속하는 참외 (*Cucumis melo* L.)와 수박(*Citrullus vulgaris* Schrad.)의 휘발성 향기성분을 SDE 방법으로 추출하여 분석한 chromagotram은 Fig. 43-44와 같고, GC의 RI와 GC/MS 분석에 의하여 동정된 휘발성 향기성분과 이들의 상대적 농도는 Table 58-59에, 관능기별 함량비교는 Table 60에 나타내었다.

참외에서는 총 97종의 화합물이 동정되었는데 모든 과일향의 주요 성분으로 알려져 있는 ester류 38종이 전체 상대농도의 47.57%를 차지하였으며, 24종의 alcohol류, 21종의 aldehyde류, 2종의 ether류, 2종의 ketone류, 2종의 terpene류, 기타 5종의 화합물이 각각 7.27%, 4.63%, 1.30%, 0.24%, 0.05%, 0.65%를 나타내었다. Ester류 중에서는 ethyl acetate가 16.15%로 가장 많이 함유되어있으며, nonanyl acetate도 8.30%로 다량 확인되었다. 2,3-Butanediol에서 유도되어 생성된 diester인 meso-2,3-butanediol diacetate는 10.23로 다량 확인되었지만 향기역가가 높기 때문에 참외의 중요 향기에 크게 기여하지 않는다. 또한 향기역가[28]가 낮아 미량만 존재하여도 관능적으로 메론의 특징적인 향기를 느끼게 하는 ethyl 2-methylpropanoate, ethyl 2-methylbutanoate, ethyl butanoate 그리고 benzyl acetate가 0.11%, 0.27%, 2.07%, 3.48%씩 검출되었다. 한편 alcohol류 중에서 수박의 향기성분으로 보고된[32] (*Z,Z*)-3,6-nonadien-1-ol이 0.79% 존재하였고, (*Z*)-6-nonen-1-ol도 0.12% 포함되어 있었다. Aldehyde류중 hexanal이 1.90%를 차지하였으며, muskmelon의 특징적인 향기성분으로 보고[37]한 2-nonenal도 (*E*)-이성질체 형태로 0.19% 존재하였으며, (*E,Z*)-2,6-nonadienal은 0.02%로 미량 확인되었다. 메론의 향기특성에 기여하는 ethyl (methylthio)acetate와 ethyl

3-(methylthio)propanoate와 같은 황함유화합물이 각각 0.86%와 0.14%의 농도로 확인되었다. 참외에서는 ethyl acetate, nonanyl acetate, benzyl acetate가 다량으로 동정되어 주성분으로 확인되었으며, 이들 C9 화합물들은 주로 과일의 세포벽에 존재하는 불포화지방산인 linoleic, linolenic acid가 lipoxygenase에 의해 특정 위치에서 과산화되고, 뒤이어 절단효소인 aldehyde lyase에 의해서 탄소-탄소 결합이 개열되고 그외 isomerase, alcohol dehydrogenase 등의 효소들의 작용에 의해 생성된다[25]. 소량 확인된 hexanal, (*E*)-2-hexenal, hexanol, (*E*)-3-hexen-1-ol은 풀내음을 내는 C6 화합물로써 C9 화합물처럼 lipoxygenase에 의한 생합성 경로에 의해 생성되며, 이 중 (*E*)-2-hexenal은 muskmelon의 일차적 향기성분으로 보고되었다[38].

수박에서는 총 66종의 화합물을 동정하였고,24종의 alcohol류가 전체 동정함량의 61.46%, 2종 확인된 aldehyde류는 8.72%를 나타내었으며, 그 외에 ester류와 ketone류가 각각 2종과 7종, terpene류와 aicd류가 각각 1종이 확인되었으며, 기타 5종의 화합물이 확인되었다. Aldehyde류로는 (*E,Z*)-2,6-nonadienal, (*E*)-2-nonenal, (*Z*)-6-nonenal 등 C9 불포화화합물이 주로 나타났다. (*E,Z*)-2,6-Nonadienal과 (*E*)-2-nonenal은 각각 0.04%, 0.19%를 차지하였으며 오이의 중요 향기성분으로 알려져 있고, 특히 (*E,Z*)-2,6-nonadienal은 오이의 impact compound로 보고되었으며 머스크메론에서도 확인되었다[38]. (*Z*)-6-Nonenal은 0.12%로 낮았으나 수용액 중에서의 향기역가[28]가 0.005 ppb로 매우 낮기 때문에 관능적 향기 특성에 기여하는 정도가 크다고 할 수 있다. 수박에서 (*Z*)-3-nonen-1-ol, (*E,Z*)-3,6-nonadien-1-ol, nonanol, (*E*)-2-Nonenal, (*E,Z*)-2,6- nonadienal이 다량으로 동정되어 C9 alcohol류와 aldehyde류가 특징적으로 나타났다. 수박과 참외에서 분리 동정한 향기 성분의 정량은 각각 12.7mg/kg, 14.4mg/kg 이었다.

다. 국내산 향신료의 향기성분 분석

1) 산초의 휘발성 향기성분 분석

산초(*Zanthorylum piperitum* DC)의 잎과 열매의 향기성분을 SDE 방법으로 추출하여 분석한 chromatogram은 Fig. 46-47과 같고, GC-FID와 GC/MS를 사용하여 분리 동정한 향기성분은 Table 61-62에, 관능기별 함량비교는 Table 63에 나타내었다. 산초잎에서 144종, 산초열매에서 92종의 화합물이 분리 동정되었고, 산초잎의 향기 성분으로 α-pinene을 포함하여 37종의 terpene류, β-citronellol을 포함하여 34종의 alcohol류, (*E*)-2-hexanal를 포함하여 23종의 aldehyde류, citronellyl acetate를 포함한 18종의 ester류, 2-undecanone을 포함한 10종의 ketone류, acetic acid를 포함한 2종의 acid류, 2종의 ether와 기타 15종의 화합물이 47.03%, 20.67%, 11.21%, 5.42%, 2.14%, 0.25%, 0.16%, 4.24% 확인되었다. 이 중에서 α-pinene, (*E*)-2-hexenal, (*Z*)-β-ocimene, linalool, (*E*)-β-ocimene, β-myrcene, α-limonene이 각각 7.73%, 7.04%, 6.26%, 6.06%, 5.90%, 3.80%, 2.94%로 주요 화합물로 간주되었다.

산초열매의 향기성분으로 geraniol 이외에 30종 alcohol류, β-myrcene 이외에 14종 terpene류, citronellyl acetate 이외에 12종 ester류, citronellal 이외에 14종 aldehyde류, 2-pentanone 이외에 8종의 ketone류와 그외 12종의 화합물이 확인되었다. 이중 α-, β-phelladrene, geranyl acetate, β-myrcene, cirtonellyl acetate, citronellal, geraniol이 21.68%, 9.21%, 17.16%, 11.32%, 8.34%, 4.29%, 4.25%로 동정되어 이들이 산초 열매의 주요 화합물로 간주되었다.

산초잎과 산초열매의 향기성분의 함량은 99.0mg/kg, 332.1mg/kg로 정량되었으며, 각각 47.03%와 44.21%로 확인된 terpene류가 주요 화합물로 동정되었다. 산초잎에서 확인된 terpene류 중 α-pinene, sabinene, β-myrcene, β-phelladrene, (*Z*)-β-ocimene, (*E*)-β-ocimene, α-terpinolene, α-limonene 등

이 다량 확인되었으며, 산초열매에서는 β-myrcene, α-, β-phelladrene등이 동정되었다. 산초잎에는 terpene류가 여러 종 함유된 반면에, 산초 열매에서는 terpene류 이외에 ester류와 aldehyde류인 neryl acetate, citronellal 등이 다량 존재하는 것으로 확인되었다. 이들 terpene류는 여러 정유에서 발견되며 monoterpene의 경우 방향성이 높은데 비하여 sesquiterpene은 향이 강하지 않은 편으로 알려져 있는데 Keffor 등[39]에 의하면 chain compound가 ring compound 보다 발향이 강하며 불포화도가 클수록 휘발성이 크다고 제시한바 있다.

2) 방아잎의 휘발성 향기성분 분석

특유하고 다양한 향기때문에 전통적으로 식용[40-41]되어오던 방아잎의 향기성분을 SDE 방법으로 추출하여 분석한 chromatogram은 Fig. 48과 같고, GC-FID와 GC/MS를 사용하여 동정한 휘발성 향기성분과 상대농도는 Table 64에 나타내었다.

방아잎에서 86종의 화합물이 분리 동정되었고, 방아잎의 향기성분을 기능기별로 살펴보면, 23종의 alcohol류가 55.80%, 20종의 aldehyde류가 16.80%, 13종의 terpene류가 13.66%, 10종의 ester류가 5.11%, 3종의 acid류가 0.93%, 13종의 ketone류가 0.79%, 3종의 ether류가 0.72%, 기타 8종의 화합물이 0.22%를 나타내었다(Table 65). 이중에서 주요 향기성분으로 estragole이 48.26%로 가장 높은 함유율을 보였으며, (*E*)-2-hexenal, α-limonene, (*Z*)-3-hexen-1-ol, octen-1-ol acetate, bornylene, (*Z*)-3-hexenal이 13.66%, 10.96%, 4.59%, 3.76%, 2.38%, 1.94%를 차지하였다. 방아잎에서의 향기성분은 alcohol류가 주요 향기성분으로 간주되었으며 향기성분의 함량은 163.7mg/kg이었다.

방아의 중요 향기성분은 estragole로써 서양의 향신료인 anise에서 다량 분리되는 발향성이 강한 성분으로 알려져 있으며[42] anethole은 estragole의 이성체로서 anise와 회향에 함유된 향이다[47]. 또한 estragole은 methylation되어 methyleugenol을 형성하였다. 방아에서 확인된 향기성분 중 terpene류는 그 자체

가 신선한 향을 부여하는 역할을 가지고 있고 또한 다른 향기 성분의 구성물질로서의 작용이 더 크며 이들에 관능기가 부가된 형태는 풍미가 더욱 우세하다고 보고된 바 있다[44]. 방아에서는 monocyclicterpene으로 α-limonene, β-myrcene, bornylene, sabinene등이 확인되었는데 특히 α-limonene은 10.96%가 동정되었다. 그리고 sesquiterpene류도 확인되었는데 caryophyllene은 후추에 약 19%, clove에 5-12%가 포함된 나무향으로 천연에 iso-form의 mixture form 으로 존재하며 향을 오래 지속시키는 휘발성성분의 고착제 역할을 한다[45,46]고 알려져 있는 성분이다.

3) 부추의 휘발성 향기성분 분석

이른 봄에 인경과 근엽을 식용하는 부추 (*Allium tuberosum* Rottler)는 지방에 따라 부초, 솔, 정구지, 졸이라고 불리며[47], 인경은 약리작용이 있어 건위, 정장, 화상치료에 이용되었으며 민간에서는 이질을 치료하는데 쓰였다고 한다[48,49].

부추는 김치를 담글 때 주재료로 사용되어 부산 및 경남지방의 향토 별미김치로 알려져 있으며[15], 또한 특유성분인 allyl sulfide류가 함유되어 있어 독특한 향미로 인해 김치의 부재료로의 이용뿐만 아니라 조리시 생선이나 육류의 냄새를 제거하는 등[49] 향신료로서도 많이 사용되고 있다.

국내에서 널리 재배되며 주로 김치의 주재료 혹은 부재료와 향신료로 이용되고 있는 부추의 향기성분을 SDE 방법으로 추출하고 분석한 chromatogram은 Fig. 49와 같고, 이를 GC-FID와 GC/MS를 사용하여 확인한 향기성분과 상대농도는 Table 66에 나타내었다. 부추에서 확인된 성분은 총 65종으로, 28종의 황함유 화합물과 aldehyde류 12종, alcohol류 9종, lactone류와 ester류가 각각 4종, acid류가 3종 그리고 기타 5종이 동정되었다. 동정된 성분들 중에서 황함유 화합물이 전체 상대농도의 77.84%로 휘발성 향기성분의 대부분을 차지하였으며, dimethyl disulfide, dimethyl trisulfide, (*E*)-1-propenylmethyl disulfide, (*E*)-2-hexenal 그리고 methyl allyl disulfide가 다량 동정되어 부추의 휘발성 향기성분의 주성

분으로 여겨졌다.

부추에서 추출 분리된 총 휘발성 향기성분 중에서 황함유 화합물이 73.78%로 대부분을 차지하였으며, 이어서 aldehyde류가 11.39%, alcohol류가 4.36%, ester류가 2.27%, terpenee류가 1.90%, acid류가 0.66%, lactone류가 0.32% 그리고 기타 0.11% 순으로 나타났다(Table 67).

동정된 성분들 중에서 dimethyl disulfide가 전체 상대농도의 19.47% 그리고 dimethyl trisulfide가 17.38%를 차지하여 이 두 가지 화합물이 부추의 휘발성 향기성분의 중요성분이었으며 이외에 (*E*)-1-propenylmethyl disulfide, 2-hexenal 그리고 methyl allyl disulfide도 다량으로 동정되었다.

휘발성 향기성분의 대부분을 차지한 함황화합물을 다시 기능기별로 분류하면 allyl- 10%, methyl- 38.18%, 1-propenyl- 22.07% 그리고 propyl- 0.76% 임을 알 수 있는데, Block 등[51,52]이 부추의 함황성분 중에서 allyl- 11%, methyl- 87%, 1-propenyl- 3%가 확인되었으며 propyl 기는 검출되지 않았다고 보고한 내용과 다소 상이하였다. 위의 보고서에서는 methyl기가 전체 함황성분의 대분분을 차지하고 있는 반면에 본 실험에서는 단지 38.18% 만을 나타내었으며 이에 반하여 1-propenyl 기는 22.07%로서 더 많은 함량을 보여주었다. 동일한 *Allium* 식물인 마늘의 휘발성 향기성분 중 diallyl disulfide와 diallyl trisulfide가 실험에 따라 약간의 차이를 가지고는 있지만 60-80%를 차지한다고 보고한 결과들과 비교해 볼 때, 이런 성분들이 부추에서는 단지 1.52%와 0.20% 만을 나타냄은 부추의 휘발성 향기성분 조성의 한 특징을 보인다.

실험 결과에 차이를 나타내는 것은 시료의 종류, 추출용매, 증류방법의 차이 등에 기인되는데 이와 같은 추출방법과 조건에 따른 관련효소의 잔존활성에 따라 최종적으로 추출되는 향기성분의 함량이 달라질 수 있기 때문이라 생각되었다.

합성항생제가 이용되기 전에는 *Allium* 식물은 발진티푸스, 이질, 결핵과 같은 전염병의 치료에 널리 쓰였으며, 특히 diallyl trisulfide는 중국에서 바이러스 감염

과 수막염을 치료하는데 이용되었다[51]. 또한 dially disulfide는 nitrosamines를 불활성화하여 종양의 증진을 억제한다고 알려져[52,53]있으며, 한 예로서 위암발생률이 높은 중국의 한 지역의 유행병학연구에서 위암발생률의 뚜렷한 감소는 마늘, 골파, 부추의 소비증가와 평행선을 이룬다고 발표되었다[54]. 지질대사 과정에서 diallyl disulfide는 3-hydroxy-3-methyl glutaryl CoA를, 이 물질의 전구체인 allicin은 acetyl CoA의 합성을 저해시켜 cholesterol과 fatty acid의 생합성을 억제시킨다[51].

대부분 황함유화합물이 주요성분들로 동정되는 가운데 전체 상대농도의 9.95%로 다량 동정된 (*E*)-2-hexenal은 hexanal과 더불어 풀내음을 내는 향기성분이다. 또한 확인된 황함유화합물 중 methyl allyl disulfide, diallyl sulfide, diallyl disulfide 그리고 2-propenethiol은 Allium 식물의 섭취 후 구취와 땀냄새를 유발시키는 물질로 확인되는 성분들이다[54].

제 3 장 결론 및 활용

국내산 식물소재에 함유된 휘발성 향기성분을 분석하기 위하여 분석기기의 최적 분석조건과 향기성분의 추출용매 및 추출방법을 수립하였다.

과일, 과채류 및 향신료와 같은 국내산 식물소재를 선택하여 총 47종의 휘발성 향기성분을 분석하였다. 과일로는 모과 1종, 황금배, 이마무라, 신고, 장십랑, 만삼길 등 5종의 배, 후지, 쓰가루, 홍옥(조나단), 홍로, 하향 등 5종의 사과, 네오머스캇, 블랙올림피아, 캠벨, 델라웨어 등 4종의 포도, 부유, 대봉 등의 2종의 감, 백도, 천도, 유명도, 대구보, 황도복숭아 등 5종의 복숭아, 뷰티, 포모사 등 2종의 자두, 1종의 살구, 1종의 매실, 감귤류는 유자, 금귤, 향상조생, 조생, 껍질을 제거한 향상조생, 껍질을 제거한 조생 등 6종, 헤이워드의 키위 1종의 휘발성 향기성분을 분석하였다.

모과에서 분리 동정된 향기성분은 총 138종으로, ester류 74종, alcohol류 21종, aldehyde류 18종, acid류 6종, ketone류 6종, ether류가 1종, 기타 9종의 화합물이 확인되었다. 이 동정된 성분들 중 ester류와 alcohol류가 다량의 향기성분으로 확인되었다.

황금배, 이마무라, 신고, 장십랑, 만삼길 등 5종의 배에서 각각 107종, 61종, 102종, 109종, 47종의 화합물이 확인되었다. 황금배에서 분리 동정된 향기성분으로 36종의 ester류, 21종의 aldehyde류, 19종의 alcohol류, 5종의 acid류, 14종의 ketone류, 2종의 ether류, 1종의 terpene류, 기타 8종의 화합물이 확인되었다. 이마무라에서 동정된 향기성분으로 alcohol류 10종, acid류 3종, ester류 12종, terpene류 1종, aldehyde류 10종, ketone류 7종이 확인되었다. 신고의 향기성분으로 alcohol류 27종, ester류 27종, aldehyde류 21종, acid류 3종, ketone류 8종, ether류 3종, terpene류 1종, 기타 7종의 화합물이 확인되었다. 장십랑에서

동정된 향기성분으로 33종의 ester류, 24종의 alcohol류, 20종의 aldehyde류, 10종의 ketone류, 4종의 acid류, 4종의 terpene류, 기타 9종의 화합물이 확인되었다. 만삼길에서 alcohol류 23종, acid류 8종, ester류 5종, terpene류 5종, aldehyde류 4종, ketone류 2종의 향기성분이 동정되었다. 배의 향기성분으로 acohol류, ester류, aldehyde류가 서로 다른함량으로 영향을 미쳤으며, C6 화합물이 많이 함유되어있다.

사과의 품종중 후지, 쓰가루, 홍옥(조나단), 홍로, 하향의 향기성분을 분석한 결과 각각 98종, 67종, 99종, 82종, 66종의 화합물이 분리 동정되었다. 후지에서 동정된 휘발성 향기성분 중 butanol과 hexanol을 포함한 15종의 alcohol류, ethyl 2-methylbutanoate를 포함한 36종의 ester류, hexanal과 (*E*)-2-hexenal을 포함한 15종의 aldehyde류, 8종의 ketone류, 3종의 terpene류, 2종의 ether류, 3종의 acid류가 확인되었다. 쓰가루에서 분리동정된 향기성분중 (*E*)-2-hxenal과 hexanal을 포함한 20종의 aldehyde, hexanol과 butanol을 포함한 17종의 alcohol류, hexyl acetate를 포함한 9종의 ester류, 5종의 ketone류, 3종의 acid류, 3종의 ether류, 기타 9종의 화합물이 확인되었다. 홍옥(조나단)에서 동정된 휘발성 향기성분은 alcohol류 25종, aldehyde류 18종, ester류 28종, terpene류가 4종, acid류 2종, ketone류 12종, ether류 2종, 기타 2종의 화합물이 확인되었다. 홍로에서 동정된 휘발성 향기성분은 alcohol류 24종, aldehyde류 16종, ester류 21종, acid류 2종, ether류 3종, terpene류 2종, ketone류 7종, 기타 5종의 화합물이 확인되었다. 하향에서 동정된 향기성분 중 15종의 alcohol류, 14종의 aldehyde류, 18종의 ester류, 2종의 terpene류, 2종의 acid류, 3종의 ether류, 9종의 ketone류, 기타 3종의 화합물이 확인되었다. 사과 5품종의 주요 향기성분은 butanol, hexanol, 3-methyl-1-butanol, hexanal, (*E*)-2-hexenal, butyl acetate, 2-methylbutyl acetate, hexyl acetate, ethyl acetate로 서로 다른 함량으로 존재하였다.

네오머스캇, 블랙올림피아, 캠벨, 델라웨어 포도등 4종의 포도의 향기성분은 각각 94종, 77종, 73종, 74종이 확인되었다. 네오머스캇에서 동정된 성분들은 34종의 ester류, 24종의 alcohol류, 15종의 aldehyde류, 3종의 ether류, 3종의 acid류, 5종의 ketone류, 1종의 terpene류, 기타 8종의 화합물이 확인되었다. 블랙올림피아에서 동정된 향기성분으로 28종의 ester류, 23종의 alcohol류, 15종의 aldehyde류, 3종의 acid류, 3종의 ether류, 1종의 ketone류, 1종의 terpene류가 0.04%, 기타 3종의 화합물이 확인되었다. 캠벨에서 동정된 성분들은 24종의 ester류, 14종의 aldehyde류, 25종의 alcohol류, 3종의 ketone류, 3종의 terpene류, 1종의 ether류, 기타 3종의 화합물이 확인되었다. 델라웨어에서 동정된 성분들로는 33종의 alcohol류, 20종의 aldehyde류, 4종의 terpene류, 3종의 ester류, 3종의 acid류, 3종의 ketone류, 2종의 ether류, 기타 6종의 화합물이 확인되었으며, 네오머스캇, 블랙올림피아, 캠벨과는 달리 alcohol류가 높은 함량을 나타내었다. 포도의 주요 향기성분으로는 모든 품종에서 공통적으로 hexanal, (*E*)-2-hexenal, hexanol, (*E*)-2-hexen-1-ol, ethyl acetate 등이 다량 확인되어 C6 화합물이 포도의 주된 향기성분으로 확인되었다.

부유와 대봉 등 2종의 감을 시료로 추출한 향기성분은 각각 69종, 99종의 화합물이 분리 동정되었다. 부유에서 동정된 향기성분중 alcohol류 22종, ester류 11종, aldehyde류 14종, ketone류 11종, ether류 2종, 1종의 acid가 확인되었다. 대봉에서 동정된 향기성분으로 alcohol류 28종, aldehyde류 21종, ester류 17종, acid류 4종, ether류 3종, terpene류 2종, 기타 13종의 화합물이 확인되었다.

국내산 감귤류중 유자, 금귤, 향상조생, 조생 그리고 껍질을 제거한 향상조생과육, 조생과육의 향기성분을 추출하여 분석한 결과, 각각 77종, 83종, 90종, 89종, 86종, 98종의 화합물이 분리 동정되었다. 유자에서 동정된 향기성분은 32종의 terpene류, 24종의 alcohol류, 8종의 ester류, 7종의 aldehyde류, 1종의 ketone류, 기타 4종의 화합물이 확인되었다. 금귤에서 동정된 향기성분은 25종의

terpene류, 23종의 alcohol류, 13종의 ester류, 7종의 aldehyde류, 5종의 ketone류, 기타 8종의 화합물이 확인되었다. 껍질을 제거하지 않은 향상조생에서 동정된 향기성분으로 25종의 terpene류, 21종의 alcohol류, 12종의 ester류, 14종의 aldehyde류, 6종의 ketone류, 1종의 ether류, 1종의 acid류, 기타 9종의 화합물이 확인되었다. 껍질을 제거하지 않은 조생에서 동정된 향기성분은 29종의 terpene류, 18종의 alcohol류, 13종의 ester류, 10종의 aldehyde류, 8종의 ketone류, 1종의 acid류, 1종의 ether류, 기타 8종의 화합물이 확인되었다. 껍질을 제거한 시료 향상조생과육에서 동정된 향기성분으로 28종의 alcohol류, 16종의 terpene류, 10종의 aldehyde류, 9종의 ester류, 9종의 ketone류, 3종의 ether류, 1종의 acid류, 기타 10종의 화합물이 확인되었다. 껍질을 제거한 시료 조생과육에 동정된 향기성분으로 18종의 terpene류, 39종의 aldehyde류, 8종의 ester류, 1종의 acid류, 11종의 aldehyde류, 10종의 keone류, 3종의 ether류, 기타 8종의 화합물이 확인되었다. 껍질을 제거하지 않은 4종류의 시료 즉 유자, 금귤, 조생 그리고 향상조생에서는 terpene류가 모두 약 90% 이상을 나타내었는데 이러한 terpene류의 대부분은 C10과 C15인 monoterpene과 sesquiterpene류였으며, 6종류의 모든 시료에 α-limonene이 가장 많이 함유되어 있었다.

백도, 천도, 유명도, 대구보, 황도 등 5종의 복숭아에 각각 86, 85종, 70종, 74종, 67종의 향기성분이 분리 동정되었다. 백도에서 확인된 성분은 26종의 alcohol류, 15종의 aldehyde류, 14종의 ketone류, 6종의 ester류, 4종의 ether류, 1종의 acid류, 2종의 terpene류, 기타 17종의 화합물이 확인되었다. 천도에서 확인된 성분은 24종의 alcohol류, 18종의 ketone류, 15종의 aldehyde류, 7종의 ester류, 5종의 ether류, 2종의 acid류, 1종의 terpene류, 기타 12종의 향기 성분이 확인되었다. 유명도에서 확인된 성분으로 (*E*)-2-hexenal을 포함 하여 15종의 aldehyde류, 22종의 alcohol류, 4종의 ether류, 5종의 ester류, 8종의 ketone류, 1종의 acid류, 기타 15종의 화합물이 있다. 대구보에서 분리 동정된 향기성분은

14종의 aldehyde류, 14종의 ketone류, 18종의 alcohol류, 7종의 ester류, ether류, 기타 16종의 화합물이 확인되었다. 황도에서 확인된 향기 성분은 9종의 aldehyde류, 20종의 alcohol류, 12종의 ketone류, 기타 14종의 화합물이 동정되었다. 백도, 천도, 대구보, 유명도, 백도에서 (*E*)-2-hexenal,(*Z*)-3-hexenal, hexanal, benzaldehyde 등이 다량 함유 되어있는 것으로 확인되었으며, lactone류가 확인되었는데 이들 중 복숭아의 특징적인 향기성분으로 알려진 γ-decalactone과 γ-dodecalactone은 유명도를 제외한 4종의 복숭아에서 모두 상당량 동정되었다.

국내에서 주로 재배되는 자두중, 뷰티와 포모사의 향기성분은 99종, 96종의 화합물이 분리 동정되었다. 뷰티의 향기성분으로 ester류 38종, alcohol류 26종, aldehyde류 12종, ketone류 11종, ether류 2종 terpene류 1종, acid류 1종과 그 외 8종의 화합물이 확인되었다. 포모사 자두의 향기성분으로 16종의 aldehyde류, 31종의 alcohol류, 6종의 ketone류, 27종의 ester류, 3종의 ether류, 1종의 acid류, 기타 11종의 화합물이 확인되었다.

살구의 휘발성 향기성분은 79종 분리 동정되었고, 20종의 aldehyde류, 23종의 alcohol류, 5종의 ether류, 8종의 ketone류, 7종의 ester류, 2종의 terpene류, 기타 12종의 화합물이 확인되었다.

매실의 향기성분은 81종의 화합물이 분리 동정되었고, alcohol류 26종, aldehyde류 19종, ester류 17종, acid류 4종, ketone류 5종, terpene류 2종과 그 외 6종의 화합물이 동정되었다. 전체 함량의 36.27%로 확인된 alcohol류가 매실의 주요한 정유성분 화합물로 간주되었다.

헤이워드 키위의 향기성분은 91종이 분리 동정되었다. 이중 aldehyde류가 19종이 동정되어 전체 화합물중 32.85%로 나타나 대부분을 차지하였고, alcohol류가 23종, ester류가 18종, ketone류가 12종, acid류가 6종, 기타 11종의 화합물이 확인되었다.

빼빼, 꼬꼬, 도태랑 토마토의 향기성분으로 85종, 77종, 68종이 분리동정되었

다. 빼빼의 향기 성분으로 aldehyde류 30종, alcohol류 23종, ketone류 14종, ester류 6종, ether류 3종, acid류 3종, terpene류 1종, 기타 5종의 화합물이 확인되었다. 이 중 *(E)*-2-hexenal, hexanal, 2-methyl-1-butanol이 빼빼의 주요한 향기성분으로 여겨졌다. 꼬꼬에서 분리 동정된 향기성분으로 30종의 alcohol류, 5종의 ester류, 19종의 aldehyde류, 12종의 ketone류, 3종의 ether류, 2종의 acid류, 2종의 terpene류, 기타 4종의 화합물이 확인되었다. 도태랑에서 분리 동정된 향기성분으로 18종의 aldehyde류, 26종의 alcohol류, 9종의 ketone류, 3종의 ether류, 1종의 terpene류, 기타 9종의 화합물이 확인되었다. 전체의 상대적 함량비교에서 빼빼와 도태랑은 aldehyde 화합물이 각각 34.17%, 26.93%로, 꼬꼬에서는 alcohol류 화합물이 44.63%로 나타나 다른 화합물에 비하여 높은 비율을 차지하였다.

수홍과 보교 등 2종의 딸기의 휘발성 향기성분은 각각 143종, 133종이 동정되었다. 수홍의 향기성분으로 63종의 ester류, 26종의 alcohol류, 12종의 aldehyde류, 21종의 ketone류, 4종의 acid류, 3종의 terpene류, 기타 7종의 화합물이 확인되었다. 보교의 향기성분으로 42종의 ester류, 31종의 alcohol류, 23종의 aldehyde류, 4종의 acid류, 17종의 ketone류, 3종의 ether류, 1종의 terpene류, 기타 8종의 화합물이 확인되었다.

별똥별, 파파이야, 머스크 메론의 휘발성 향기성분은 각각 121종, 106종의 화합물이 분리 동정되었다. 별똥별 메론의 향기성분으로 32종의 ester류, 26종의 alcohol류, 2종의 ether류, 13종의 aldehyde류, 1종의 acid류, 6종의 ketone류, 기타 6종의 화합물이 확인되었다. 파파이야 메론에서 분리동정 된 향기성분으로 51종의 ester류, 31종의 alcohol류, 16종의 aldehyde류, 2종의 acid류, 2종의 ether류, 12종의 ketone류, 기타 5종의 화합물이 확인되었다. 머스크 메론에서 분리동정된 향기성분으로 55종의 ester류, 21종의 alcohol류, 11종의 aldehyde류, 3종의 acid류, 2종의 terpene류, 6종의 ketone류, 기타 6종의 화합물이 확인되었

다. 별똥별, 파파이야, 머스크 메론의 향기성분의 전체적 상대적 함량비교에서 각각 ester 화합물이 51.89%, 47.04%, 59.4%로 매우 높은 비율을 차지하였으며, C9 화합물이 상당량 함유되어 있는 alcohol류도 메론의 주요 향기 성분으로 간주되었으며, 소량 확인된 황함유 화합물 또한 중요한 역할을 하는 것으로 여겨졌다.

참외와 수박에서 총 97종, 66종의 향기성분이 분리 동정되었다. 참외의 향기성분으로 ester류 38종, 24종의 alcohol류, 21종의 aldehyde, 2종의 ether류, 2종의 ketone류, 2종의 terpene류, 기타 5종의 화합물이 확인되었으며, ethyl acetate, nonanyl acetate, benzyl acetate과 C9 화합물이 주요 향기성분으로 여겨졌다. 수박에서는 24종의 alcohol류, 21종의 aldehyde류, 2종의 ester, 7종의 ketone류, 1종의 terpene류, 1종의 acid류, 기타 5종의 화합물이 확인되었다. 수박에서 (*Z*)-3-nonen-1-ol, (*E,Z*)-3,6-nonadien-1-ol, nonanol, (*E*)-2-nonenal, (*E,Z*)-2,6-nonadienal이 다량으로 동정되어 C9 alcohol류와 aldehyde류가 특징적으로 나타났다.

산초의 잎과 열매의 향기성분은 각각 144종, 92종의 화합물이 분리 동정되었고, 산초잎의 향기 성분으로 α-pinene을 포함한 37종 terpene류, β-citronellol을 포함한 34종 alcohol류, (*E*)-2-hexanal을 포함한 23종의 aldehyde류, citronellyl acetate를 포함한 18종의 ester류, 2-undecanone을 포함한 10종의 ketone류, acetic acid를 포함한 2종의 acid류, 2종의 ether와 기타 15종의 화합물이 확인되었다. 산초열매의 향기성분으로 geraniol 이외에 30종 alcohol류, β-myrcene 이외에 14종 terpene류, citronellyl acetate 이외에 12종 ester류, citronellal 이외에 14종 aldehyde류, 2-pentanone 이외에 8종의 ketone류와 그외 12종의 화합물이 확인되었다. 산초의 잎과 열매에서 각각 47.03%와 44.21%로 확인된 terpene류가 주요 화합물로 동정되었다. 산초잎에서 확인된 terpene류 중 α-pinene, sabinene, β-myrcene, β-phelladrene, (*Z*)-β-ocimene, (*E*)-β-ocimene, α-terpinolene, α-limonene 등이 다량 확인되었으며, 산초열매에서는

β-myrcene, α-, β-phelladrene등이 동정되었다

방아잎에서 86종의 화합물이 분리 동정되었고, 23종의 alcohol류, 20종의 aldehyde류, 13종의 terpene류, 10종의 ester류, 3종의 acid류, 13종의 ketone류, 3종의 ether류, 기타 8종의 화합물이 확인되었다. 이중에서 주요 향기성분으로 estragole이 48.26%로 가장 높은 함유율을 보였으며, alcohol류가 주요한 향기성분으로 간주되었다.

부추에서 확인된 성분은 총 65종으로 28종의 황함유 화합물과 aldehyde류 12종, alcohol류 9종, 4종의 lactone류, 4종의 ester류, 3종의 acid류, 기타 5종의 화합물이 동정되었다. 동정된 성분들 중에서 황함유화합물이 전체 상대농도의 77.84%로 휘발성 향기성분의 대부분을 차지하였으며, dimethyl disulfide, dimethyl trisulfide, (*E*)-1-propenylmethyl disulfide, (*E*)-2-hexenal 그리고 methyl allyl disulfide가 다량 동정되어 부추의 휘발성 향기성분의 주성분으로 여겨졌다.

본 연구를 통하여 축적된 국내산 과일 및 과채류와 향신료의 항기성분 데이터는 다양한 분야의 기초자료로 이용하고자 하였다. 식품 산업에서 식물소재에 함유되어 있는 향기성분의 손실 및 변화를 추적하는 자료로 이용하므로써 제품을 고급화시킬수 있으며, 미생물을 이용한 천연향 생산에 관한 연구개발 및 식물소재에 다량 존재하는 천연향 전구물질의 이용에 관한 연구, 식물소재에 함유되어 있는 천연향에서 고부가가치 chiral성 향기성분의 연구자료로 활용할 수 있으며, 수입 농산물과의 품질비교를 위한 기초자료, 농산물의 경쟁력 확보를 위한 홍보자료로 활용할 수 있으며, 과잉 생산된 과일이나 낙과, 폐과를 이용하여 고부가가치 천연향 소재로 활용하므로써 농민의 소득증대를 기여할 수 있다.

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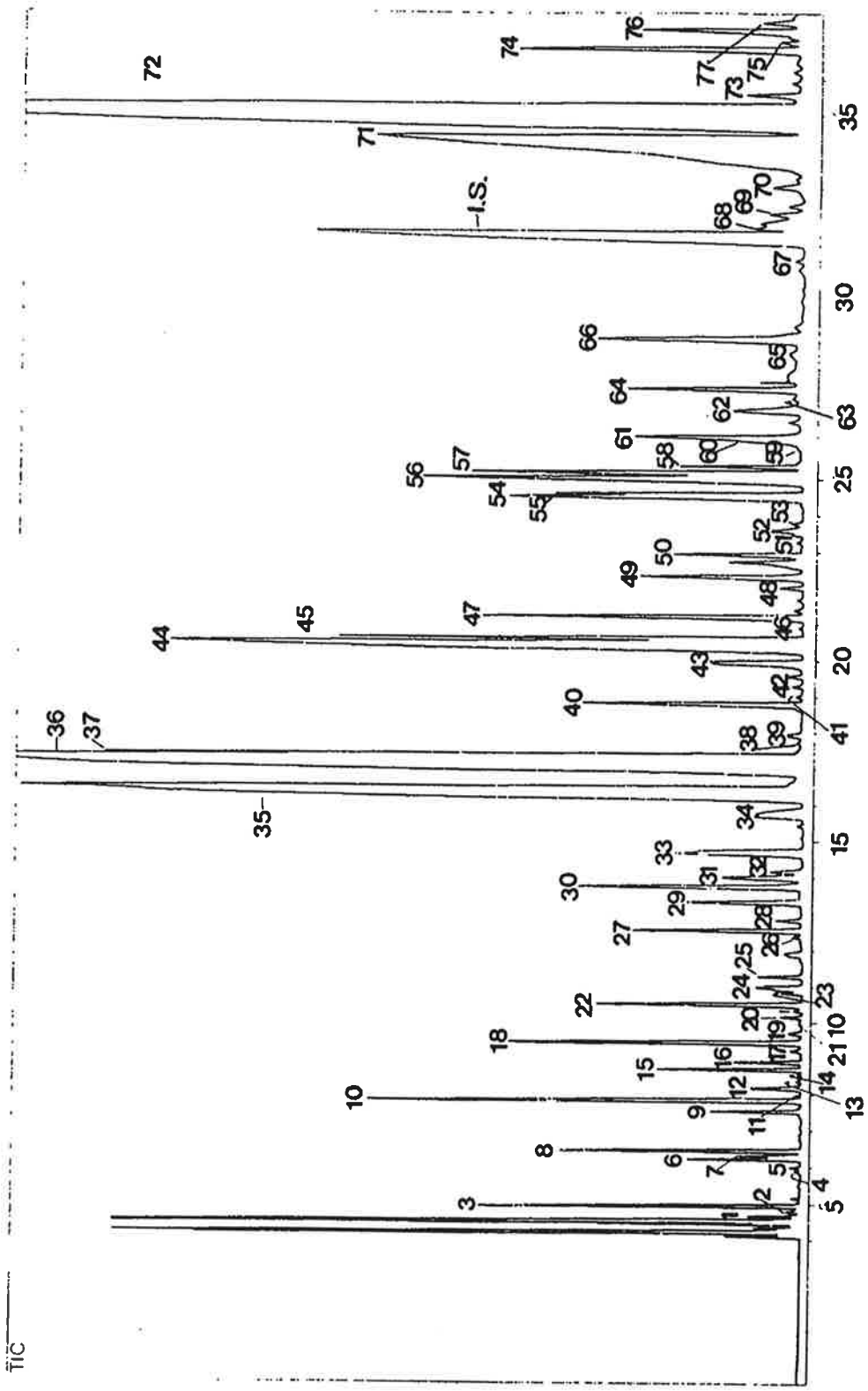

Fig. 2. GC chromatogram of volatile flavor components in Chinese quince I

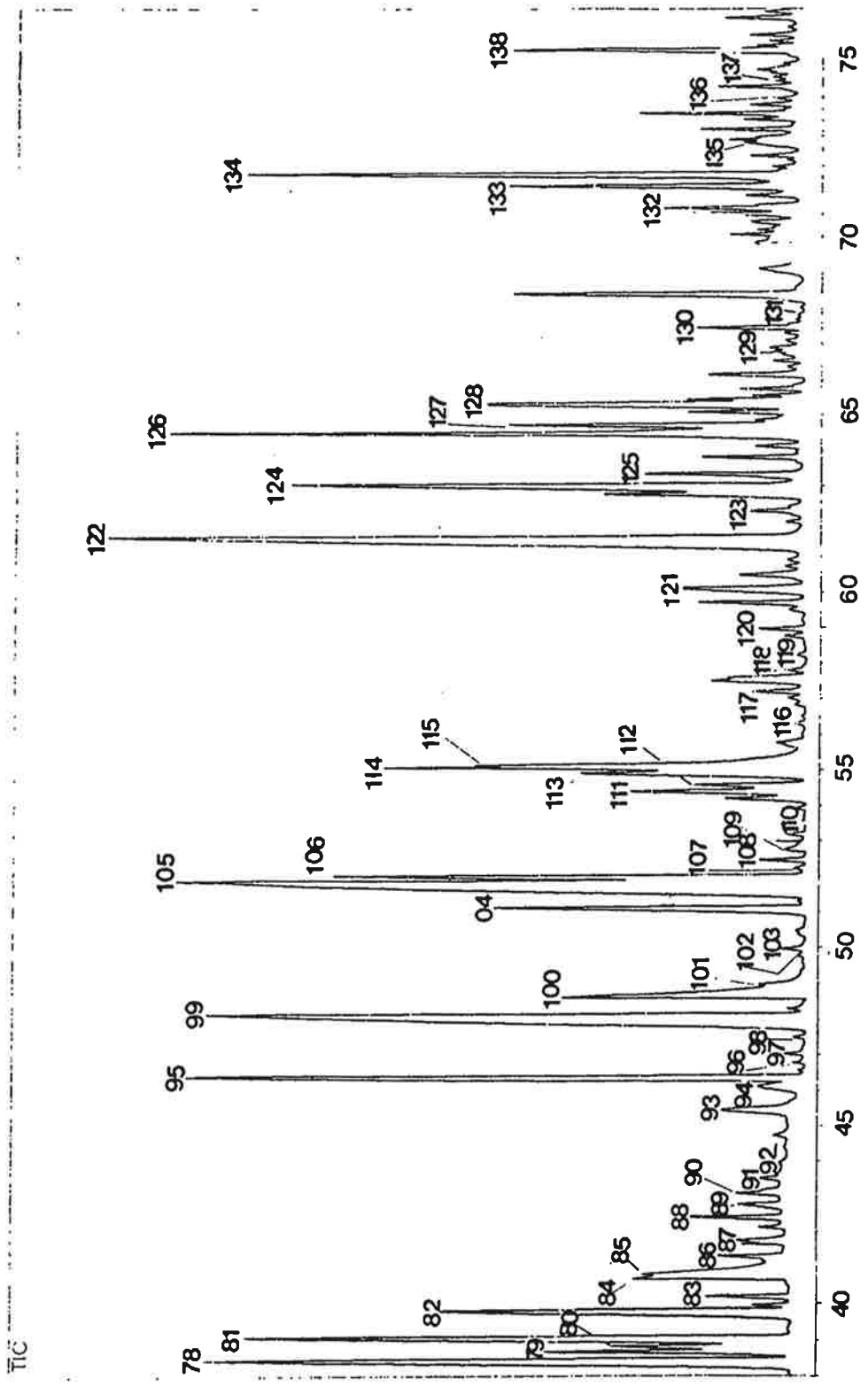

Fig. 2. GC chromatogram of volatile flavor components in Chinese quince II

Table 3. Volatile flavor components identified from Chinese quince

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.675	527	$C_5H_{12}O$	88	0.04
2	2-Methyl-1-pentene	4.792	610	C_6H_{12}	84	0.01
3	Acetaldehyde	4.950	697	C_2H_4O	44	0.48
4	Propanal	5.900	791	C_3H_6O	58	0.01
5	Octane	6.000	800	C_8H_{18}	114	0.01
6	2-Methylpropanal	6.230	808	C_4H_8O	72	0.16
7	2-Propanone	6.325	810	C_3H_6O	58	0.08
8	Ethyl formate	6.458	824	$C_3H_6O_2$	74	0.40
9	Butanal	7.542	874	C_4H_8O	72	0.14
10	Ethyl acetate	7.850	893	$C_4H_8O_2$	88	0.79
11	Diethylacetal	7.983	899	$C_4H_8O_2$	88	0.01
12	Methanol	8.183	904	CH_4O	32	0.10
13	Methyl propanoate	8.375	910	$C_4H_8O_2$	88	0.01
14	2-Methylbutanal	8.717	919	$C_5H_{10}O$	86	0.01
15	3-Methylbutanal	8.917	929	$C_5H_{10}O$	86	0.23
16	Methyl 2-methylpropanoate	8.917	938	$C_5H_{12}O_2$	102	0.10
17	2-Propanol	9.233	942	C_3H_8O	60	0.01
18	Ethanol	9.467	944	C_2H_6O	46	0.59
19	3-Buten-2-one	9.708	948	C_4H_6O	70	0.02
20	Ethyl propanate	10.158	957	$C_5H_{12}O_2$	102	0.02

(continued)

21	Isopropyl propanoate	10.333	961	$C_6H_{12}O_2$	116	0.01
22	Ethyl 2-methylpropanoate	10.517	966	$C_6H_{12}O_2$	116	0.37
23	Propyl acetate	10.883	970	$C_5H_{12}O_2$	102	0.04
24	Pentanal	10.983	973	$C_5H_{10}O$	86	0.13
25	Methyl butanoate	11.283	980	$C_5H_{12}O_2$	102	0.07
26	Methyl 2-methylbutanoate	12.375	997	$C_6H_{12}O_2$	116	0.01
27	2-Methylpropyl acetate	12.550	999	$C_6H_{12}O_2$	116	0.34
28	Butyl formate	12.825	1000	$C_5H_{12}O_2$	102	0.05
29	2-Butanol	13.333	1002	C_4H_8O	72	0.26
30	Ethyl butanoate	13.758	1010	$C_6H_{12}O_2$	116	0.49
31	Isopropyl butanoate	14.000	1015	$C_7H_{14}O_2$	130	0.23
32	Propyl propanoate	14.167	1029	$C_6H_{12}O_2$	116	0.07
33	Propyl 2-methylpropanoate	14.667	1036	$C_7H_{14}O_2$	130	0.48
34	Butyl acetate	15.692	1053	$C_6H_{12}O_2$	116	0.29
35	Hexanal	16.483	1085	$C_6H_{12}O$	100	0.01
36	2-Methylpropanol	17.350	1109	$C_4H_{10}O$	74	8.57
37	2-Methylpropyl 2-methylpropanoate	17.417	1114	$C_8H_{16}O_2$	144	0.78
38	2-Methylhexanal	17.733	1121	$C_7H_{14}O$	114	0.01
39	3-Pentanol	17.967	1123	$C_5H_{12}O$	88	0.04
40	Propyl butanoate	18.833	1131	$C_7H_{14}O_2$	130	0.54
41	2-Pentenal	19.033	1133	C_5H_8O	84	0.01
42	5-Hexenal	19.308	1136	$C_6H_{10}O$	98	0.02

(continued)

43	Butyl propanoate	19.933	1142	$C_7H_{14}O_2$	130	0.36
44	Butanol	20.517	1160	$C_4H_{10}O$	74	3.47
45	Butyl 2-methylpropanoate	20.642	1164	$C_8H_{16}O_2$	144	0.79
46	Propyl 3-methylbutanoate	20.908	1165	$C_8H_{16}O_2$	144	0.01
47	2-Methylpropyl butanoate	21.233	1167	$C_8H_{16}O_2$	144	0.74
48	Pentyl acetate	22.017	1173	$C_7H_{14}O_2$	130	0.04
49	2-Methylpropyl 2-methylbutanoate	22.325	1183	$C_9H_{18}O_2$	158	0.42
50	Methyl hexanoate	22.936	1190	$C_7H_{14}O_2$	130	0.25
51	2-Methylpropyl 3-methylbutanoate	23.263	1197	$C_9H_{18}O_2$	158	0.01
52	3-Methylbutyl 2-methylpropanoate	23.492	1198	$C_9H_{18}O_2$	158	0.01
53	(*Z*)-3-Hexenal	23.783	1199	$C_6H_{10}O$	98	0.02
54	2-Methyl-1-butanol	24.525	1202	$C_5H_{12}O$	88	0.85
55	3-Methyl-1-butanol	24.608	1203	$C_5H_{12}O$	88	0.37
56	(*E*)-2-Hexenal	25.058	1223	$C_6H_{10}O$	98	1.36
57	Butyl butanoate	25.208	1224	$C_8H_{16}O_2$	144	0.83
58	Hexyl formate	25.358	1227	$C_7H_{14}O_2$	130	0.23
59	2-Pentylfuran	25.875	1231	$C_9H_{14}O$	138	0.01
60	Butyl 2-methylbutanoate	29.200	1233	$C_9H_{18}O_2$	158	0.01
61	Ethyl hexanoate	26.175	1237	$C_8H_{16}O_2$	144	0.60
62	Pentyl 2-methylpropanoate	26.883	1251	$C_9H_{18}O_2$	158	0.26
63	Butyl 3-methylbutanoate	27.217	1253	$C_9H_{18}O_2$	158	0.02
64	Pentanol	27.483	1262	$C_5H_{12}O$	88	0.41

(continued)

65	*p*-Cymene	28.467	1272	$C_{10}H_{14}$	134	0.04
66	Hexyl acetate	28.858	1278	$C_8H_{16}O_2$	144	0.72
67	4-Penten-1-ol	31.017	1292	$C_5H_{10}O$	86	0.02
I.S.	Butylbenzene	31.800	1313	$C_{10}H_{14}$	134	3.00
68	(*Z*)-3-Hexenyl acetate	31.917	1320	$C_8H_{14}O_2$	142	0.14
69	(*Z*)-2-Heptenal	32.308	1327	$C_7H_{12}O$	112	0.11
70	(*E*)-2-Hexenyl acetate	33.042	1348	$C_8H_{14}O_2$	142	0.11
71	Hexyl 2-methylpropanoate	34.442	1354	$C_7H_{12}O_2$	172	5.28
72	Hexanol	35.300	1378	$C_6H_{12}O$	102	13.45
73	*(E)*-3-Hexen-1-ol	35.583	1380	$C_6H_{12}O$	100	0.16
74	*(Z)*-3-Hexen-1-ol	36.875	1394	$C_6H_{12}O$	100	0.77
75	Methyl octanoate	37.067	1397	$C_9H_{18}O_2$	158	0.05
76	(*Z*)-3-Hexenyl butanoate	37.400	1401	$C_{10}H_{18}O_2$	170	0.44
77	(*E*)-2-Hexenyl butanoate	37.608	1412	$C_{10}H_{18}O_2$	170	0.11
78	(*E*)-2-Hexen-1-ol	38.458	1423	$C_6H_{12}O$	100	2.74
79	5-Hexen-1-ol	38.675	1427	$C_6H_{12}O$	100	0.70
80	Butyl hexanoate	38.825	1431	$C_{10}H_{20}O_2$	172	0.50
81	Hexyl butanoate	39.092	1433	$C_{10}H_{20}O_2$	172	2.06
82	Hexyl 2-methylbutanoate	39.808	1438	$C_{11}H_{22}O_2$	186	1.32
83	Ethyl octanoate	40.183	1440	$C_{10}H_{20}O_2$	172	0.18
84	Acetic acid	40.692	1449	$C_2H_4O_2$	60	0.43
85	Hexyl pentanoate	40.825	1453	$C_{11}H_{22}O_2$	186	0.74

(continued)

86	Butyl heptanoate	41.325	1467	$C_{11}H_{22}O_2$	186	0.18
87	3-Methylbutyl hexanoate	41.767	1472	$C_{11}H_{22}O_2$	186	0.20
88	(*Z*)-2-Hexenyl butanoate	42.417	1482	$C_{10}H_{18}O_2$	170	0.22
89	(*E*)-2-Hexenyl butanoate	42.775	1490	$C_{10}H_{18}O_2$	170	0.13
90	(*Z*)-3-Hexenyl 2-methylbutanoate	43.100	1493	$C_{11}H_{20}O_2$	184	0.14
91	Ethyl (*Z*)-4-octenoate	43.525	1503	$C_{10}H_{18}O_2$	170	0.05
92	2-Ethyl-1-hexanol	43.950	1514	$C_8H_{18}O$	130	0.01
93	Pentyl hexanoate	45.450	1521	$C_{11}H_{20}O_2$	186	0.34
94	Propyl octanoate	46.125	1526	$C_{11}H_{20}O_2$	186	0.23
95	Unknown	46.379	1527			2.10
96	Butyl (*E*)-2-hexenoate	46.775	1529	$C_{10}H_{18}O_2$	170	0.02
97	(*E*)-2-Nonenal	47.025	1537	$C_9H_{16}O$	140	0.04
98	(*E*)-Decalin	47.500	1539	$C_{10}H_{18}$	138	0.02
99	Ethylpropyl octanoate	48.133	1556	$C_{13}H_{26}O_2$	214	4.06
100	2-Methylpropanoic acid	48.600	1568	$C_4H_8O_2$	88	1.19
101	Ethyl 3-octenoate	48.967	1572	$C_{10}H_{18}O_2$	170	0.14
102	Dimethyl sulfoxide	49.775	1589	C_2H_6S	78	0.02
103	(*Z*)-2-Nenen-1-ol	49.950	1591	$C_9H_{18}O$	142	0.06
104	(*E*)-2-Nonen-1-ol	51.125	1603	$C_9H_{18}O$	142	1.07
105	Hexyl hexanoate	51.850	1620	$C_{12}H_{24}O_2$	200	4.79
106	Butyl octanoate	52.008	1627	$C_{12}H_{24}O_2$	200	1.32
107	Propyl nonanoate	52.225	1631	$C_{12}H_{24}O_2$	200	0.04

(continued)

108	Methyl (*Z*)-4-decenoate	52.445	1645	$C_{11}H_{20}O_2$	184	0.10
109	Butanoic acid	52.767	1648	$C_4H_8O_2$	88	0.08
110	Butyl 3-hydroxybutanoate	53.508	1656	$C_8H_{16}O_3$	160	0.01
111	Hexyl (*Z*)-2-hexenoate	54.400	1666	$C_{12}H_{22}O_2$	198	0.58
112	3-Methylbutyl octanoate	54.583	1668	$C_{13}H_{26}O_2$	214	0.31
113	(*Z*)-2-Hexenyl hexanoate	54.925	1672	$C_{12}H_{22}O_2$	198	0.84
114	3-Methylbutanoic acid	55.067	1676	$C_5H_{10}O_2$	102	0.96
115	(*E*)-2-Hexenyl hexanoate	55.142	1677	$C_{12}H_{22}O_2$	198	1.01
116	Ethyl 4-decenoate	56.317	1694	$C_{12}H_{22}O_2$	198	0.02
117	γ-Hexalactone	57.033	1702	$C_6H_{10}O_2$	114	0.06
118	Butyl nonanoate	57.817	1742	$C_{13}H_{26}O_2$	214	0.05
119	Propyl decanoate	58.258	1750	$C_{13}H_{26}O_2$	214	0.02
120	Hexyl (*E*)-2-hexenoate	58.992	1763	$C_{12}H_{22}O_2$	198	0.11
121	Butyl decanoate	60.125	1784	$C_{14}H_{28}O_2$	228	0.53
122	Tridecanal	61.558	1807	$C_{13}H_{26}O$	198	4.38
123	1,11-Dodecadiene	62.308	1818	$C_{12}H_{22}$	166	0.19
124	Hexyl octanoate	63.033	1836	$C_{14}H_{28}O_2$	228	2.08
125	Methyl 4-nonenoate	63.342	1842	$C_{10}H_{18}O_2$	170	0.47
126	Hexanoic acid	64.483	1863	$C_{10}H_{20}O_2$	172	2.04
127	2-Hydroxylcyclopentadecanone	64.733	1867	$C_{13}H_{26}O_2$	240	0.86
128	Unknown	65.304	1878			1.31
129	Dimethyl sulfone	66.725	1904	$C_2H_2S_2$	94	0.07

(continued)

130	Cyclohexyl hexanol	67.483	1924	$C_7H_{14}O$	184	0.24
131	*(E)*-5-Dodecenal	67.817	1933	$C_{12}H_{22}O$	182	0.02
132	Methyleugenol	70.683	2010	$C_{11}H_{14}O_2$	178	0.35
133	1-Heptenol-2-octylcyclopropene	71.475	2035	$C_{18}H_{34}O_2$	266	0.84
134	Unknown	71.791	2045			1.85
135	Methyl tetradecadienoate	72.692	2073	$C_{15}H_{26}O_2$	238	0.20
136	3-Ethyl-4-hydroxy-6-methyl-2H-pyran-2-one	73.942	2113	$C_{10}H_{18}O$	154	0.06
137	2-Hydroxytetradecanoic acid	74.433	2130	$C_{14}H_{28}O_2$	244	0.06
138	γ-Decalactone	75.308	2160	$C_{10}H_{18}O_2$	170	0.72
	Total					96.97

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 4. Relative content of functional groups in Chinese quince

Peak area%

Functional group	Chinese quince
Aldehydes	7.15
Alcohols	34.24
Esters	39.51
Terpenes	-
Acids	4.76
Ethers	0.04
Ketones	1.80
Miscellaneous	1.21
T o t a l	88.71

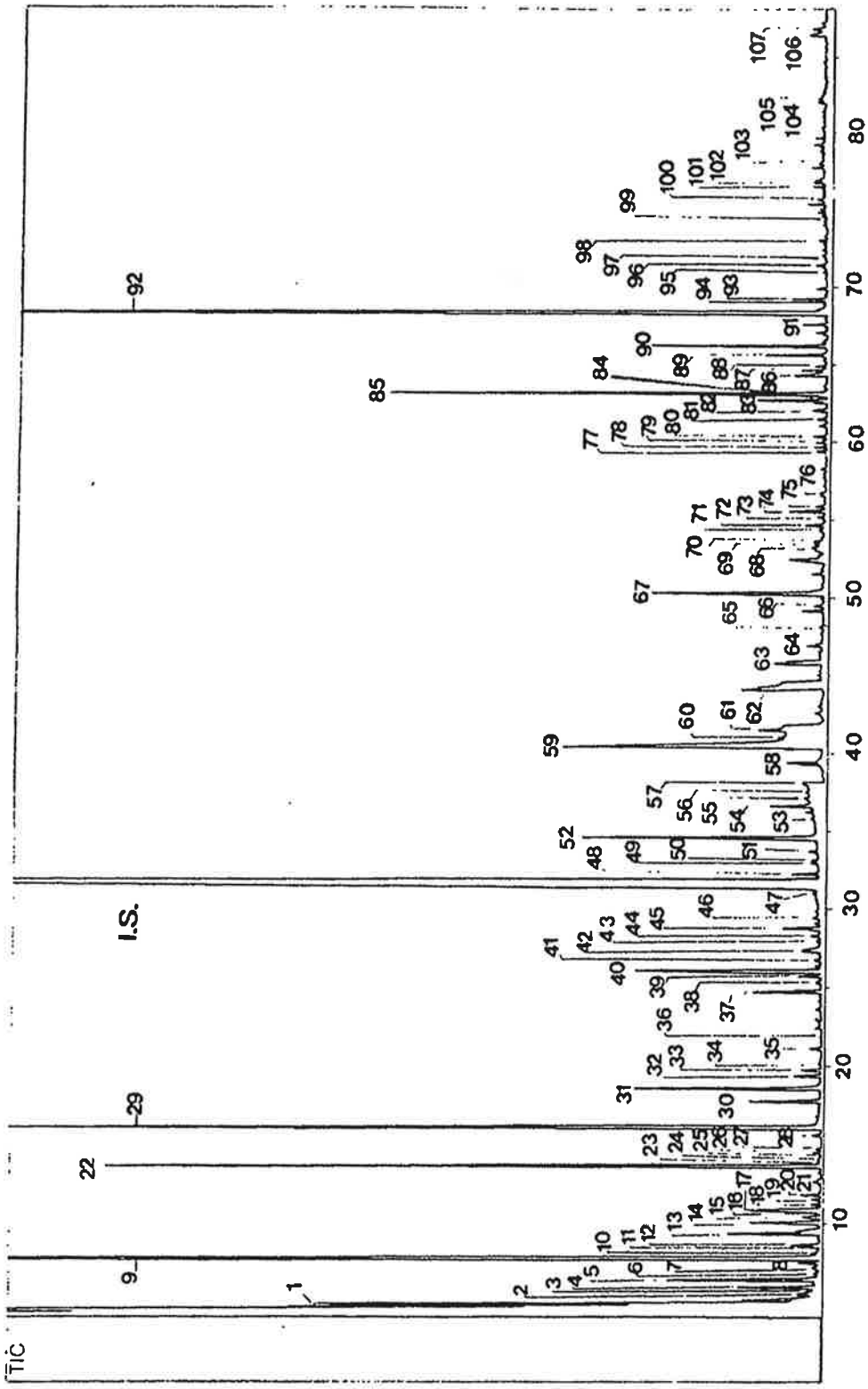

Fig. 3. GC chromatogram of volatile flavor components in Whangkeum pear

Table 5. Volatile flavor components in Mansamgil pear

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl acetate	3.271	811	$C_4H_8O_2$	88	4.34
2	Ethyl propanoate	3.517	851	$C_5H_{10}O_2$	102	0.01
3	Propyl acetate	3.619	889	$C_5H_{10}O_2$	102	1.63
4	3-Buten-2-ol	4.342	1021	C_4H_8O	72	0.01
5	Hexanal	4.554	1045	$C_6H_{12}O$	100	11.20
6	3-Pentanol	4.872	1063	$C_5H_{12}O$	88	0.25
7	2-Pentanol	5.087	1077	$C_5H_{12}O$	88	1.89
8	*(Z)*-3-Hexenal	5.285	1100	$C_6H_{10}O$	98	0.44
9	1-Penten-3-one	5.933	1137	C_5H_8O	86	1.50
10	*(E)*-2-Hexenal	6.684	1172	$C_6H_{10}O$	98	0.28
11	2-Ethoxyethanol	6.851	1191	$C_4H_{10}O_2$	90	0.08
12	3-Methyl-1-butanol	7.647	1210	$C_4H_8O_2$	88	0.09
13	2-Methyl-1-butanol	8.801	1260	$C_4H_8O_2$	88	0.16
I.S.	Butylbenzene	9.409	1273	$C_{10}H_{14}$	134	28.80
14	6-Methyl-5-hepten-2-one	9.920	1291	$C_8H_{14}O$	126	0.16
15	Hexanol	10.544	1304	$C_6H_{14}O$	102	1.54
16	*(Z)*-3-Hexenol	11.267	1331	$C_6H_{12}O$	100	1.80
17	*(E)*-2-Hexenol	11.800	1349	$C_6H_{12}O$	100	0.16
18	Acetic acid	13.023	1380	$C_2H_4O_2$	60	1.14
19	Heptanol	13.658	1402	$C_7H_{16}O$	116	0.08

(continued)

20	4-Ethoxybutanol	14.358	1422	$C_6H_{14}O_2$	118	0.09
21	2-Ethyl-1-hexanol	14.788	1438	$C_8H_{18}O$	130	0.75
22	Octanol	16.825	1479	$C_8H_{18}O$	130	0.09
23	4-Methyl-2-pentenyl acetate	17.700	1492	$C_8H_{16}O_2$	144	0.08
24	Ethyl 2-hydroxypropanoate	17.792	1524	$C_5H_{10}O_3$	118	6.18
25	*(E)*-Caryophyllene	18.038	1543	$C_{15}H_{24}$	204	0.35
26	Benzenacetaldehyde	18.467	1573	C_8H_8O	120	0.49
27	Nonanol	19.917	1586	$C_9H_{20}O$	144	0.01
28	Germacrene D	21.292	1641	$C_{15}H_{24}$	204	0.74
29	γ-Himachalene	21.320	1653	$C_{15}H_{24}$	204	1.44
30	α-Selinene	21.525	1662	$C_{15}H_{24}$	204	0.49
31	δ-Cadinene	22.532	1700	$C_{15}H_{24}$	204	0.18
32	Hexanoic acid	24.646	1733	$C_6H_{12}O_2$	116	0.21
33	Phenethyl alcohol	25.914	1768	$C_8H_{10}O$	122	0.56
34	2-Ethylhexanoic acid	27.502	1875	$C_8H_{16}O_2$	144	0.45
35	Dodecanol	28.466	1913	$C_{12}H_{26}O$	186	0.36
36	Methyleugenol	28.915	1938	$C_{11}H_{14}O_2$	178	5.81
37	Nonanoic acid	32.853	1998	$C_9H_{18}O_2$	158	0.35
38	Tetradecanol	33.633	2112	$C_{14}H_{30}O$	214	0.18
39	Decanoic acid	35.347	2190	$C_{10}H_{20}O_2$	172	0.44
40	Pentadecanol	37.233	2217	$C_{15}H_{32}O$	228	0.10
41	Hexadecanol	38.408	2322	$C_{16}H_{34}O$	242	0.30

(continued)

42	Dodecanoic acid	40.075	2393	$C_{12}H_{24}O_2$	200	2.09
43	Octadecanol	42.860	2516	$C_{18}H_{38}O$	270	0.70
44	Tetradecanoic acid	44.437	2629	$C_{14}H_{28}O_2$	228	2.09
45	Eicosanol	47.025	2757	$C_{20}H_{42}O$	298	0.18
46	Hexadecanoic acid	48.973	2883	$C_{16}H_{32}O_2$	256	11.19
47	Heneicosanol	49.523	2903	$C_{21}H_{44}O$	312	1.44
	Total					92.90

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Fig. 4. GC chromatogram of volatile flavor components in Imaura pear

Table 6. Volatile flavor components in Immamura pear

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Isopropyl ethyl ether	4.667	530	$C_5H_{12}O$	88	6.78
2	2,3-Dimethyl-2-butene	4.792	592	C_6H_{12}	84	3.23
3	Acetaldehyde	4.958	698	C_2H_4O	44	14.57
4	2-Methylpropyl ethyl ether	5.267	728	$C_6H_{14}O$	102	0.48
5	4-Methyl heptane	5.550	756	C_8H_{18}	114	0.04
6	3-Ethyl hexane	5.683	769	C_8H_{18}	114	0.02
7	Propanal	5.899	790	C_3H_6O	58	0.34
8	2-Methylpropanal	6.242	810	C_4H_8O	72	0.15
9	2-Propanone	6.308	810	C_3H_6O	58	0.13
10	Ethyl formate	6.467	806	$C_3H_6O_2$	74	8.23
11	2-Propenone	6.858	812	C_3H_4O	56	0.02
12	2-Methyltetrahydrofuran	7.433	848	$C_5H_{10}O$	86	0.02
13	Butanal	7.542	858	C_4H_8O	72	0.34
14	Ethyl acetate	7.850	872	$C_4H_8O_2$	88	20.69
15	Diethylacetal	7.975	880	$C_6H_{14}O_2$	118	0.36
16	Isopropyl acetate	8.113	883	$C_5H_{10}O_2$	102	0.25
17	2-Butanone	8.200	890	$C_4H_8O_2$	88	0.02
18	2-Methyl-2-propanol	8.358	893	$C_4H_{10}O$	74	0.29
19	2-Methylbutanal	8.567	897	$C_5H_{10}O$	86	1.22
20	3-Methylbutanal	8.700	900	$C_5H_{10}O$	86	0.27

(continued)

21	1-Methylbutylhydroperoxide	9.067	919	$C_5H_{12}O$	104	0.17
22	Ethanol	9.493	941	$C_2H_6O_2$	46	14.66
23	Vinyloxyethanol	9.925	942	$C_4H_8O_2$	88	0.04
24	4-Methyl nonane	10.008	943	$C_{10}H_{22}$	142	0.08
25	Ethyl propanoate	10.158	944	$C_5H_{10}O_2$	102	0.02
26	Propyl acetate	10.808	962	$C_5H_{10}O_2$	102	0.02
27	2-Pentanone	10.912	978	$C_5H_{10}O$	86	0.80
28	Decane	11.813	1000	$C_{10}H_{22}$	142	0.69
29	2-Butanol	13.272	1025	C_4H_{10}	74	0.34
30	Ethyl butanoate	13.675	1036	$C_6H_{12}O_2$	116	0.02
31	Propanol	13.992	1045	C_3H_8O	60	0.02
32	Butyl acetate	15.625	1059	$C_6H_{12}O_2$	116	0.23
33	Hexanal	16.125	1074	$C_6H_{12}O$	100	0.29
34	2-Methylpropanol	16.858	1092	$C_4H_{10}O$	74	0.40
35	Undecane	17.158	1100	$C_{11}H_{24}$	156	0.04
36	3-Pentanol	17.850	1110	$C_5H_{12}O$	88	0.90
37	2-Pentanol	18.675	1116	$C_5H_{12}O$	88	2.27
38	3-Methylbutyl acetate	19.478	1129	$C_7H_{14}O_2$	130	0.08
39	*(E)*-Ocimene	20.190	1150	$C_{10}H_{16}$	136	0.06
40	Dodecane	23.636	1200	$C_{12}H_{26}$	170	0.61
41	*(E)*-2-Hexenal	24.825	1214	$C_6H_{10}O$	98	0.02
42	2-Ethoxyethanol	25.317	1215	$C_4H_{10}O_2$	90	0.34

(continued)

43	Ethyl hexanoate	26.067	1230	$C_8H_{16}O_2$	144	0.02
44	Pentanol	27.838	1266	$C_5H_{12}O$	88	0.02
45	Dihydro-2-methyl-3-furanone	28.017	1268	$C_5H_8O_2$	144	0.02
I.S.	Butylbenzene	31.434	1312	$C_{10}H_{14}$	134	1.60
46	Acetic acid	40.725	1454	$C_2H_4O_2$	60	7.73
47	Furfural	41.642	1460	$C_5H_4O_2$	96	0.90
48	3-Methylbutanoic acid	55.467	1739	$C_5H_{10}O_2$	102	0.02
49	2-Ethyl-3-hydroxyl hexylester-2-methyl propanoic acid	65.333	1939	$C_{12}H_{24}O_3$	216	0.11
50	2-Methyl-2-phenyl undecane	66.258	1958	$C_{18}H_{30}$	246	0.02
51	Dimethyl sulfone	66.658	1966	$C_2H_6O_2S$	94	0.02
52	Dodecanol	69.167	2033	$C_{12}H_{26}O$	186	0.17
53	Pentylbenzenemethanol	69.305	2035	$C_{12}H_{18}O$	178	0.21
54	Isopropyl tetradecanoate	71.442	2066	$C_{17}H_{34}O_2$	270	0.63
55	*(E)*-3-Eicosene	71.783	2075	$C_{20}H_{40}$	280	0.02
56	6,10,14-Trimethyl-2-pentanone	74.239	2142	$C_{18}H_{36}O$	268	0.32
57	Tetradecanol	75.622	2179	$C_{14}H_{30}O$	214	0.08
58	Methyl hexadecanoate	76.900	2225	$C_{17}H_{34}O_2$	270	0.08
59	Hexadecyl acetate	79.375	2300	$C_{18}H_{36}O_2$	284	0.02
60	2,4-Di-tert-butylphenol	79.680	2309	$C_{14}H_{22}O$	206	0.38
61	Hexadecanol	82.108	2382	$C_{16}H_{34}O$	242	0.21
	Total					92.13

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

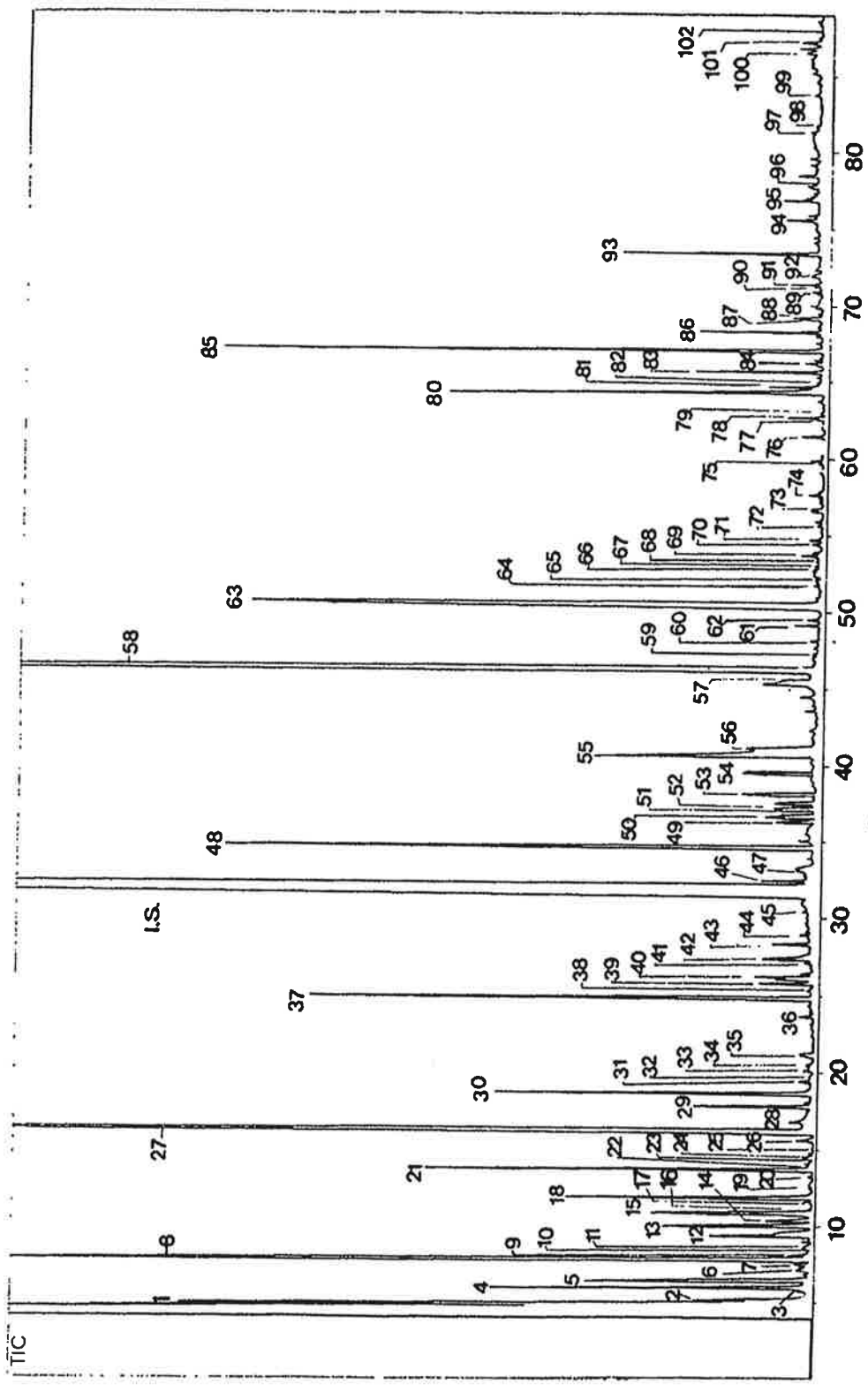

Fig. 5. GC chromatogram of volatile flavor components in Shingo pear

Table 7. Volatile flavor components in Shingo pear

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Acetaldehyde	4.900	696	C_2H_4O	44	1.85
2	Ethyl 2-methylpropyl ether	5.217	742	$C_6H_{14}O$	102	0.15
3	Propanal	5.825	783	C_3H_6O	58	0.04
4	Butyl ethyl ether	5.933	791	$C_6H_{14}O$	102	1.14
5	Ethyl formate	6.383	822	$C_3H_6O_2$	74	1.54
6	Tetrahydrofuran	7.171	846	C_4H_8O	72	0.05
7	Butanal	7.500	861	C_4H_8O	72	0.09
8	Ethyl acetate	7.792	890	$C_4H_8O_2$	88	6.88
9	Nonane	8.108	907	C_9H_{20}	128	0.06
10	2-Methylbutanal	8.508	912	$C_5H_{10}O$	86	0.04
11	3-Methylbutanal	8.631	914	$C_5H_{10}O$	86	0.05
12	Ethanol	9.367	943	C_2H_6O	46	0.65
13	Ethyl propanoate	10.083	952	$C_5H_{10}O_2$	102	0.41
14	Ethyl 2-methylpropanoate	10.442	956	$C_6H_{12}O_2$	116	0.16
15	2-Pentanone	10.867	963	$C_5H_{10}O$	86	1.28
16	Methyl butanoate	11.208	965	$C_5H_{10}O_2$	102	0.01
17	Ethyl isopropyl ether	11.667	968	$C_5H_{12}O$	88	0.01
18	Decane	11.867	978	$C_{10}H_{22}$	142	1.24
19	2-Methylpropyl acetate	12.467	994	$C_6H_{12}O_2$	116	0.01
20	2-Butanol	13.225	1014	$C_4H_{10}O$	74	0.01

(continued)

21	Ethyl butanoate	13.683	1035	$C_6H_{12}O_2$	116	1.74
22	Propanol	13.925	1041	C_3H_8O	60	0.01
23	3-Hexanone	14.408	1050	$C_6H_{12}O$	100	0.03
24	Ethyl 2-methylbutanoate	14.525	1052	$C_7H_{14}O_2$	130	0.05
25	Camphene	15.083	1059	$C_{10}H_{16}$	136	0.01
26	Butyl acetate	15.625	1071	$C_6H_{12}O_2$	116	0.10
27	Hexanal	16.308	1086	$C_6H_{12}O$	100	11.05
28	2-Methylpropanol	16.833	1100	$C_4H_{10}O$	74	0.06
29	3-Pentanol	17.833	1115	$C_5H_{12}O$	88	0.56
30	2-Pentanol	18.667	1129	$C_5H_{12}O$	88	1.60
31	2-Methyl-4-pentenal	19.467	1141	$C_6H_{10}O$	98	0.06
32	(*Z*)-3-Hexenal	19.808	1146	$C_6H_{10}O$	98	0.01
33	Butanol	20.167	1152	$C_4H_{10}O$	74	0.04
34	3-Heptanone	20.517	1162	$C_7H_{14}O$	114	0.01
35	Ethyl 2-butenoate	21.175	1173	$C_6H_{10}O_2$	114	0.09
36	(*Z*)-3-Hexenal	23.675	1203	$C_6H_{10}O$	98	0.08
37	*(E)*-2-Hexenal	24.900	1218	$C_6H_{10}O$	98	3.03
38	2-Hexanol	25.342	1222	$C_6H_{14}O$	158	0.01
39	2-Pentylfuran	25.800	1226	$C_9H_{14}O$	138	0.30
40	Ethyl hexanaote	26.200	1234	$C_8H_{16}O_2$	144	0.49
41	2-Methylbutyl acetate	27.092	1254	$C_7H_{14}O_2$	130	0.03
42	Pentanol	27.350	1260	$C_5H_{12}O$	88	0.46

(continued)

43	3,3-Dimethyl-2-hexanone	28.317	1271	$C_8H_{16}O$	144	0.18
44	Hexyl acetate	28.925	1280	$C_8H_{16}O_2$	144	0.04
45	1-Hydroxy-2-propanone	30.433	1300	$C_3H_6O_2$	74	0.03
I.S.	Butylbenzene	32.150	1322	$C_{10}H_{14}$	134	34.74
46	(*E*)-2-Heptenal	32.450	1325	$C_7H_{12}O$	112	0.18
47	2-Phenylpropanal	33.108	1332	$C_9H_{10}O$	134	0.03
48	Hexanol	34.700	1366	$C_6H_{14}O$	102	3.99
49	5-Methylindan	36.333	1374	$C_{10}H_{12}$	132	0.08
50	*(Z)*-3-Hexen-1-ol	36.675	1376	$C_6H_{12}O$	100	0.13
51	Nonanal	37.108	1393	$C_9H_{18}O$	142	0.04
52	1-Methylindan	37.242	1398	$C_{10}H_{12}$	132	0.06
53	(*E*)-2-Hexen-1-ol	38.167	1416	$C_6H_{12}O$	100	0.23
54	(*E*)-2-Octenal	39.533	1432	$C_8H_{14}O$	126	0.14
55	Acetic acid	40.617	1451	$C_2H_4O_2$	60	1.48
56	7-Octen-4-ol	41.133	1460	$C_8H_{16}O$	128	0.08
57	Benzaldehyde	45.567	1518	C_7H_6O	106	0.01
58	*(E)*-2-Nonenal	46.983	1575	$C_9H_{16}O$	140	0.19
59	Linalool	47.308	1579	$C_{10}H_{18}O$	154	0.01
60	Octanol	48.133	1589	$C_8H_{18}O$	130	0.04
61	Dimethyl sulfoxide	49.533	1606	C_2H_6OS	78	0.06
62	(*E,Z*)-2,6-Nonadienal	49.708	1608	$C_9H_{14}O$	138	0.01
63	1,2-Propanediol	50.592	1619	$C_3H_8O_2$	76	7.81

(continued)

64	(*E*)-2-Octenol	51.733	1630	$C_8H_{16}O$	128	0.01
65	2-(2-Ethoxyethoxy)-ethanol	52.133	1639	$C_6H_{14}O_3$	134	0.03
66	2-Hydroxyethyl acetate	52.800	1655	$C_4H_8O_3$	104	0.04
67	3,4-Epoxy-2-octanone	53.017	1657	$C_8H_{14}O_2$	142	0.03
68	1-Nonen-4-ol	53.567	1663	$C_9H_{18}O$	142	0.01
69	Acetophenone	53.720	1665	C_8H_8O	120	0.09
70	Nonanol	54.467	1685	$C_9H_{20}O$	144	0.04
71	Ethyl benzoate	54.742	1692	$C_9H_{20}O_2$	150	0.05
72	Ethyl 3-hydroxyhexanoate	55.642	1697	$C_8H_{16}O_3$	160	0.03
73	(*E*,*E*)-2,4-Nonadienal	56.758	1705	$C_9H_{14}O$	138	0.05
74	Decanol	57.700	1721	$C_{10}H_{22}O$	158	0.06
75	(*E*)-2-Undecenal	59.692	1754	$C_{11}H_{20}O$	168	0.03
76	4-Ethylphenyl acetate	61.483	1789	$C_{10}H_{12}O_2$	164	0.09
77	Methyl dodecanoate	62.558	1802	$C_{13}H_{26}O_2$	214	0.03
78	(*E*,*E*)-2,4-Decadienal	62.692	1812	$C_{10}H_{16}O$	152	0.15
79	Phenylethyl acetate	62.992	1818	$C_{10}H_{12}O_2$	164	0.01
80	Hexanoic acid	64.258	1856	$C_6H_{12}O_2$	116	1.88
81	Geranylacetone	64.692	1863	$C_{13}H_{22}O$	194	0.24
82	(*E*)-2-Dodecenal	64.967	1870	$C_{12}H_{22}O$	182	0.03
83	Unknown	65.675	1888			0.44
84	Ethyl 3-hydroxyoctanoate	65.325	1896	$C_{10}H_{20}O_3$	188	0.01
85	Unknown	67.092	1905			2.86

(continued)

86	Ethyl 3-hydroxynonanoate	68.325	1961	$C_{11}H_{22}O_3$	202	0.46
87	Dodecanol	69.167	1980	$C_{12}H_{26}O$	186	0.05
88	1-Phenyl-1-butanol	69.283	1981	$C_{10}H_{14}O$	150	0.11
89	2-Pentadecanone	70.967	2011	$C_{15}H_{30}O$	226	0.03
90	Tridecanol	71.233	2013	$C_{13}H_{28}O$	200	0.01
91	Isopropyl tetradecanoate	71.433	2015	$C_{17}H_{34}O_2$	270	0.10
92	Methyl 4-tert-butylbenzoate	71.933	2040	$C_{12}H_{16}O_2$	192	0.03
93	Unknown	73.433	2112			0.73
94	Tetradecanol	75.633	2188	$C_{14}H_{30}O$	214	0.18
95	Methyl hexadecanoate	76.892	2234	$C_{17}H_{34}O_2$	270	0.13
96	Ethyl hexadecanoate	77.994	2284	$C_{18}H_{36}O_2$	284	0.03
97	*(E,E)*-Farnesol	81.367	2378	$C_{15}H_{26}O$	222	0.01
98	Hexadecanol	82.092	2397	$C_{16}H_{34}O$	326	0.20
99	Methyl octadecanoate	83.783	2430	$C_{19}H_{38}O_2$	298	0.03
100	Dodecanoic acid	86.658	1494	$C_{12}H_{24}O_2$	200	0.10
101	Methyl (*E,E*)-9,12-octadecadi-enoate	86.850	2498	$C_{19}H_{34}O_2$	294	0.11
102	Farnesol	88.658	2538	$C_{15}H_{22}O_4$	222	0.01
	Total					93.58

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

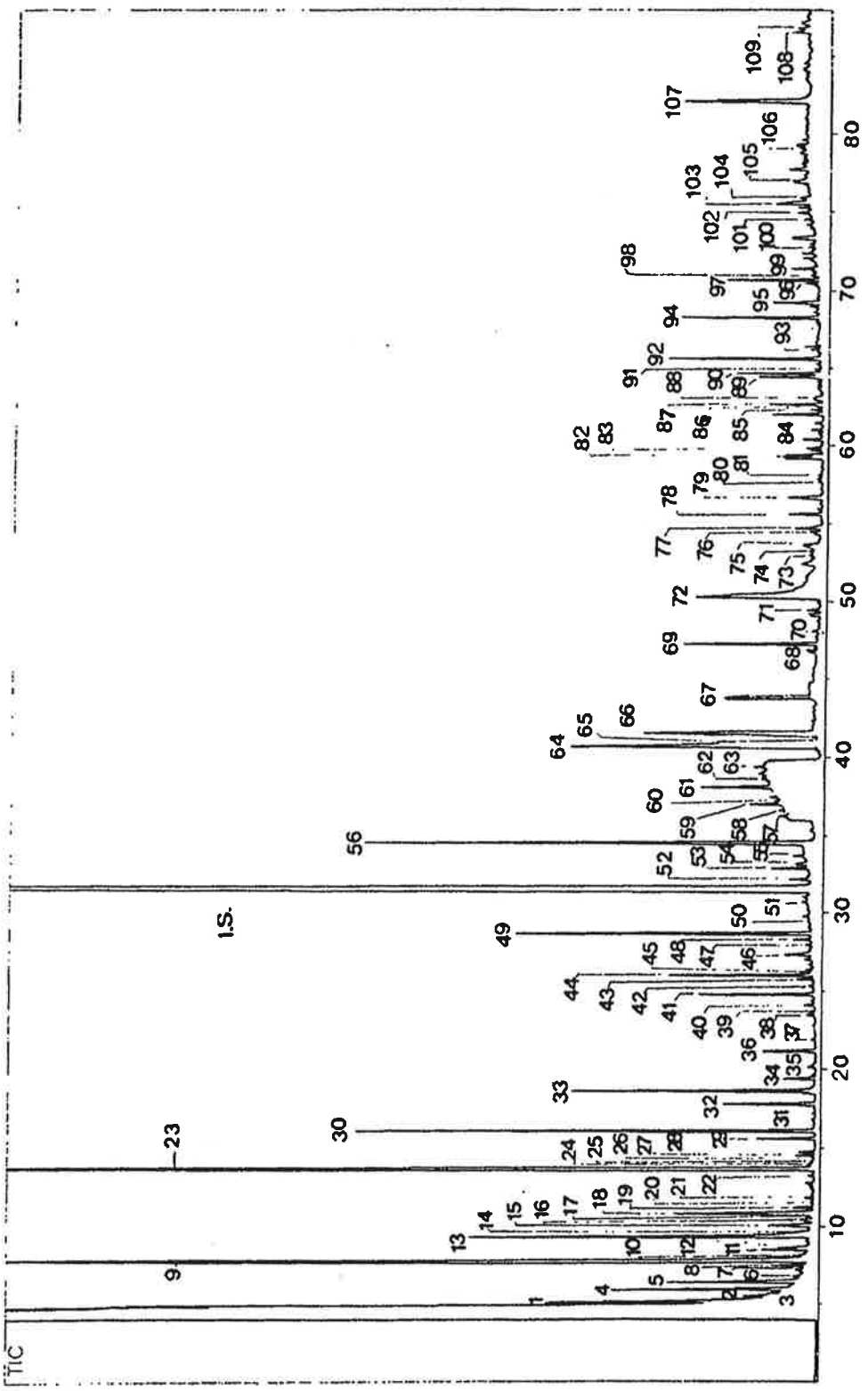

Fig. 6. GC chromatogram of volatile flavor components in Jangshiplang pear

Table 8. Volatile flavor components in Whangkeum pear

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Acetaldehyde	4.933	697	C_2H_4O	44	0.22
2	Ethyl isobutyl ether	5.242	744	$C_6H_{14}O$	102	0.10
3	Propanal	5.863	783	C_3H_6O	58	0.04
4	Butyl ethyl ether	5.958	792	$C_6H_{14}O$	102	0.38
5	Ethyl formate	6.427	822	$C_3H_6O_2$	74	1.03
6	2-Propenal	6.817	842	C_3H_4O	56	0.02
7	Tetrahydrofuran	7.200	861	C_4H_8O	72	0.04
8	Butanal	7.508	875	C_4H_8O	72	0.13
9	Ethyl acetate	7.867	892	$C_4H_8O_2$	88	12.10
10	Nonane	8.117	908	C_9H_{20}	128	0.02
11	2-Methylbutanal	8.525	913	$C_5H_{10}O$	86	0.10
12	3-Methylbutanal	8.658	918	$C_5H_{10}O$	86	0.13
13	Ethanol	9.392	943	C_2H_6O	46	0.61
14	Ethyl propanoate	10.100	955	$C_5H_{10}O_2$	102	0.35
15	Ethyl 2-methylpropanoate	10.442	963	$C_6H_{12}O_2$	116	0.10
16	Propyl acetate	10.767	975	$C_5H_{10}O_2$	102	0.01
17	2-Pentanone	10.858	978	$C_5H_{10}O$	86	0.76
18	Methyl butanoate	11.208	986	$C_5H_{10}O_2$	102	0.06
19	Ethyl propenoate	11.542	993	$C_5H_8O_2$	100	0.05
20	Decane	11.825	998	$C_{10}H_{22}$	142	0.08
21	2-Butanol	13.225	1026	$C_4H_{10}O$	74	0.01

(continued)

22	Ethyl butanoate	13.717	1036	$C_6H_{12}O_2$	116	4.60
23	Propanol	13.892	1040	C_3H_8O	60	0.02
24	Ethyl 2-methylpropenoate	14.175	1046	$C_6H_{10}O_2$	114	0.01
25	3-Hexanone	14.375	1048	$C_6H_{12}O$	100	0.01
26	Ethyl 2-methylbutanoate	14.508	1050	$C_7H_{14}O_2$	130	0.04
27	2,3-Pentanedione	14.733	1056	$C_5H_8O_2$	100	0.04
28	Butyl acetate	15.592	1071	$C_6H_{12}O_2$	116	0.07
29	Hexanal	16.192	1082	$C_6H_{12}O$	100	6.65
30	3-Pentanol	17.800	1111	$C_5H_{12}O$	88	0.42
31	2-Pentanol	18.625	1128	$C_5H_{12}O$	88	1.20
32	Ethyl pentanoate	19.417	1134	$C_7H_{14}O_2$	130	0.19
33	2-Methyl-4-pentenal	19.767	1141	$C_6H_{10}O$	98	0.11
34	Butanol	20.125	1146	$C_4H_{10}O$	74	0.01
35	Ethyl 2-butenoate	21.142	1162	$C_6H_{10}O_2$	114	0.07
36	Pentyl acetate	21.875	1176	$C_7H_{14}O_2$	130	0.01
37	*(E)*-2-Hexenal	24.758	1217	$C_6H_{10}O$	98	0.46
38	2-Hexanol	25.325	1220	$C_6H_{14}O$	102	0.05
39	2-Pentylfuran	25.750	1230	$C_9H_{14}O$	138	0.13
40	Ethyl hexanoate	26.100	1235	$C_8H_{16}O_2$	144	1.94
41	Dodecene	26.733	1241	$C_{12}H_{24}$	168	0.04
42	Pentanol	27.383	1260	$C_5H_{12}O$	88	0.25
43	Dihydro-2-methyl-3-furanone	27.942	1267	$C_5H_8O_2$	100	0.02

(continued)

44	3,4-Epoxy-2-pentanone	28.267	1271	$C_5H_8O_2$	100	0.05
45	Hexyl acetate	28.642	1274	$C_8H_{16}O_2$	144	0.28
46	3-Hydroxy-2-butanone	29.417	1283	$C_4H_8O_2$	88	0.04
47	Ethyl-(*Z*)-3-hexenoate	31.233	1305	$C_8H_{14}O_2$	142	0.01
I.S.	Butylbenzene	31.922	1313	$C_{10}H_{14}$	134	32.39
48	(*E*)-2-Heptenal	32.267	1317	$C_7H_{12}O$	112	0.13
49	Ethyl heptanoate	32.967	1324	$C_9H_{18}O_2$	158	0.05
50	6-Methyl-5-hepten-2-one	33.142	1328	$C_8H_{14}O$	126	0.05
51	Ethyl-(*E*)-2-hexenoate	33.717	1342	$C_8H_{14}O_2$	142	0.05
52	Hexanol	34.625	1363	$C_6H_{14}O$	158	1.85
53	5-Methylindan	36.250	1372	$C_{10}H_{12}$	132	0.05
54	(*Z*)-3-Hexen-1-ol	36.667	1374	$C_6H_{12}O$	100	0.35
55	Nonanal	37.033	1382	$C_9H_{18}O$	142	0.02
56	1-Methylindan	37.158	1392	$C_{10}H_{12}$	132	0.04
57	(*E*)-2-Hexen-1-ol	38.058	1410	$C_6H_{12}O$	100	0.01
58	(*E*)-2-Octenal	39.467	1438	$C_8H_{14}O$	126	0.10
59	Acetic acid	40.050	1450	$C_2H_4O_2$	60	3.74
60	7-Octen-4-ol	41.050	1459	$C_8H_{16}O$	128	0.04
61	Furfural	41.542	1463	$C_5H_4O_2$	96	0.19
62	Octyl acetate	43.892	1495	$C_{10}H_{20}O_2$	172	0.02
63	Ethyl 3-hydroxybutanoate	45.783	1520	$C_6H_{12}O_3$	132	0.44
64	2-Nonenal	46.908	1544	$C_9H_{16}O$	140	0.07

(continued)

65	Octanol	48.100	1569	$C_8H_{18}O$	130	0.02
66	Dimethyl sulfide	49.458	1599	C_2H_6OS	78	0.08
67	1,2-Propanediol	50.317	1615	$C_3H_8O_2$	76	1.62
68	Phenylacetaldehyde	53.067	1654	C_8H_8O	120	0.12
69	(*E*)-2-Decenal	53.245	1656	$C_{10}H_{18}O$	154	0.11
70	Acetophenone	53.650	1659	C_8H_8O	120	0.06
71	Nonanol	54.452	1665	$C_9H_{20}O$	144	0.01
72	Ethyl benzoate	54.692	1670	$C_9H_{20}O_2$	150	0.11
73	Ethyl succinate	55.208	1682	$C_8H_{14}O_4$	174	0.04
74	Ethyl 3-hydroxyhexanoate	55.592	1690	$C_8H_{16}O_3$	160	0.24
75	3-Decenol	55.883	1703	$C_{10}H_{20}O$	156	0.07
76	(*E*,*E*)-2,4-Nonadienal	56.750	1718	$C_9H_{14}O$	138	0.05
77	(*Z*,*E*)-α-Farnesene	59.392	1762	$C_{15}H_{24}$	204	0.06
78	(*E*)-2-Undecenal	59.667	1767	$C_{11}H_{20}O$	168	0.07
79	(*E*,*Z*)-2,4-Decadienal	60.350	1778	$C_{10}H_{16}O$	152	0.10
80	Ethylphenyl acetate	61.450	1797	$C_{10}H_{12}O_2$	164	0.05
81	Butylrophenone	61.992	1807	$C_{10}H_{12}O$	148	0.08
82	Methyl dodecanoate	62.333	1813	$C_{13}H_{22}O_2$		0.07
83	(*E*,*E*)-2,4-Decadienal	62.533	1816	$C_{10}H_{16}O$	152	0.07
84	Phenethyl acetate	62.950	1823	$C_{10}H_{12}O_2$	164	0.07
85	Unknown	63.142	1828			3.13
86	Hexanoic acid	64.308	1856	$C_6H_{12}O_2$	116	0.34

(continued)

87	Geranylacetone	64.658	1862	$C_{13}H_{22}O$	194	0.18
88	(*E*)-2-Tridecenal	64.917	1867	$C_{13}H_{24}O$	196	0.06
89	2,2,4-Trimethyl-pentan-1,3-diol-isobutanoate	65.642	1888	$C_{16}H_{30}O_4$	286	0.35
90	Ethyl 3-hydroxyoctanoate	66.225	1905	$C_{10}H_{20}O_3$	188	0.95
91	Methyl 3-hydroxynonanoate	67.092	1949	$C_{10}H_{20}O_3$	188	0.07
92	Ethyl 3-hydroxynonanoate	67.417	1965	$C_{11}H_{22}O_3$	202	12.61
93	Tridecanol	69.142	1981	$C_{13}H_{28}O$	200	0.02
94	1-Phenyl-1-butanol	69.250	1982	$C_{10}H_{14}O$	150	0.18
95	2-Hexadecanone	70.950	2035	$C_{16}H_{32}O$	240	0.02
96	Isopropyl tetradecanoate	71.408	2050	$C_{17}H_{34}O_2$	270	0.05
97	γ-Nonalactone	71.483	2052	$C_9H_{16}O_2$	156	0.01
98	Octanoic acid	72.367	2080	$C_8H_{16}O_2$	144	0.04
99	Ethyl 4-methylbenzoate	74.758	2155	$C_{10}H_{12}O_3$	180	0.05
100	Nonanoic acid	75.525	2179	$C_9H_{18}O_2$	158	0.04
101	δ-Undecalactone	76.725	2217	$C_{11}H_{20}O_2$	184	0.07
102	Methyl hexadecanoate	76.858	2221	$C_{17}H_{34}O_2$	270	0.06
103	Ethyl hexadecanoate	77.958	2273	$C_{18}H_{36}O_2$	284	0.02
104	Farnesylacetone	82.017	2397	$C_{18}H_{30}O$	262	0.05
105	Hexadecanol	82.200	2402	$C_{16}H_{34}O$	242	0.04
106	Dodecanoic acid	86.425	2550	$C_{12}H_{24}O_2$	200	0.20
107	Methyl 9,12-octadecadienoate	86.808	2565	$C_{19}H_{34}O_2$	294	0.12
	Total					94.41

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

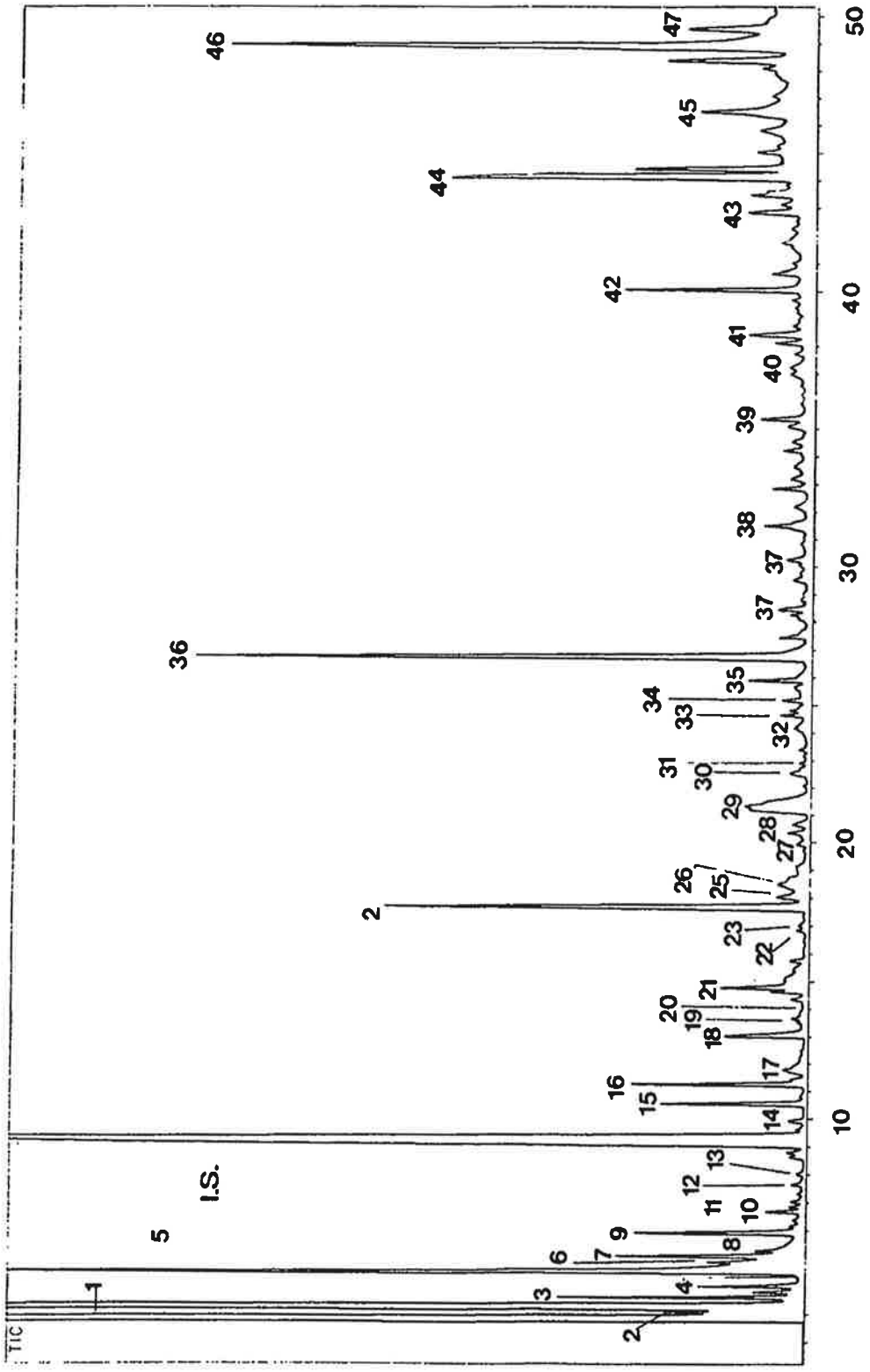

Fig. 7. GC chromatogram of volatile flavor components in Mansangil pear

Table 9. Volatile flavor components in Jangshiplang pear

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Acetaldehyde	4.925	697	C_2H_4O	44	6.44
2	Ethyl 2-methylpropyl ether	5.242	745	$C_6H_{14}O$	102	0.81
3	Propanal	5.845	785	C_3H_6O	58	0.02
4	Butyl ethyl ether	5.958	792	$C_6H_{14}O$	102	0.74
5	Ethyl formate	6.425	822	$C_3H_6O_2$	74	0.94
6	2-Propenal	6.789	840	CH_4O	56	0.02
7	Tetrahydrofuran	7.208	861	C_4H_8O	71	0.05
8	Butanal	7.492	875	C_4H_8O	72	0.14
9	Ethyl acetate	7.804	891	$C_4H_8O_2$	88	10.86
10	Nonane	8.117	898	C_9H_{20}	128	0.07
11	2-Methylbutanal	8.522	908	$C_5H_{10}O$	86	0.21
12	3-Methylbutanal	8.658	913	$C_5H_{10}O$	86	0.14
13	Ethanol	9.400	943	C_2H_6O	46	2.21
14	4,5-Dimethyloctane	9.667	949	$C_{10}H_{22}$	142	0.07
15	Ethyl propanoate	10.108	960	$C_5H_{10}O_2$	102	0.21
16	Ethyl 2-methylpropanoate	10.467	968	$C_6H_{12}O_2$	116	0.05
17	Propyl acetate	10.783	976	$C_5H_{10}O_2$	102	0.02
18	2-Pentanone	10.875	978	$C_5H_{10}O$	86	1.13
19	Methyl butanoate	11.225	999	$C_5H_{10}O_2$	102	0.09
20	Ethyl propenoate	11.533	1003	$C_5H_8O_2$	100	0.02

(continued)

21	Decane	11.831	1008	$C_{10}H_{22}$	142	0.02
22	2-Butanol	13.233	1028	$C_4H_{10}O$	74	0.02
23	Ethyl butanoate	13.750	1035	$C_6H_{12}O_2$	116	11.91
24	Propanol	13.908	1037	C_3H_8O	60	0.02
25	Ethyl 2-methylpropenoate	14.200	1041	$C_6H_{10}O_2$	114	0.02
26	3-Hexanone	14.458	1044	$C_6H_{12}O$	100	0.02
27	Ethyl 2-methylbutanoate	14.533	1046	$C_7H_{14}O_2$	130	0.09
28	2,3-Pentanedione	14.750	1049	$C_5H_8O_2$	100	0.07
29	Butyl acetate	15.625	1071	$C_6H_{12}O_2$	116	0.30
30	Hexanal	16.108	1080	$C_6H_{12}O$	100	2.28
31	Undecane	17.200	1103	$C_{11}H_{24}$	156	0.02
32	3-Pentanol	17.803	1115	$C_5H_{12}O$	88	0.58
33	2-Pentanol	18.625	1128	$C_5H_{12}O$	88	1.40
34	Ethyl pentanoate	19.417	1141	$C_7H_{14}O_2$	130	0.18
35	Butanol	20.150	1153	$C_4H_{10}O$	74	0.02
36	Ethyl 2-butenoate	21.167	1170	$C_6H_{10}O_2$	114	0.25
37	Pentyl acetate	21.883	1182	$C_7H_{14}O_2$	130	0.02
38	α-Limonene	23.458	1206	$C_{10}H_{16}$	136	0.02
39	(*Z*)-2-Heptenal	23.642	1209	$C_7H_{12}O$	112	0.02
40	β-Phellandrene	24.092	1216	$C_{10}H_{16}$	136	0.02
41	*(E)*-2-Hexenal	24.783	1226	$C_6H_{10}O$	98	0.64
42	2-Hexanol	25.300	1230	$C_6H_{14}O$	102	0.02

(continued)

43	2-Pentylfuran	25.758	1233	$C_9H_{14}O$	138	0.09
44	Ethyl hexanoate	26.025	1238	$C_8H_{16}O_2$	144	0.81
45	Ethyl 2-methylbutenoate	26.175	1240	$C_7H_{12}O_2$	128	0.02
46	Pentanol	27.333	1257	$C_5H_{12}O$	88	0.21
47	Dihydro-2-methyl-3-furanone	27.950	1266	$C_5H_8O_2$	100	0.02
48	3,4-Epoxy-2-pentanone	28.292	1271	$C_5H_8O_2$	100	0.09
49	Hexyl acetate	28.717	1277	$C_8H_{16}O_2$	144	1.96
50	Octanal	29.775	1291	$C_8H_{16}O$	128	0.02
51	Ethyl *(Z)*-3-hexenoate	31.050	1309	$C_8H_{14}O_2$	142	0.02
I.S.	Butylbenzene	31.711	1318	$C_{10}H_{14}$	134	29.92
52	*(E)*-2-Heptenal	32.192	1323	$C_7H_{12}O$	112	0.14
53	*(E)*-2-Hexenyl acetate	32.908	1331	$C_8H_{14}O_2$	142	0.21
54	6-Methyl-5-hepten-2-one	33.142	1338	$C_8H_{14}O$	126	0.02
55	Ethyl *(E)*-2-hexenoate	33.708	1355	$C_8H_{14}O_2$	142	0.05
56	Hexanol	34.573	1365	$C_6H_{14}O$	158	3.36
57	5-Methylindan	36.267	1375	$C_{10}H_{12}$	132	0.02
58	*(Z)*-3-Hexenol	36.633	1376	$C_6H_{12}O$	100	0.02
59	Nonanal	37.008	1383	$C_9H_{18}O$	142	0.18
60	1-Methylindan	37.175	1393	$C_{10}H_{12}$	132	0.02
61	*(E)*-2-Hexenol	38.108	1416	$C_6H_{12}O$	100	0.48
62	Hexyl butanoate	38.617	1421	$C_{10}H_{20}O_2$	172	0.02
63	*(E)*-2-Octenal	39.433	1429	$C_8H_{14}O$	126	0.02

(continued)

64	Acetic acid	40.712	1450	$C_2H_4O_2$	60	1.43
65	7-Octen-4-ol	41.008	1455	$C_8H_{16}O$	128	0.02
66	Fufrural	41.570	1463	$C_5H_4O_2$	96	0.58
67	Octyl acetate	43.817	1499	$C_{10}H_{20}O_2$	172	0.02
68	2-Nonenal	46.833	1548	$C_9H_{16}O$	140	0.02
69	Linalool	47.283	1553	$C_{10}H_{18}O$	154	0.76
70	Octanol	48.117	1566	$C_8H_{18}O$	130	0.02
71	Dimethyl sulfide	49.458	1586	C_2H_6OS	78	0.09
72	1,2-Propanediol	50.308	1599	$C_3H_8O_2$	76	1.52
73	Phenylacetaldehyde	52.992	1645	C_8H_8O	120	0.02
74	*(E)*-2-Decenal	53.283	1648	$C_{10}H_{18}O$	154	0.02
75	Acetophenone	53.675	1653	C_8H_8O	120	0.09
76	Nonanol	54.458	1665	$C_9H_{20}O$	144	0.02
77	Ethyl benzoate	54.717	1677	$C_9H_{20}O_2$	150	0.16
78	Ethyl 3-hydroxyhexanoate	55.617	1685	$C_8H_{16}O_3$	160	0.21
79	α-Terpineol	56.700	1696	$C_{10}H_{18}O$	154	0.23
80	*(E)*-2-Nonenol	57.667	1706	$C_9H_{18}O$	142	0.02
81	*(Z,Z)*-α-Farnesene	58.117	1710	$C_{15}H_{24}$	204	0.02
82	*(Z,E)*-α-Farnesene	59.406	1723	$C_{15}H_{24}$	204	0.18
83	*(E)*-2-Undecenal	59.692	1729	$C_{11}H_{20}O$	168	0.07
84	Ethylphenyl acetate	61.475	1763	$C_{10}H_{12}O_2$	164	0.02
85	Nerol	62.317	1779	$C_{10}H_{18}O$	154	0.07

(continued)

86	Methyl dodecanoate	62.525	1783	$C_{13}H_{22}O_2$	210	0.02
87	*(E,E)*-2,4-Decadienal	62.674	1785	$C_{10}H_{16}O$	152	0.28
88	Phenethyl acetate	62.967	1791	$C_{10}H_{12}O_2$	164	0.02
89	Geraniol	64.442	1856	$C_{10}H_{18}O$	154	0.35
90	Geranylacetone	64.667	1863	$C_{13}H_{22}O$	194	0.39
91	*(E)*-2-Tridecenal	64.933	1870	$C_{13}H_{24}O$	196	0.02
92	Unknown	65.642	1888			0.76
93	Ethyl 3-hydroxyoctanoate	66.225	1905	$C_{10}H_{20}O_3$	188	0.05
94	Ethyl 3-hydroxynonanoate	68.300	1961	$C_{11}H_{22}O_3$	202	0.69
95	1-Phenyl 1-butanol	69.267	1982	$C_{10}H_{14}O$	150	0.32
96	Unknown	70.467	2019			0.02
97	Methyl eugenol	70.700	2026	$C_{11}H_{14}O_2$	178	0.44
98	2-Hexadecanone	70.958	2034	$C_{16}H_{32}O$	240	0.02
99	Isopropyl tetradecanoate	71.425	2048	$C_{17}H_{34}O_2$	270	0.12
100	Unknown	72.588	2084			0.02
101	6,10,14-Trimethyl-2-pentadecanone	74.233	2148	$C_{10}H_{36}O$	268	0.02
102	Ethyl 4-methylbenzoate	74.542	2149	$C_{10}H_{12}O_3$	180	0.02
103	Nonanoic acid	75.533	2184	$C_9H_{18}O_2$	158	0.18
104	Pentadecanol	75.658	2189	$C_{15}H_{32}O$	228	0.14
105	Methyl hexadecanoate	76.875	2232	$C_{17}H_{34}O_2$	270	0.02
106	Decanoic acid	78.767	2299	$C_{10}H_{20}O_2$	172	0.02
107	Hexadecanol	82.158	2389	$C_{16}H_{34}O$	242	1.27

(continued)

108	Dodecanoic acid	86.575	2447	$C_{12}H_{24}O_2$	200	0.18
109	Methyl (*E*,*E*)-9,12-octadecadienoate	86.842	2498	$C_{19}H_{34}O_2$	294	0.07
	Total					90.91

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 10. Relative content of functional groups in Pears

Peak area%

Functional group	Mansamgil	Imamura	Shingo	Whangkeum	Jangshiplang
Aldehydes	12.41	18.46	17.16	8.95	11.28
Alcohols	16.63	20.33	16.41	6.78	13.52
Esters	12.24	30.29	12.7	36.34	29.47
Terpenes	3.2	0.06	0.01	0.06	0.24
Acids	17.96	7.86	3.46	4.36	1.81
Ketones	1.66	1.39	1.92	1.44	1.87
Miscellaneous	-	4.88	1.85	0.48	0.45
T o t a l	64.10	83.27	53.51	58.41	58.64

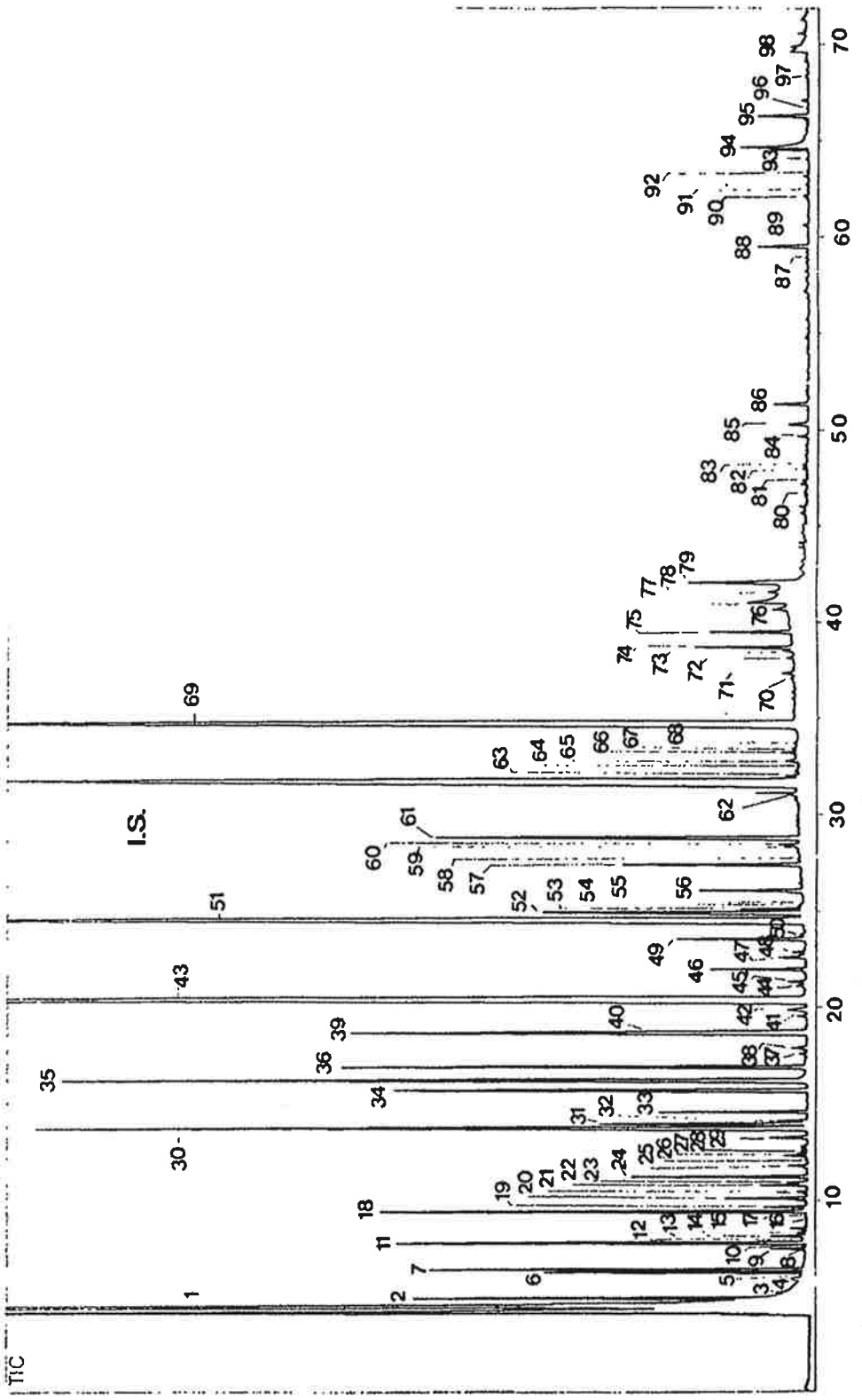

Fig. 8. GC chromatogram of volatile flavor components in Fugi apple

Table 11. Volatile flavor components in Fugi apple

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Isopropyl ethyl ether	4.667	520	$C_5H_{12}O$	88	0.01
2	Acetaldehyde	4.942	695	C_2H_4O	44	1.60
3	Ethyl 2-methylpropyl ether	5.242	698	$C_6H_{14}O$	102	0.02
4	Propanal	5.883	792	C_3H_6O	58	0.04
5	Octane	5.992	798	C_8H_{18}	114	0.02
6	2-Propanone	6.292	814	C_3H_6O	58	0.73
7	Ethyl formate	6.450	822	$C_3H_6O_2$	74	1.21
8	Tetrahydrofuran	7.417	842	C_4H_8O	72	0.01
9	Butanal	7.525	875	C_4H_8O	72	0.11
10	2-Methyl-2-propenal	7.650	887	$C_4H_6O_2$	70	0.01
11	Ethyl acetate	7.833	890	$C_4H_8O_2$	88	1.59
12	2-Methylfuran	8.042	895	C_5H_6O	82	0.04
13	Methanol	8.175	898	CH_4O	32	0.16
14	Methyl propanoate	8.367	903	$C_4H_8O_2$	88	0.02
15	2-Methylbutanal	8.558	908	$C_5H_{10}O$	86	0.06
16	3-Methylbutanal	8.700	914	$C_5H_{10}O$	86	0.01
17	2-Propanol	9.217	934	C_3H_8O	60	0.01
18	Ethanol	9.458	944	C_2H_6O	46	1.93
19	3-Buten-2-one	9.692	956	C_4H_6O	70	0.16
20	Ethyl propanoate	10.150	964	$C_5H_{10}O_2$	102	0.26

(continued)

21	Ethyl 2-methylpropanoate	10.483	969	$C_6H_{12}O_2$	116	0.04
22	Propyl acetate	10.817	974	$C_5H_{10}O_2$	102	0.17
23	Pentanal	10.958	979	$C_5H_{10}O$	86	0.12
24	Methyl butanoate	11.275	986	$C_5H_{10}O_2$	102	0.62
25	Decane	11.850	997	$C_{10}H_{22}$	96	0.09
26	2-Methylpentanal	12.125	1002	$C_6H_{12}O$	100	0.01
27	Methyl 2-methylbutanoate	12.358	1007	$C_6H_{12}O_2$	116	0.10
28	2-Methylpropyl acetate	12.525	1010	$C_6H_{12}O_2$	116	0.12
29	2-Butanol	13.308	1018	$C_4H_{10}O$	74	0.18
30	Ethyl butanoate	13.817	1038	$C_6H_{12}O_2$	116	4.99
31	Propanol	14.000	1043	C_3H_8O	60	0.95
32	Propyl propanoate	14.158	1047	$C_6H_{12}O_2$	116	0.10
33	Ethyl 2-methylbutanoate	14.617	1052	$C_7H_{14}O_2$	130	0.58
34	Butyl acetate	15.742	1073	$C_6H_{12}O_2$	116	2.44
35	Hexanal	16.292	1085	$C_6H_{12}O$	100	4.98
36	2-Methylpropanol	16.950	1102	$C_4H_{10}O$	74	2.26
37	Ethyl carbonate	17.608	1112	$C_5H_{10}O_3$	118	0.02
38	3-Pentanol	17.900	1116	$C_5H_{12}O$	88	0.10
39	2-Methylbutyl acetate	18.700	1125	$C_7H_{14}O_2$	130	3.12
40	Propyl butanoate	18.775	1130	$C_7H_{14}O_2$	130	0.43
41	2-Methyl-4-pentenal	19.542	1136	$C_6H_{10}O$	98	0.05
42	Propyl 2-methylbutanoate	19.875	1143	$C_8H_{16}O_2$	144	0.14

(continued)

43	Butanol	20.542	1160	$C_4H_{10}O$	74	15.36
44	2-Methylpropyl butanoate	21.133	1165	$C_8H_{16}O_2$	144	0.04
45	3,4-Dimethyl hexanone	21.358	1167	$C_8H_{16}O$	128	0.09
46	Pentyl acetate	21.992	1175	$C_7H_{14}O_2$	130	0.30
47	Cylcopentanone	22.608	1187	C_5H_8O	84	0.17
48	Methyl hexanoate	22.883	1189	$C_7H_{14}O_2$	130	0.06
49	α-Limonene	23.592	1193	$C_{10}H_{16}$	136	0.69
50	*(Z)*-2-Heptenal	23.758	1203	$C_7H_{12}O$	112	0.04
51	3-Methyl-1-butanol	24.675	1221	$C_5H_{12}O$	88	12.37
52	*(E)*-2-Hexenal	24.975	1224	$C_6H_{10}O$	98	1.69
I.S.	Butyl butanoate	25.150	1226	$C_8H_{16}O_2$	144	0.25
53	2-Ethoxy-1-ethanol	25.433	1228	$C_4H_{10}O_2$	90	0.01
54	Butyl 2-methylbutanoate	26.017	1234	$C_9H_{18}O_2$	158	0.01
55	Ethyl hexanoate	26.133	1235	$C_8H_{16}O_2$	144	0.53
56	Pentanol	27.450	1260	$C_5H_{12}O$	88	0.89
57	Ethylhexylacetal	27.725	1263	$C_{10}H_{22}O_2$	174	0.01
58	Pentyl 2-methylpropanoate	28.342	1271	$C_9H_{18}O_2$	158	0.02
59	*p*-Cymene	28.492	1273	$C_{10}H_{14}$	134	0.10
60	Hexyl acetate	28.858	1277	$C_8H_{16}O_2$	144	2.52
61	Cylcopentanol	31.083	1304	$C_5H_{10}O$	86	0.10
62	Butylbenzene	31.858	1314	$C_{10}H_{14}$	134	13.39
63	Propyl hexanoate	31.025	1322	$C_9H_{18}O_2$	158	0.10

(continued)

64	*(Z)*-3-Hexenyl acetate	32.483	1330	$C_8H_{14}O_2$	142	0.01
65	1-Hydroxy-3-methyl-2-butanone	32.783	1332	$C_5H_{10}O_2$	102	0.07
66	6-Methyl-5-hepten-2-one	33.058	1340	$C_8H_{14}O$	126	0.07
67	Hexyl propanoate	33.433	1347	$C_9H_{18}O_2$	158	0.04
68	Hexyl 2-methylpropanoate	33.700	1351	$C_{10}H_{20}O_2$	172	0.02
69	Hexanol	34.833	1370	$C_6H_{14}O$	158	12.41
70	Nonanal	37.092	1390	$C_9H_{18}O$	142	0.01
71	3-Octanol	37.375	1399	$C_8H_{18}O$	130	0.09
72	*(E)*-2-Hexen-1-ol	38.167	1405	$C_6H_{12}O$	100	0.04
73	Butyl hexanoate	38.542	1415	$C_{10}H_{20}O_2$	172	0.06
74	Hexyl butanoate	38.750	1420	$C_{10}H_{20}O_2$	172	0.49
75	Hexyl 2-methylbutanoate	39.533	1432	$C_{11}H_{22}O_2$	186	0.69
76	Linalool oxide	40.692	1451	$C_{10}H_{18}O_2$	170	0.11
77	Acetic acid	41.033	1455	$C_2H_4O_2$	60	0.49
78	Heptanol	41.600	1463	$C_7H_{16}O_2$	116	0.12
79	6-Methyl-5-hepten-2-ol	42.092	1470	$C_8H_{16}O$	128	0.58
80	Butyl-*(E)*-2-hexenoate	46.758	1545	$C_{10}H_{18}O_2$	170	0.01
81	Linalool	47.375	1555	$C_{10}H_{18}O$	154	0.02
82	1-Octyn-4-ol	47.975	1565	$C_{10}H_{14}O$	126	0.02
83	Octanol	48.158	1568	$C_8H_{18}O$	130	0.01
84	3-Acetopropanol	49.683	1578	$C_5H_{10}O_2$	102	0.05
85	1,2-Propanediol	50.300	1598	$C_3H_8O_2$	76	0.11

(continued)

86	Hexyl hexanoate	51.342	1612	$C_{12}H_{24}O_2$	200	0.17
87	Hexyl-*(E)*-2-hexenoate	58.908	1732	$C_{12}H_{22}O_2$	198	0.01
88	*(E,E)*-α-Farnesene	59.500	1738	$C_{15}H_{24}$	204	0.26
89	β-Citronellol	60.625	1744	$C_{10}H_{20}O$	156	0.02
90	Butyrophenone	62.117	1797	$C_{10}H_{12}O$	148	0.02
91	*(E,E)*-2,4-Decadienal	62.733	1811	$C_{10}H_{16}O$	152	0.01
92	β-Damascenone	63.408	1827	$C_{13}H_{18}O$	190	0.01
93	Geraniol	64.483	1853	$C_{10}H_{18}O$	154	0.05
94	Hexanoic acid	64.667	1857	$C_6H_{12}O$	116	0.49
95	Farnesol	66.308	1918	$C_{15}H_{26}O$	222	0.26
96	Dimethyl sulfone	66.675	1938	$C_2H_6O_2S$	94	0.01
97	Ethyl 3-hydroxydecanoate	68.350	1970	$C_{12}H_{24}O_3$	216	0.01
98	2-Hexenoic acid	69.667	1980	$C_6H_{10}O_2$	114	0.14
	Total					95.33

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

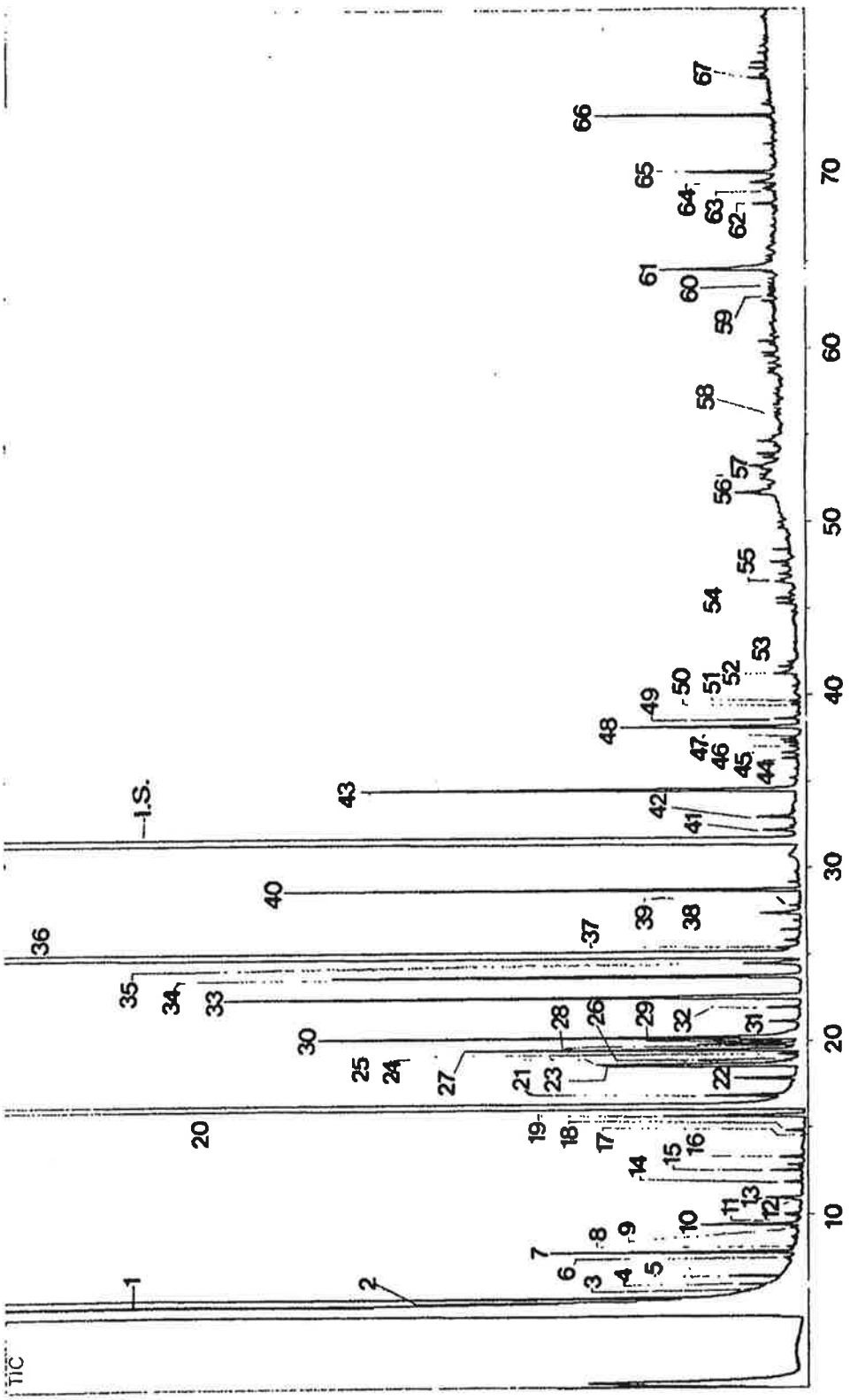

Fig. 9. GC chromatogram of volatile flavor components in Tsugaru apple

Table 12. Volatile flavor components in Tsugaru apple

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Isopropyl ethyl ether	4.692	520	$C_5H_{12}O$	88	0.35
2	Propyl ethyl ether	4.958	695	$C_5H_{12}O$	88	0.14
3	3,4-Dimethyl-2-pentane	5.675	755	C_7H_{14}	98	0.01
4	Ethyl butyl ether	5.983	780	$C_6H_{14}O$	102	0.03
5	Ethyl formate	6.458	820	$C_3H_6O_2$	74	0.05
6	Butanal	7.533	873	C_4H_8O	72	0.01
7	Ethyl acetate	7.833	888	$C_4H_8O_2$	88	0.28
8	3-Methylbutanal	7.433	907	$C_5H_{10}O$	86	0.01
9	2-Propanol	9.217	929	C_3H_8O	60	0.01
10	Ethanol	9.433	942	C_2H_6O	46	0.13
11	2-Ethylfuran	9.958	953	C_6H_8O	96	0.01
12	2,3-Butanedione	10.842	975	$C_4H_6O_2$	86	0.02
13	Pentanal	10.958	978	$C_5H_{10}O$	86	0.06
14	Decane	11.858	1003	$C_{10}H_{22}$	142	0.02
15	2-Methylpropyl acetate	12.525	1013	$C_6H_{12}O_2$	116	0.04
16	2-Butanol	13.283	1033	$C_4H_{10}O$	74	0.04
17	3-Methyl-2-pentanone	14.475	1054	$C_5H_8O_2$	100	0.01
18	2,3-Pentanedione	14.808	1047	$C_5H_8O_2$	100	0.03
19	Butyl acetate	15.700	1075	$C_6H_{12}O_2$	116	0.30
20	Hexanal	16.367	1089	$C_6H_{12}O$	100	29.10

(continued)

21	2-Methylpropanol	16.883	1101	$C_4H_{10}O$	74	0.12
22	3-Pentanol	17.875	1114	$C_5H_{12}O$	88	0.10
23	2-Methylbutyl acetate	18.597	1116	$C_7H_{14}O_2$	130	0.32
24	2-Pentanol	18.683	1122	$C_5H_{12}O$	88	0.33
25	*(E)*-2-Pentenal	18.942	1129	$C_6H_{10}O$	98	0.02
26	*p*-Xylene	19.283	1133	C_8H_{10}	106	0.03
27	2-Methyl-4-pentenal	19.533	1136	$C_6H_{10}O$	98	0.56
28	*m*-Xylene	19.692	1139	C_8H_{10}	106	0.02
29	*(Z)*-3-Hexenal	19.858	1142	$C_6H_{10}O$	98	0.16
30	Butanol	20.233	1153	$C_4H_{10}O$	74	1.03
31	1-Penten-3-ol	21.150	1163	$C_5H_{10}O$	86	0.05
32	Pentyl acetate	21.967	1170	$C_7H_{14}O_2$	130	0.06
33	o -Xylene	22.542	1178	C_8H_{10}	106	1.15
34	*(Z)*-2-Heptenal	23.750	1203	$C_7H_{12}O$	112	0.96
35	3-Methyl-1-butanol	24.500	1217	$C_5H_{12}O$	88	0.16
36	*(E)*-2-Hexenal	25.150	1229	$C_6H_{10}O$	98	29.36
37	2-Pentylfuran	25.833	1238	$C_9H_{14}O$	138	0.02
38	Pentanol	27.400	1259	$C_5H_{12}O$	88	0.11
39	1-Methyl-2-ethylbenzene	27.817	1263	C_9H_{12}	120	0.02
40	Hexyl acetate	28.750	1273	$C_8H_{16}O_2$	144	0.92
I.S.	Butylbenzene	31.758	1318	$C_{10}H_{14}$	134	25.09
41	*(E)*-2-Heptenal	32.142	1321	$C_7H_{12}O$	112	0.08

(continued)

42	*(E)*-2-Hexenyl acetate	32.983	1335	$C_8H_{14}O_2$	142	0.10
43	Hexanol	34.550	1363	$C_6H_{14}O$	102	1.06
44	*(Z)*-2-Phenyl-2-butene	36.333	1375	$C_{10}H_{12}$	132	0.03
45	*(Z)*-3-Hexen-1-ol	36.642	1381	$C_6H_{12}O$	100	0.04
46	Nonanal	37.025	1388	$C_9H_{18}O$	142	0.01
47	(*E,E*)-2,4-Hexadienal	37.575	1405	C_6H_8O	96	0.01
48	(*E*)-2-Hexen-1-ol	38.150	1414	$C_6H_{12}O$	100	0.39
49	Hexyl 2-methylpropylacetate	38.633	1429	$C_{10}H_{20}O_2$	172	0.04
50	(*E*)-2-Octenal	39.458	1437	$C_8H_{14}O$	126	0.01
51	2-Methyl-1-hexanol	39.633	1439	$C_7H_{16}O$	116	0.01
52	Acetic acid	41.233	1455	$C_2H_4O_2$	60	0.02
53	Furfural	41.646	1462	$C_5H_4O_2$	96	0.03
54	Benzaldehyde	45.625	1536	C_7H_6O	106	0.04
55	2-Nonenal	46.592	1550	$C_9H_{16}O$	140	0.03
56	4-Methylbenzaldehyde	51.708	1625	C_8H_8O	120	0.10
57	Phenylacetaldehyde	53.217	1650	C_8H_8O	120	0.03
58	Dodecanal	54.933	1679	$C_{12}H_{24}O$	184	0.01
59	*(E,E)*-2,4-Decadienal	62.742	1824	$C_{10}H_{16}O$	152	0.02
60	β-Damascenone	63.383	1837	$C_{13}H_{18}O$	190	0.01
61	Hexanoic acid	64.533	1860	$C_6H_{12}O_2$	116	0.31
62	β-Ionone	68.350	1947	$C_{13}H_{20}O$	192	0.04
63	Tridecanol	69.192	1960	$C_{13}H_{28}O$	200	0.03

(continued)

64	2-Hexenoic acid	69.550	1965	$C_6H_{10}O_2$	114	0.06
65	*o*-Methylbenzyl alcohol	70.142	1981	$C_8H_{10}O$	122	0.19
66	Unknown	73.475	2113			0.27
67	Tetradecanol	75.650	2131	$C_{14}H_{30}O$	214	0.01
	Total					94.22

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

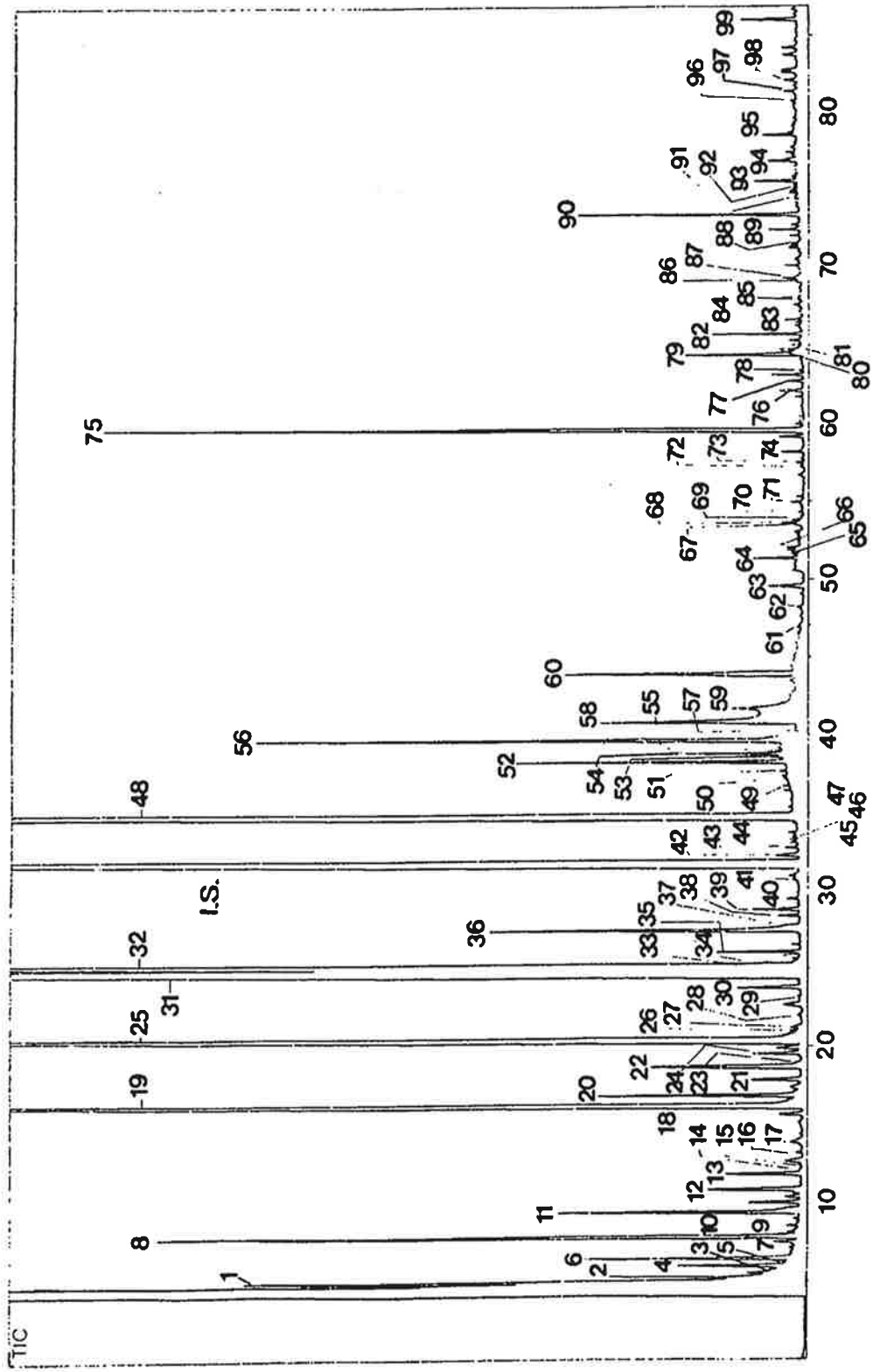

Fig. 10. GC chromatogram of volatile flavor components in Jonathan apple

Table 13. Volatile flavor components in Jonathan apple

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Acetaldehyde	4.958	696	C_2H_4O	44	1.22
2	Ethyl 2-methylpropyl ether	5.275	726	$C_6H_{14}O$	102	0.04
3	Propanal	5.892	784	C_3H_6O	58	0.02
4	Ethyl butyl ether	6.000	794	$C_6H_{14}O$	102	0.26
5	2-Propanone	6.297	812	C_3H_6O	58	0.01
6	Ethyl formate	6.467	823	$C_3H_6O_2$	74	0.66
7	Butanal	7.542	875	C_4H_8O	72	0.04
8	Ethyl acetate	7.850	892	$C_4H_8O_2$	88	2.59
9	2-Methylbutanal	8.583	908	$C_5H_{10}O$	86	0.02
10	3-Methylbutanal	8.700	914	$C_5H_{10}O$	86	0.01
11	Ethanol	9.458	943	C_2H_6O	46	0.86
12	2-Pentanone	10.950	979	$C_5H_{10}O$	86	0.40
13	Decane	11.950	1007	$C_{10}H_{22}$	142	0.25
14	2-Methylpentanal	12.133	1011	$C_6H_{12}O$	100	0.01
15	2-Methylpropyl acetate	12.542	1018	$C_6H_{12}O_2$	116	0.01
16	2-Butanol	13.300	1033	$C_4H_{10}O$	74	0.02
17	Propanol	13.975	1045	C_3H_8O	60	0.03
18	Butyl acetate	15.742	1071	$C_6H_{12}O_2$	116	0.11
19	Hexanal	16.350	1086	$C_6H_{12}O$	100	7.74
20	2-Methylpropanol	16.925	1097	$C_4H_{10}O$	74	0.65

(continued)

21	3-Pentanol	17.908	1116	$C_5H_{12}O$	88	0.18
22	2-Pentanol	18.729	1130	$C_5H_{12}O$	88	0.77
23	(*E*)-2-Pentenal	18.958	1134	C_5H_8O	84	0.02
24	2-Methyl-4-pentenal	19.550	1142	$C_6H_{10}O$	98	0.16
25	Butanol	20.525	1158	$C_4H_{10}O$	74	9.67
26	3-Heptanone	20.808	1166	$C_7H_{14}O$	114	0.01
27	1-Penten-3-ol	21.208	1172	$C_5H_{10}O$	86	0.02
28	Pentyl acetate	22.025	1185	$C_7H_{14}O_2$	130	0.01
29	Pentyl propanoate	23.225	1199	$C_8H_{16}O$	144	0.01
30	(*Z*)-3-Hexenal	23.792	1203	$C_6H_{10}O$	98	0.26
31	3-Methyl-1-butanol	24.942	1226	$C_5H_{12}O$	88	18.43
32	*(E)*-2-Hexenal	25.286	1229	$C_6H_{10}O$	98	9.04
33	Hexyl formate	25.458	1229	$C_7H_{14}O_2$	130	0.03
34	2-Pentylfuran	25.950	1235	$C_9H_{14}O$	138	0.01
35	Butyl 2-methylbutanoate	26.100	1236	$C_9H_{18}O_2$	158	0.22
36	Pentanol	27.500	1260	$C_5H_{12}O$	88	1.32
37	Ethylhexylacetal	27.792	1263	$C_{10}H_{22}O_2$	174	0.01
38	3,3-Dimethyl-2-hexanone	28.433	1271	$C_8H_{16}O$	144	0.05
39	Hexyl acetate	28.850	1276	$C_8H_{16}O_2$	144	0.17
40	2-Methylbutyl 2-methylbutanoate	29.517	1287	$C_{10}H_{20}O_2$	172	0.03
41	3-Heptanol	30.758	1302	$C_7H_{16}O$	116	0.02
I.S.	Butylbenzene	31.973	1316	$C_{10}H_{14}$	134	14.06

(continued)

42	4-Methyl-3-heptanone	32.267	1321	$C_8H_{16}O$	128	0.11
43	Pentyl 3-methylbutanoate	32.767	1329	$C_{10}H_{20}O_2$	172	0.04
44	2-Phenylpropanal	33.108	1336	$C_9H_{10}O$	134	0.02
45	6-Methyl-5-hepten-2-one	33.250	1345	$C_8H_{14}O$	126	0.01
46	Hexyl propanoate	33.475	1350	$C_9H_{18}O_2$	158	0.02
47	Hexyl 2-methylpropanoate	33.742	1354	$C_{10}H_{20}O_2$	172	0.03
48	Hexanol	34.942	1371	$C_6H_{14}O$	158	13.57
49	*(Z)*-3-Hexen-1-ol	36.725	1393	$C_6H_{12}O$	100	0.02
50	Nonanal	37.142	1398	$C_9H_{18}O$	142	0.02
51	5-Methylindan	37.325	1400	$C_{10}H_{12}O$	132	0.02
52	(*E*)-2-Hexen-1-ol	38.233	1416	$C_6H_{12}O$	100	0.91
53	Butyl hexanoate	38.567	1423	$C_{10}H_{20}O_2$	172	0.05
54	Heptyl butanoate	38.758	1433	$C_{11}H_{22}O_2$	186	0.27
55	2,4-Dimethyl-4-heptanol	38.933	1439	$C_9H_{20}O$	144	0.02
56	Hexyl 2-methylbutanoate	39.658	1440	$C_{11}H_{22}O_2$	186	1.98
57	2,6-Diemthyl-2-octanol	39.775	1441	$C_{10}H_{22}O$	116	0.03
58	Acetic acid	40.753	1450	$C_2H_4O_2$	60	0.87
59	Furfural	41.658	1469	$C_5H_4O_2$	96	0.09
60	2-Ethyl-1-hexanol	43.942	1495	$C_8H_{18}O$	130	0.61
61	(*E*)-2-Nonenal	46.950	1549	$C_9H_{16}O$	140	0.01
62	Octanol	48.233	1565	$C_8H_{18}O$	130	0.01
63	Dimethyl sulfoxide	49.583	1581	C_2H_6OS	78	0.16

(continued)

64	Hexyl hexanoate	51.358	1611	$C_{12}H_{24}O_2$	200	0.13
65	Butyl octanoate	51.558	1615	$C_{12}H_{24}O_2$	200	0.01
66	Hexyl 2-methyl-1-butenoate	52.050	1627	$C_{11}H_{20}O_2$	184	0.03
67	α-Himachalene	53.483	1650	$C_{15}H_{24}$	204	0.01
68	1-Nonen-4-ol	53.617	1656	$C_9H_{18}O$	142	0.05
69	Acetophenone	53.687	1657	C_8H_8O	120	0.05
70	3-Methylbutyl octanoate	54.308	1661	$C_{13}H_{26}O_2$	214	0.01
71	Estragole	54.975	1666	$C_{10}H_{12}O$	148	0.04
72	Butyl 3-hydroxybutanoate	57.267	1705	$C_8H_{16}O_3$	160	0.01
73	β-Himachalene	57.767	1714	$C_{15}H_{24}$	204	0.01
74	(*Z*,*E*)-α-Farnesene	58.225	1722	$C_{15}H_{24}$	204	0.06
75	(*E*,*E*)-α-Farnesene	59.683	1747	$C_{15}H_{24}$	204	3.01
76	Butyrophenone	62.125	1796	$C_{10}H_{12}O$	148	0.07
77	(*E*,*E*)-2,4-Decadienal	62.742	1805	$C_{10}H_{16}O$	152	0.05
78	β-Damascenone	63.417	1825	$C_{13}H_{18}O$	190	0.01
79	Hexanoic acid	64.375	1855	$C_6H_{12}O_2$	116	0.46
80	Geranylacetone	64.758	1866	$C_{13}H_{22}O$	194	0.03
81	3-Methylbutyl decanoate	65.050	1875	$C_{15}H_{30}O_2$	242	0.01
82	Unknown	65.725	1893			0.20
83	Dimethyl sulfone	66.692	1919	$C_2H_6O_2S$	94	0.01
84	4-Phenyl-3-buten-2-one	67.642	1931	$C_{10}H_{10}O$	146	0.03
85	Denderalasin	67.992	1934	$C_{15}H_{22}O$	218	0.01

(continued)

86	Dodecanol	69.217	1975	$C_{12}H_{26}O$	186	0.02
87	1-Phenyl-1-butanol	69.367	1978	$C_{10}H_{14}O$	150	0.05
88	Isopropyl tetradecanoate	71.500	2037	$C_{17}H_{34}O_2$	270	0.02
89	3-Methylbutyl dodecanoate	72.517	2047	$C_{17}H_{34}O_2$	270	0.07
90	Unknown	73.500	2096			0.50
91	Neopentyl benzoate	74.617	2151	$C_{12}H_{16}O_2$	192	0.03
92	γ-Decalactone	75.217	2169	$C_{10}H_{18}O_2$	170	0.01
93	Tetradecanol	75.692	2183	$C_{14}H_{30}O$	214	0.13
94	Methyl hexadecanoate	76.967	2211	$C_{17}H_{34}O_2$	270	0.07
95	3-Methylbutyl tetradecanoate	78.625	2279	$C_{19}H_{38}O_2$	298	0.07
96	α-Sinensal	80.808	2372	$C_{15}H_{22}O$	218	0.01
97	*(E,E)*-Farnesol	81.450	2390	$C_{15}H_{26}O$	222	0.03
98	Hexadecanol	82.158	2413	$C_{16}H_{34}O$	326	0.04
99	3-Methylbutyl hexadecanoate	85.067	2493	$C_{21}H_{44}O_2$	326	0.01
100	Octadecanol	91.267	2589	$C_{18}H_{38}O$	270	0.01
	Total					93.68

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

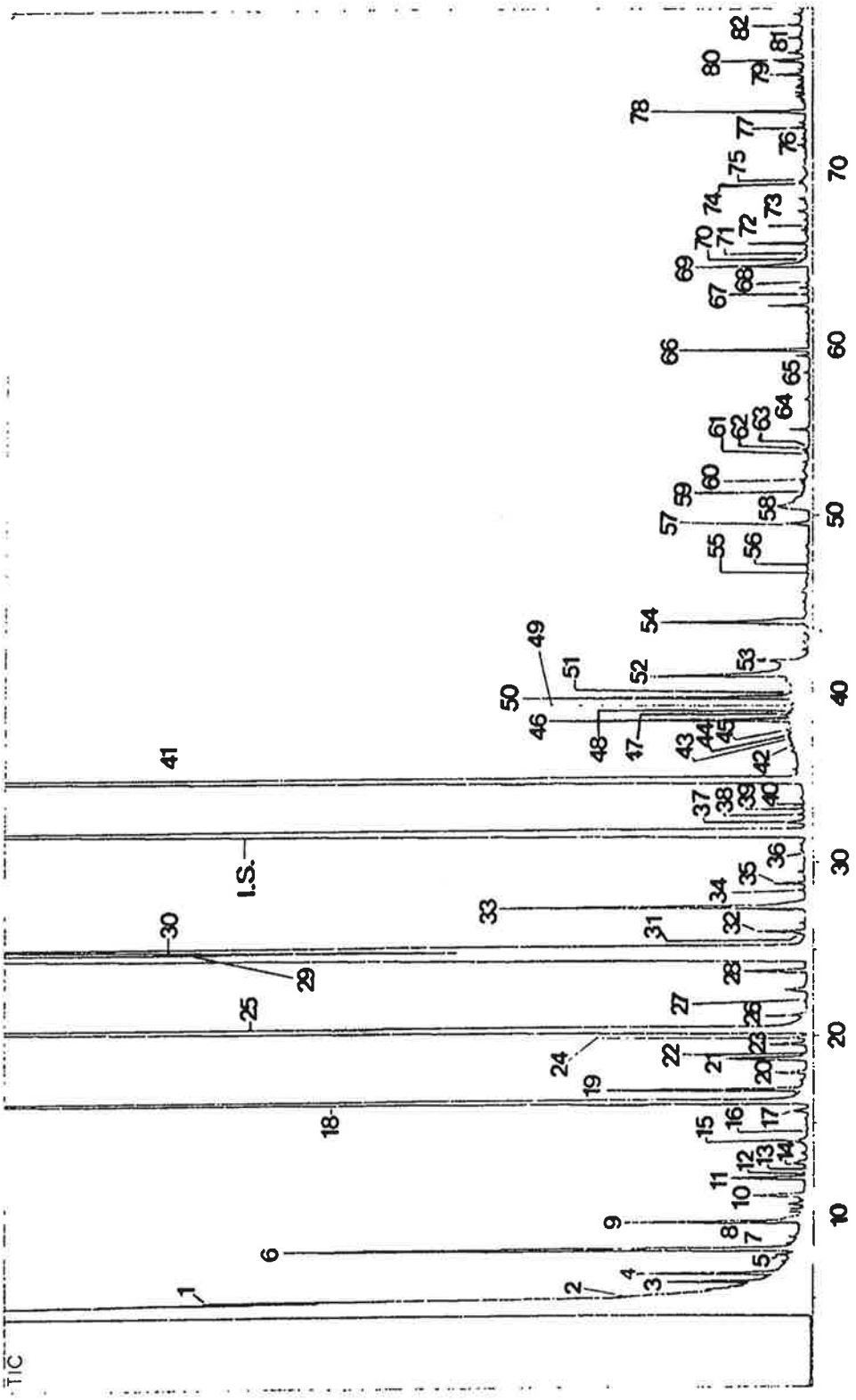

Fig. 11. GC chromatogram of volatile flavor components in Honglo apple

Table 14. Volatile flavor components in Honglo apple

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Propyl ethyl ether	4.950	697	$C_5H_{12}O$	88	0.80
2	Ethyl 2-methylpropyl ether	5.267	727	$C_6H_{14}O$	102	0.01
3	Butyl ethyl ether	5.992	795	$C_6H_{14}O$	102	0.28
4	Ethyl formate	6.458	824	$C_3H_6O_2$	74	0.48
5	Butanal	7.533	885	C_4H_8O	72	0.06
6	Ethyl acetate	7.842	892	$C_4H_8O_2$	88	2.43
7	2-Methylbutanal	8.567	916	$C_5H_{10}O$	86	0.02
8	3-Methylbutanal	8.717	920	$C_5H_{10}O$	86	0.01
9	Ethanol	9.442	944	C_2H_6O	46	0.72
10	Pentanal	10.958	981	$C_5H_{10}O$	86	0.29
11	Decane	11.933	1007	$C_{10}H_{22}$	142	0.34
12	2-Methylpentanal	12.142	1011	$C_6H_{12}O_2$	116	0.01
13	2-Methylpropyl acetate	12.533	1019	$C_6H_{12}O_2$	116	0.01
14	2-Butanol	13.292	1034	$C_4H_{10}O$	74	0.02
15	Propanol	13.950	1046	C_3H_8O	60	0.08
16	3-Hexanone	14.517	1054	$C_6H_{12}O$	100	0.01
17	Butyl acetate	15.717	1071	$C_6H_{12}O_2$	116	0.08
18	Hexanal	16.333	1083	$C_6H_{12}O$	100	9.21
19	2-Methylpropanol	16.917	1101	$C_4H_{10}O$	74	0.86
20	3-Pentanol	17.892	1118	$C_5H_{12}O$	88	0.14

(continued)

21	2-Methylbutyl acetate	18.717	1129	$C_7H_{14}O_2$	130	0.51
22	(*E*)-2-Pentenal	18.958	1131	C_5H_8O	84	0.01
23	2-Methyl-4-pentenal	19.550	1136	$C_6H_{10}O$	98	0.16
24	(*Z*)-3-Hexenal	19.883	1145	$C_6H_{10}O$	98	0.07
25	Butanol	20.533	1163	$C_4H_{10}O$	74	13.36
26	1-Penten-3-ol	21.208	1177	$C_5H_{10}O$	86	0.05
27	Pentyl acetate	22.027	1186	$C_7H_{14}O_2$	130	0.01
28	(*Z*)-2-Heptenal	23.773	1203	$C_7H_{12}O$	112	0.32
29	3-Methyl-1-butanol	24.883	1233	$C_5H_{12}O$	88	20.98
30	*(E)*-2-Hexenal	25.229	1237	$C_6H_{10}O$	98	9.74
31	2-Pentylfuran	25.925	1245	$C_9H_{14}O$	138	0.02
32	Butyl 2-methylbutanoate	26.067	1599	$C_9H_{18}O_2$	158	0.16
33	Pentanol	27.483	1263	$C_5H_{12}O$	88	1.67
34	3,3-Dimethyl-2-hexanone	28.417	1275	$C_8H_{16}O$	144	0.02
35	Hexyl acetate	28.800	1280	$C_8H_{16}O_2$	144	0.14
36	3-Heptanol	30.758	1306	$C_7H_{16}O$	116	0.02
I.S.	Butylbenzene	31.883	1321	$C_{10}H_{14}$	134	13.90
37	2-Octanone	32.258	1330	$C_8H_{16}O$	128	0.11
38	Pentyl 3-methylbutanoate	32.708	1341	$C_{10}H_{20}O_2$	172	0.03
39	2-Phenylpropanal	33.075	1349	$C_9H_{10}O$	134	0.02
40	6-Methyl-5-hepten-2-one	33.233	1353	$C_8H_{14}O$	126	0.01
41	Hexanol	34.758	1376	$C_6H_{14}O$	158	12.80

(continued)

42	(*Z*)-3-Hexenol	36.692	1400	$C_6H_{12}O$	100	0.01
43	Nonanal	37.133	1406	$C_9H_{18}O$	142	0.01
44	5-Methylindan	37.333	1408	$C_{10}H_{12}$	132	0.02
45	3-Heptenyl acetate	37.583	1411	$C_9H_{16}O_2$	156	0.03
46	(*E*)-2-Hexenol	38.208	1419	$C_6H_{12}O$	100	1.00
47	Butyl hexanoate	38.500	1423	$C_{10}H_{20}O_2$	172	0.04
48	Heptyl 2-methylpropanoate	38.692	1425	$C_{11}H_{22}O_2$	186	0.02
49	2,4-Dimethyl-4-heptanol	38.850	1427	$C_9H_{20}O$	144	0.01
50	Hexyl 2-methylbutanoate	39.533	1435	$C_{11}H_{22}O_2$	186	1.07
51	2,3-Dimethyl-2-pentanol	39.717	1437	$C_7H_{16}O$	116	0.02
52	Acetic acid	40.767	1449	$C_2H_4O_2$	60	0.89
53	Furfural	41.658	1465	$C_5H_4O_2$	96	0.05
54	2-Ethyl-1-hexanol	43.867	1505	$C_8H_{18}O$	130	0.63
55	2-Nonenal	46.667	1548	$C_9H_{16}O$	140	0.01
56	Octanol	48.208	1564	$C_8H_{18}O$	130	0.01
57	Dimethyl sulfide	49.533	1578	C_2H_6OS	78	0.15
58	1,2-Propanediol	50.544	1599	$C_3H_8O_2$	76	0.21
59	Hexyl hexanoate	51.333	1615	$C_{12}H_{24}O_2$	200	0.01
60	Hexyl 2-methyl-2-butenoate	52.025	1625	$C_{11}H_{20}O_2$	184	0.03
61	1-Nonen-4-ol	53.583	1647	$C_9H_{18}O$	142	0.01
62	Acetophenone	53.775	1650	C_8H_8O	120	0.03
63	3-Methylbutyl octanoate	54.308	1657	$C_{13}H_{26}O_2$	214	0.01

(continued)

64	Estragole	54.950	1666	$C_{10}H_{12}O$	148	0.07
65	(*Z*,*E*)-α-Farnesene	58.192	1722	$C_{15}H_{24}$	204	0.02
66	(*E*,*E*)-α-Farnesene	59.517	1745	$C_{15}H_{24}$	204	0.47
67	(*E*,*E*)-2,4-Decadienal	62.742	1820	$C_{10}H_{16}O$	152	0.03
68	β-Damascenone	63.392	1835	$C_{13}H_{18}O$	190	0.01
69	Hexanoic acid	64.358	1856	$C_6H_{12}O_2$	116	0.58
70	Geranylacetone	64.742	1865	$C_{13}H_{22}O$	194	0.01
71	3-Methylbutyl decanoate	65.042	1872	$C_{15}H_{30}O_2$	242	0.01
72	Unknown	67.708	1888			0.03
73	Dimethyl sulfone	66.658	1920	$C_2H_6O_2S$	94	0.01
74	Tridecanol	69.208	1978	$C_{13}H_{28}O$	200	0.02
75	Isopropylbenzyl alcohol	69.358	1983	$C_{10}H_{14}O$	150	0.03
76	Methylethyl tetradecanoate	71.475	2052	$C_{17}H_{34}O_2$	270	0.02
77	3-Methylbutyl dodecanoate	72.492	2083	$C_{17}H_{34}O_2$	270	0.05
78	Unknown	73.475	2113			0.45
79	Tetradecanol	75.667	2175	$C_{14}H_{30}O$	214	0.12
80	Methyl hexadecanoate	76.950	2258	$C_{17}H_{34}O_2$	270	0.04
81	Pentadecanol	77.883	2275	$C_{15}H_{32}O$	228	0.04
82	3-Methylbutyl tetradecanoate	78.608	2284	$C_{19}H_{38}O_2$	298	0.04
	Total					96.29

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

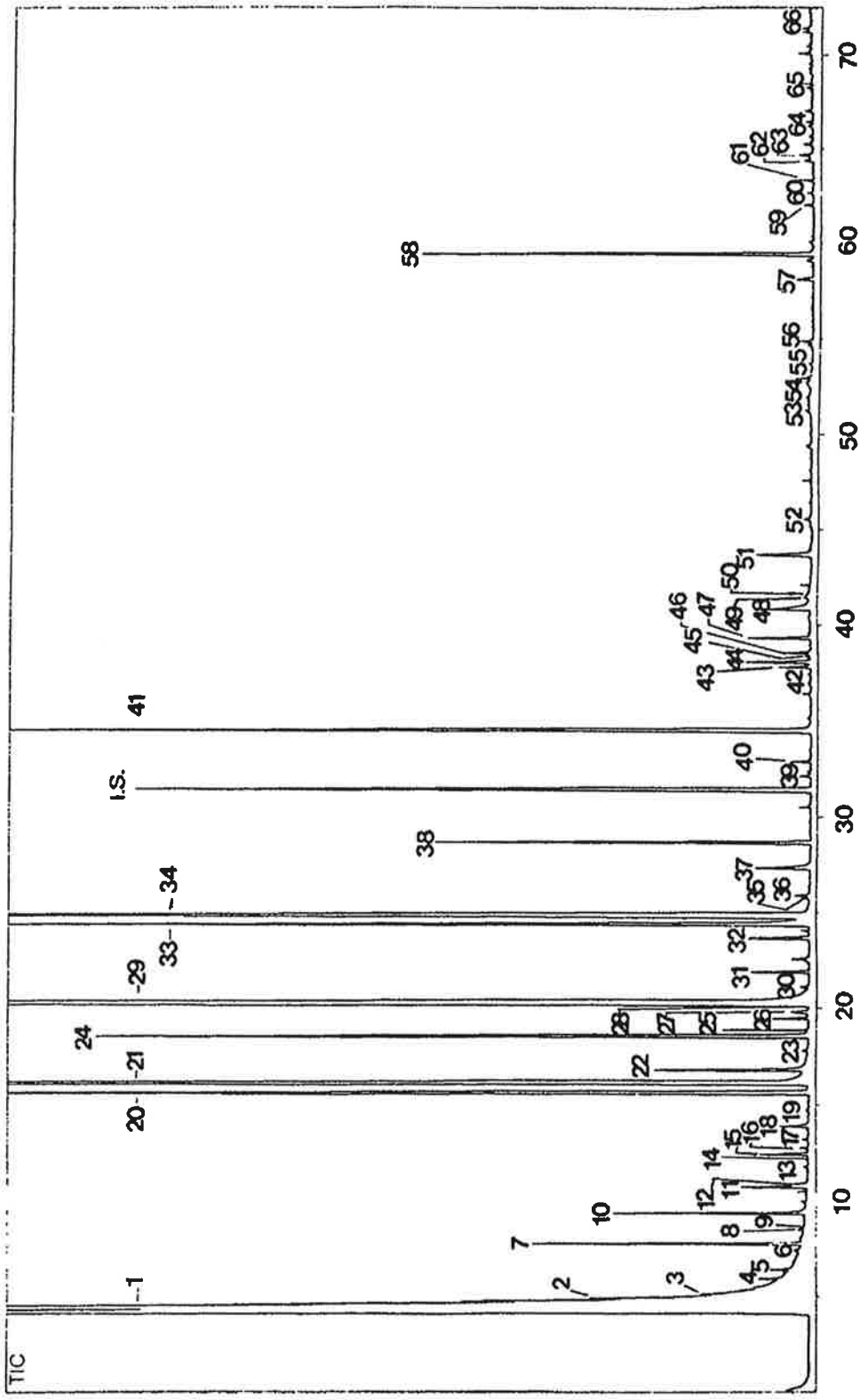

Fig. 12. GC chromatogram of volatile flavor components in Hahyang apple

Table 15. Volatile flavor components in Hahyang apple

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Isopropyl ethyl ether	4.667	522	$C_5H_{12}O$	88	0.33
2	Propyl ethyl ether	4.942	699	$C_5H_{12}O$	88	0.14
3	Ethyl 2-methylpropyl ether	5.242	794	$C_6H_{14}O$	102	0.01
4	2-Propanone	6.275	817	C_3H_6O	58	0.01
5	Ethyl formate	6.433	820	$C_3H_6O_2$	74	0.08
6	Butanal	7.492	857	C_4H_8O	72	0.02
7	Ethyl acetate	7.800	868	$C_4H_8O_2$	88	1.06
8	2-Methylbutanal	8.525	906	$C_5H_{10}O$	86	0.02
9	3-Methylbutanal	8.658	911	$C_5H_{10}O$	86	0.01
10	Ethanol	9.400	941	C_2H_6O	46	0.98
11	Propyl acetate	10.775	973	$C_5H_{10}O_2$	102	0.30
12	Pentanal	10.908	977	$C_5H_{10}O$	86	0.16
13	Decane	11.833	998	$C_{10}H_{22}$	96	0.01
14	3-Methyl-2-pentanone	12.167	1006	$C_6H_{12}O$	100	0.01
15	2-Methylpropyl acetate	12.475	1013	$C_6H_{12}O_2$	116	0.22
16	1-Penten-3-one	12.792	1020	C_5H_8O	84	0.04
17	2-Butanol	13.308	1025	$C_4H_{10}O$	74	0.03
18	Propanol	13.917	1032	C_3H_8O	60	0.18
19	2,3-Pentanedione	14.758	1058	$C_5H_8Oc_2$	100	0.01
20	Butyl acetate	15.700	1075	$C_6H_{12}O_2$	116	8.61

(continued)

21	Hexanal	16.233	1085	$C_6H_{12}O$	100	14.69
22	2-Methylpropanol	16.833	1100	$C_4H_{10}O$	74	0.91
23	3-Pentanol	17.817	1115	$C_5H_{12}O$	88	0.02
24	2-Methylbutyl acetate	18.592	1123	$C_7H_{14}O_2$	130	4.65
25	*(E)*-2-Pentenal	18.883	1129	C_5H_8O	84	0.03
26	2-Methyl-4-pentenal	19.467	1136	$C_6H_{10}O$	98	0.21
27	*p*-Xylene	19.633	1139	C_8H_{10}	106	0.01
28	*(Z)*-3-Hexenal	19.808	1142	$C_6H_{10}O$	98	0.13
29	Butanol	20.400	1158	$C_4H_{10}O$	74	23.42
30	1-Penten-3-ol	21.117	1166	$C_5H_{10}O$	86	0.03
31	Pentyl acetate	21.908	1174	$C_7H_{14}O_2$	130	0.31
32	*(Z)*-2-Heptenal	23.667	1191	$C_7H_{12}O$	112	0.36
33	3-Methyl-1-butanol	24.433	1202	$C_5H_{12}O$	88	6.45
34	*(E)*-2-Hexenal	24.968	1218	$C_6H_{10}O$	98	13.09
35	2-Pentylfuran	25.767	1226	$C_9H_{14}O$	138	0.03
36	Butyl 2-methylbutanoate	25.900	1231	$C_9H_{18}O_2$	158	0.07
37	Pentanol	27.342	1258	$C_5H_{12}O$	88	0.52
38	Hexyl acetate	28.700	1272	$C_8H_{16}O_2$	144	2.23
I.S.	Butylbenzene	31.484	1307	$C_{10}H_{14}$	134	5.69
39	*(Z)*-3-Hexenyl acetate	32.358	1328	$C_8H_{14}O_2$	142	0.03
40	*(E)*-2-Hexenyl acetate	32.883	1333	$C_8H_{14}O_2$	142	0.12
41	Hexanol	34.550	1363	$C_6H_{14}O$	158	7.04

(continued)

42	Nonanal	36.967	1398	$C_9H_{18}O$	142	0.01
43	2-Butoxyethanol	37.825	1410	$C_6H_{14}O_2$	118	0.22
44	*(E)*-2-Hexen-1-ol	38.083	1414	$C_6H_{12}O$	100	0.47
45	Butyl hexanoate	38.383	1422	$C_{10}H_{20}O_2$	172	0.04
46	Heptyl 2-methylpropanoate	38.558	1426	$C_{11}H_{22}O_2$	186	0.14
47	Hexyl 2-methylbutanoate	39.342	1436	$C_{11}H_{22}O_2$	186	0.39
48	Acetic acid	40.842	1454	$C_2H_4O_2$	60	0.44
49	2-Butoxyethyl acetate	41.452	1463	$C_8H_{16}O_3$	160	0.05
50	Furfural	41.558	1468	$C_5H_4O_2$	96	0.01
51	2-Ethyl-1-hexanol	43.700	1497	$C_8H_{18}O$	130	0.52
52	Benzaldehyde	45.558	1519	C_7H_6O	106	0.03
53	Hexyl hexanoate	51.242	1612	$C_{12}H_{24}O_2$	200	0.02
54	Hexyl 2-methyl-2-butenoate	51.933	1624	$C_{11}H_{20}O_2$	184	0.01
55	Acetophenone	53.687	1653	C_8H_8O	120	0.03
56	Estragole	54.867	1666	$C_{10}H_{12}O$	148	0.09
57	*(Z,E)*-α-Farnesene	58.117	1721	$C_{15}H_{24}$	204	0.11
58	*(E,E)*-α-Farnesene	59.467	1745	$C_{15}H_{24}$	204	2.62
59	Butyrophenone	62.024	1799	$C_{10}H_{12}O$	148	0.05
60	*(E,E)*-2,4-Decadienal	62.667	1813	$C_{10}H_{16}O$	152	0.03
61	β-Damascenone	63.325	1827	$C_{13}H_{18}O$	190	0.05
62	Hexanoic acid	64.367	1850	$C_6H_{12}O_2$	116	0.07
63	Nerylacetone	64.667	1856	$C_{13}H_{22}O$	194	0.09

(continued)

64	Farnesol	66.200	1902	$C_{15}H_{26}O$	222	0.03
65	β-Ionone	68.283	1958	$C_{13}H_{20}O$	192	0.01
66	Isopropyl tetradecanoate	71.425	2049	$C_{17}H_{34}O_2$	270	0.05
	Total					97.85

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 16. Relative content of functional groups in Apples

Peak area%

Functional group	Fugi	Tsugaru	Honglo	Jonathan	Hahyang
Aldehydes	8.75	60.61	20.02	18.75	28.8
Alcohols	48.1	3.81	52.88	47.5	40.91
Esters	21.29	2.11	1.09	6.7	18.38
Terpenes	1.05	-	0.49	3.09	2.73
Acids	1.12	0.39	1.47	1.33	0.51
Ethers	0.03	0.52	1.09	0.3	0.48
Ketones	1.32	0.11	0.2	0.79	0.3
Miscellaneous	0.28	1.31	0.54	0.46	0.05
T o t a l	81.94	68.86	77.78	78.92	92.16

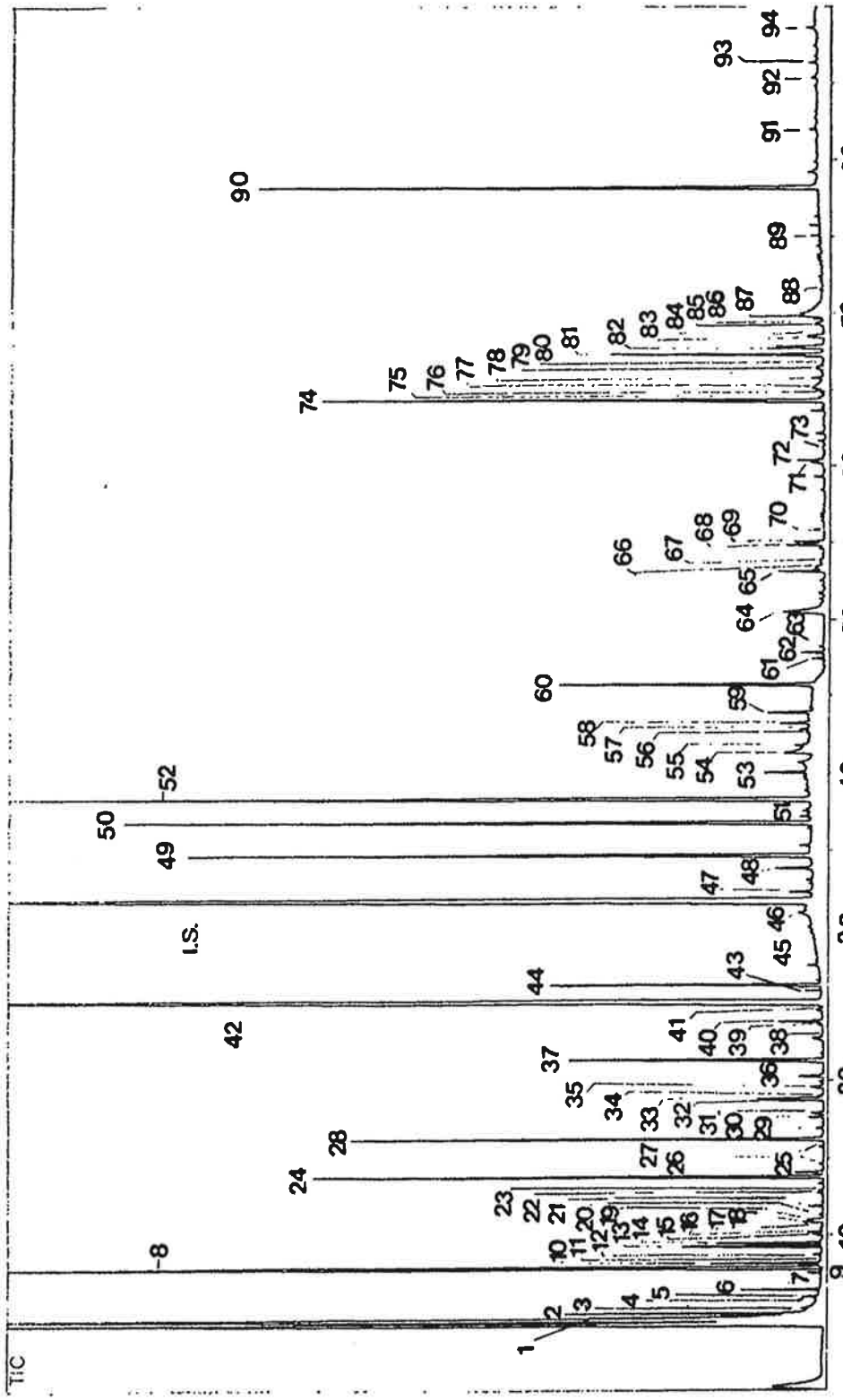

Fig. 13. GC chromatogram of volatile flavor components in Neomuscat grape

Table 17. Volatile flavor components in Neomuscat grape

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropylether	4.708	530	$C_5H_{12}O$	88	1.01
2	Acetaldehyde	4.983	696	C_2H_4O	44	1.05
3	sec-Butyl ethyl ether	5.292	708	$C_6H_{14}O$	102	0.04
4	Propanal	5.925	779	C_3H_6O	58	0.01
5	Octane	6.042	792	C_8H_{18}	114	0.05
6	Ethyl formate	6.492	821	$C_3H_6O_2$	74	0.29
7	Butanal	7.592	875	$C_4H_8O_2$	72	0.06
8	Ethyl acetate	7.942	894	$C_4H_8O_2$	88	11.33
9	Diethylacetal	8.042	899	$C_6H_{14}O_2$	118	0.04
10	Isopropyl acetate	8.192	907	$C_5H_{10}O_2$	102	0.39
11	2-Methylbutanal	8.608	914	$C_5H_{10}O$	86	0.01
12	3-Methylbutanal	8.750	917	$C_5H_{10}O$	86	0.04
13	2-Propanol	9.275	936	C_3H_8O	60	0.60
14	Ethanol	9.492	943	C_2H_6O	46	0.47
15	2-Ethylfuran	10.008	952	$C_5H_{10}O_2$	96	0.03
16	Ethyl propanoate	10.208	955	$C_5H_{10}O_2$	102	0.06
17	Propyl acetate	10.875	978	$C_5H_{10}O_2$	102	0.09
18	2-Pentanone	10.975	980	$C_5H_{10}O$	86	0.05
19	Pentanal	11.017	981	$C_5H_{10}O_2$	86	0.08
20	Methyl butanoate	11.333	987	$C_5H_{10}O_2$	102	0.01

(continued)

21	Decane	11.892	999	$C_{10}H_{10}O_2$	142	0.06
22	1-Penten-3-one	12.900	1018	C_5H_8O	84	0.01
23	2-Butanol	13.350	1027	$C_4H_{10}O$	74	0.03
24	Ethyl butanoate	13.808	1036	$C_5H_{12}O_2$	116	2.67
25	2-Methyl-3-buten-2-ol	14.092	1047	$C_5H_{10}O$	86	0.16
26	Ethyl 2-methylbutanoate	14.642	1051	$C_7H_{14}O_2$	130	0.01
27	Butyl acetate	15.750	1072	$C_6H_{12}O_2$	116	0.01
28	Hexanal	16.258	1082	$C_6H_{12}O$	100	2.68
29	2-Methylpropanol	16.950	1100	$C_4H_{10}O$	70	0.04
30	Methyl *(E)*-2-butenoate	17.650	1107	$C_5H_8O_2$	100	0.08
31	Propyl isopropyl ether	17.883	1115	$C_6H_{14}O$	102	0.09
32	2-Pentanol	18.767	1128	$C_5H_{12}O$	88	0.38
33	3-Penten-2-one	18.825	1128	C_5H_8O	84	0.33
34	*(E)*-2-Pentenal	19.008	1130	C_5H_8O	84	0.04
35	2-Methyl-4-pentenal	19.583	1136	$C_6H_{10}O$	98	0.10
36	Butanol	20.300	1152	$C_4H_{10}O$	74	0.15
37	Ethyl 2-butenoate	21.342	1163	$C_6H_{10}O_2$	114	1.68
38	Methyl hexanoate	22.933	1194	$C_7H_{14}O_2$	130	0.01
39	α-Limonene	23.633	1201	$C_{10}H_{16}$	136	0.03
40	*(Z)*-3-Hexenal	23.825	1203	$C_6H_{10}O$	98	0.29
41	3-Methyl-1-butanol	24.617	1215	$C_5H_{12}O$	88	0.05
42	*(E)*-2-Hexenal	25.167	1224	$C_6H_{10}O$	98	14.84

(continued)

43	2-Pentylfuran	25.917	1232	$C_9H_{14}O$	138	0.01
44	Ethyl hexanoate	26.208	1235	$C_8H_{16}O_2$	144	1.70
45	Pentanol	27.492	1259	$C_5H_{12}O$	88	0.06
46	Ethyl *(Z)*-3-hexenoate	30.958	1308	$C_8H_{14}O_2$	142	0.01
I.S.	Butylbenzene	31.854	1313	$C_{10}H_{14}$	134	18.09
47	*(Z)*-2-Penten-1-ol	32.308	1329	$C_5H_{10}O$	86	0.14
48	Ethyl 2-hexenoate	33.875	1346	$C_6H_{14}O_2$	142	0.23
49	Hexanol	34.725	1365	$C_6H_{14}O_2$	102	5.04
50	*(Z)*-3-Hexen-1-ol	36.842	1395	$C_6H_{12}O$	100	5.88
51	Nonanal	37.233	1398	$C_9H_{18}O$	142	0.05
52	*(E)*-2-Hexen-1-ol	38.367	1418	$C_6H_{12}O$	100	8.04
53	Ethyl octanoate	40.050	1436	$C_{10}H_{20}O_2$	172	0.25
54	Acetic acid	41.267	1454	$C_2H_4O_2$	60	0.21
55	Furfural	41.767	1477	$C_5H_4O_2$	96	0.05
56	Linalool oxide	42.600	1489	$C_{10}H_{18}O_2$	170	0.01
57	Ethyl *(Z)*-4-octenoate	42.817	1492	$C_{10}H_{18}O_2$	170	0.04
58	Methyl hydroxyhexanoate	43.217	1500	$C_7H_{14}O_3$	146	0.20
59	2-Ethyl-1-hexanol	43.892	1509	$C_8H_{18}O$	130	0.29
60	Ethyl 3-hydroxybutanoate	45.717	1533	$C_{10}H_{18}O$	132	1.97
61	Linalool	47.447	1550	$C_{10}H_{18}O$	154	0.08
62	Ethyl-2-octenoate	47.867	1554	$C_{10}H_{18}O$	170	0.14
63	Octanol	48.258	1564	$C_8H_{18}O$	130	0.01

(continued)

64	1,2-Propanediol	50.533	1604	$C_3H_8O_2$	76	0.58
65	Ethyl decanoate	53.150	1651	$C_{12}H_{24}O_2$	200	0.28
66	Benzenacetaldehyde	53.333	1653	C_8H_8O	120	0.01
67	Acetophenone	53.892	1658	C_8H_8O	120	0.01
68	Ethyl *(Z)*-4-decenoate	54.867	1665	$C_{12}H_{22}O_2$	198	0.30
69	*p*-Allylanisole	55.069	1667	$C_8H_{16}O_3$	148	0.21
70	Ethyl 3-hydroxyhexanoate	55.800	1681	$C_8H_{16}O_3$	160	0.09
71	5-Hexen-2-ol	60.233	1764	$C_6H_{12}O$	100	0.08
72	Ethyl *(E)*-2-decenoate	60.375	1764	$C_{12}H_{22}O_2$	198	0.16
73	Ethyl phenylacetate	61.658	1791	$C_{10}H_{12}O_2$	164	0.01
74	Ethyl *(E,Z)*-2,4-decadienoate	64.367	1853	$C_{12}H_{20}O_2$	196	3.72
75	Nerol	64.583	1858	$C_{10}H_{18}O$	154	0.04
76	2.3-Dimethyl-3-phenylbutane	64.833	1865	$C_{12}H_{12}O_2$	162	0.01
77	Hexanoic acid	65.183	1874	$C_6H_{12}O_2$	116	0.01
78	Benzyl alcohol	65.858	1891	C_7H_8O	108	0.01
79	Ethyl-3-hydroxyhexanoate	66.383	1905	$C_8H_{16}O_3$	160	0.04
80	Dimethyl sulfone	66.758	1914	$C_2H_6O_2S$	94	0.01
81	Phenethyl alcohol	67.342	1929	$C_8H_{10}O$	122	1.44
82	Methyl 9,12,15-octadecatrienoate	67.750	1936	$C_{19}H_{32}O_2$	292	0.14
83	β-Ionone	68.450	1951	$C_{13}H_{20}O$	192	0.10
84	β-Quinoline	68.567	1951	C_9H_7N	129	0.11
85	Dodecanol	69.267	1961	$C_{12}H_{26}O$	186	0.03

(continued)

86	1-Phenyl-1-butanol	69.400	1962	$C_{10}H_{14}O$	150	0.03
87	2-Hexenoic acid	69.808	1981	$C_6H_{10}O_2$	114	0.32
88	Isopropyl tetradecanoate	71.558	2039	$C_{17}H_{34}O_2$	270	0.01
89	Diethyl succinate	75.075	2158	$C_8H_{14}O_4$	174	0.05
90	Unknown	78.183	2254			4.35
91	1,6-Diethyl hexanedioate	82.050	2365	$C_{10}H_{18}O_4$	202	0.04
92	Ethyl octadecanoate	85.400	2461	$C_{20}H_{40}O_2$	312	0.01
93	Ethyl (*E*)-9-octadecanoate	86.350	2478	$C_{20}H_{38}O_2$	310	0.05
94	Methyl 11,14-eicosadienoate	88.642		$C_{21}H_{38}O_2$	322	0.04
	Total					94.24

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

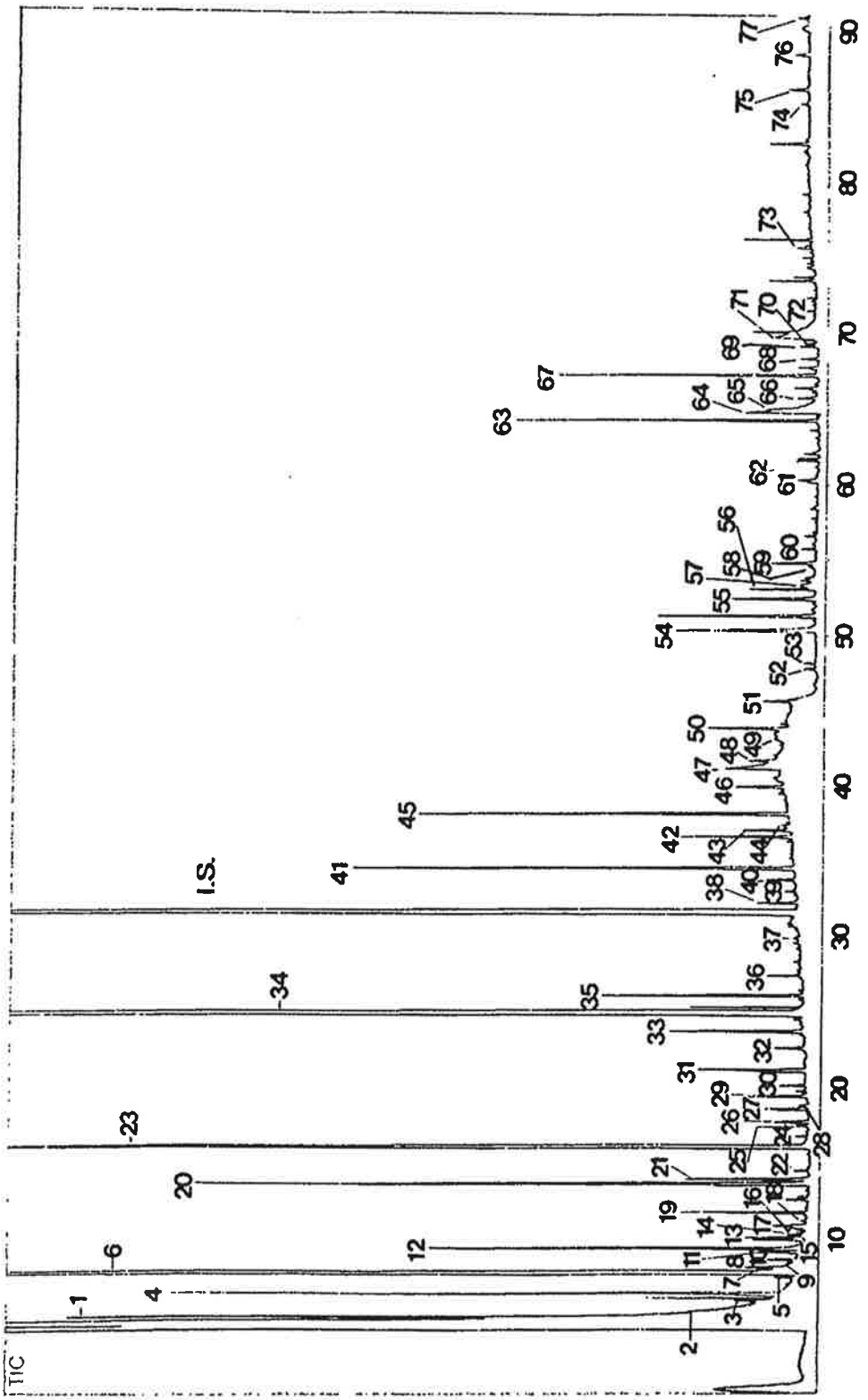

Fig. 14. GC chromatogram of volatile flavor components in Blackolympia grape

Table 18. Volatile flavor components in Blackolympia grape

Peak No.	Components	RTa)	RI	MFb)	FWc)	Peak Area (%)
1	Ethyl isopropyl ether	4.692	528	$C_5H_{12}O$	88	0.49
2	sec-Butyl ethyl ether	5.275	706	$C_6H_{14}O$	102	0.01
3	Octane	6.017	800	C_8H_{18}	114	0.06
4	Ethyl formate	6.392	821	$C_3H_6O_2$	74	1.38
5	Butanal	7.558	875	C_4H_8O	72	0.06
6	Ethyl acetate	7.792	894	$C_4H_8O_2$	88	18.06
7	Diethylacetal	8.025	899	$C_6H_{14}O_2$	118	13.24
8	Methanol	8.200	904	CH_4O	32	0.29
9	2-Methylbutanal	8.583	914	$C_5H_{10}O$	86	0.01
10	3-Methylbutanal	8.725	917	$C_5H_{10}O$	86	0.08
11	2-Propanol	9.250	936	C_3H_8O	60	0.15
12	Ethanol	9.467	943	C_2H_6O	46	1.25
13	Ethyl propanoate	10.183	955	$C_5H_{10}O_2$	102	0.12
14	3-Ethyloctane	10.392	962	$C_{10}H_{22}$	142	0.04
15	Ethyl 2-methylpropanoate	10.517	966	$C_6H_{12}O_2$	116	0.01
16	Propyl acetate	10.858	978	$C_5H_{10}O_2$	102	0.06
17	Pentanal	10.983	981	$C_5H_{10}O$	86	0.16
18	Methyl butanoate	11.300	987	$C_5H_{10}O_2$	102	0.01
19	Decane	11.858	1000	$C_{10}H_{22}$	142	0.25
20	Ethyl butanoate	13.767	1036	$C_6H_{12}O_2$	116	2.19

(continued)

21	2-Methyl-3-buten-2-ol	14.067	1047	$C_5H_{10}O$	86	0.53
22	Ethyl 2-methylbutanoate	14.617	1051	$C_7H_{14}O_2$	130	0.04
23	Hexanal	16.283	1082	$C_6H_{12}O$	100	9.02
24	2-Methylpropanol	16.917	1095	$C_4H_{10}O$	74	0.04
25	2-β-Pinene	17.625	1110	$C_{10}H_{16}$	136	0.04
26	Isopropyl propyl ether	17.858	1115	$C_6H_{14}O$	102	0.17
27	2-Pentanol	18.725	1128	$C_5H_{12}O$	88	0.24
28	(*E*)-2-Pentenal	18.975	1130	C_5H_8O	84	0.01
29	2-Methyl-4-pentenal	19.567	1136	$C_6H_{10}O$	98	0.25
30	Butanol	20.258	1152	$C_4H_{10}O$	74	0.09
31	Ethyl 2-butenoate	21.292	1163	$C_6H_{10}O_2$	114	0.57
32	Heptanal	22.700	1185	$C_7H_{14}O$	114	0.12
33	(*Z*)-3-Hexenal	23.800	1203	$C_6H_{10}O$	98	0.58
34	(*E*)-2-Hexenal	25.142	1224	$C_6H_{10}O$	98	20.36
35	Ethyl hexanoate	26.133	1235	$C_8H_{16}O_2$	144	0.72
36	Pentanol	27.442	1259	$C_5H_{12}O$	88	0.13
37	Ethyl (*Z*)-3-hexenoate	30.908	1308	$C_8H_{14}O_2$	142	0.01
I.S.	Butylbenzene	31.775	1313	$C_{10}H_{14}$	134	17.10
38	(*Z*)-2-Penten-1-ol	32.267	1329	$C_5H_{10}O$	86	0.17
39	Ethyl heptanoate	33.050	1338	$C_9H_{18}O_2$	158	0.15
40	Ethyl 2-hexenoate	33.833	1346	$C_8H_{14}O_2$	142	0.10
41	Hexanol	34.617	1365	$C_6H_{14}O$	102	1.78

(continued)

42	(*Z*)-3-Hexen-1-ol	36.700	1372	$C_6H_{12}O$	100	0.43
43	Nonanal	37.108	1387	$C_9H_{18}O$	142	0.20
44	*(E,E)*-2,4-Hexadienal	37.625	1404	C_6H_8O	96	0.01
45	(*E*)-2-Hexen-1-ol	38.217	1418	$C_6H_{12}O$	100	1.49
46	Ethyl octanoate	39.992	1436	$C_{10}H_{20}O_2$	172	0.18
47	Acetic acid	41.200	1454	$C_2H_4O_2$	60	0.41
48	Furfural	41.725	1477	$C_5H_4O_2$	96	0.10
49	Ethyl (*Z*)-4-octenoate	42.783	1492	$C_{10}H_{18}O_2$	170	0.01
50	2-Ethyl-1-hexanol	43.867	1520	$C_8H_{18}O$	130	0.33
51	Ethyl 3-hydroxybutanoate	45.675	1533	$C_6H_{12}O_3$	132	0.18
52	Ethyl 2-octenoate	47.833	1554	$C_{10}H_{18}O_2$	170	0.01
53	Octanol	48.217	1564	$C_8H_{18}O$	130	0.04
54	1,2-Propanediol	50.367	1598	$C_3H_8O_2$	76	0.71
55	1,2-Ethanediol	52.483	1639	$C_2H_6O_2$	62	0.46
56	Ethyl decanoate	53.100	1651	$C_{12}H_{24}O_2$	200	0.26
57	α-Tolualdehyde	53.342	1653	C_8H_8O	120	0.01
58	Nonanol	54.575	1665	$C_9H_{20}O$	144	0.01
59	Ethyl (*Z*)-4-decenoate	54.808	1667	$C_{12}H_{22}O_2$	198	0.19
60	Ethyl 3-hydroxyhexanoate	55.750	1681	$C_8H_{16}O_3$	160	0.05
61	Ethyl (*E*)-2-decenoate	60.317	1764	$C_{12}H_{22}O_2$	198	0.10
62	Ethyl phenylacetate	61.625	1791	$C_{10}H_{12}O_2$	164	0.11
63	Ethyl (*E,Z*)-2,4-decadienoate	64.275	1853	$C_{12}H_{20}O_2$	196	1.07

(continued)

64	Hexanoic acid	64.792	1874	$C_6H_{12}O_2$	116	0.59
65	Guaiacol	65.067	1879	C_7H_8O	124	0.37
66	Benzyl alcohol	65.858	1891	C_7H_8O	108	0.04
67	Phenethyl alcohol	67.300	1929	$C_8H_{10}O$	122	1.02
68	β-Ionone	68.400	1951	$C_{13}H_{20}O$	192	0.07
69	Dodecanol	69.300	1962	$C_{12}H_{26}O$	186	0.05
70	Ethyl phenylglycolate	69.367	1978	$C_{10}H_{12}O_3$	180	0.01
71	2-Hexenoic acid	69.800	1981	$C_6H_{10}O_2$	114	0.01
72	Isopropyl tetradecanoate	71.500	2039	$C_{17}H_{34}O_2$	270	0.03
73	Tetradecanol	75.667	2178	$C_{14}H_{30}O$	214	0.05
74	Ethyl octadecanoate	85.300	2461	$C_{20}H_{40}O_2$	312	0.01
75	Ethyl-*(Z)*-9-octadecenoate	86.283	2478	$C_{20}H_{38}O_2$	310	0.09
76	Methyl 9-octadecynoate	88.558	2532	$C_{19}H_{34}O_2$	294	0.01
77	Octadecanol	91.275	2593	$C_{18}H_{38}O$	270	0.06
	Total					98.91

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

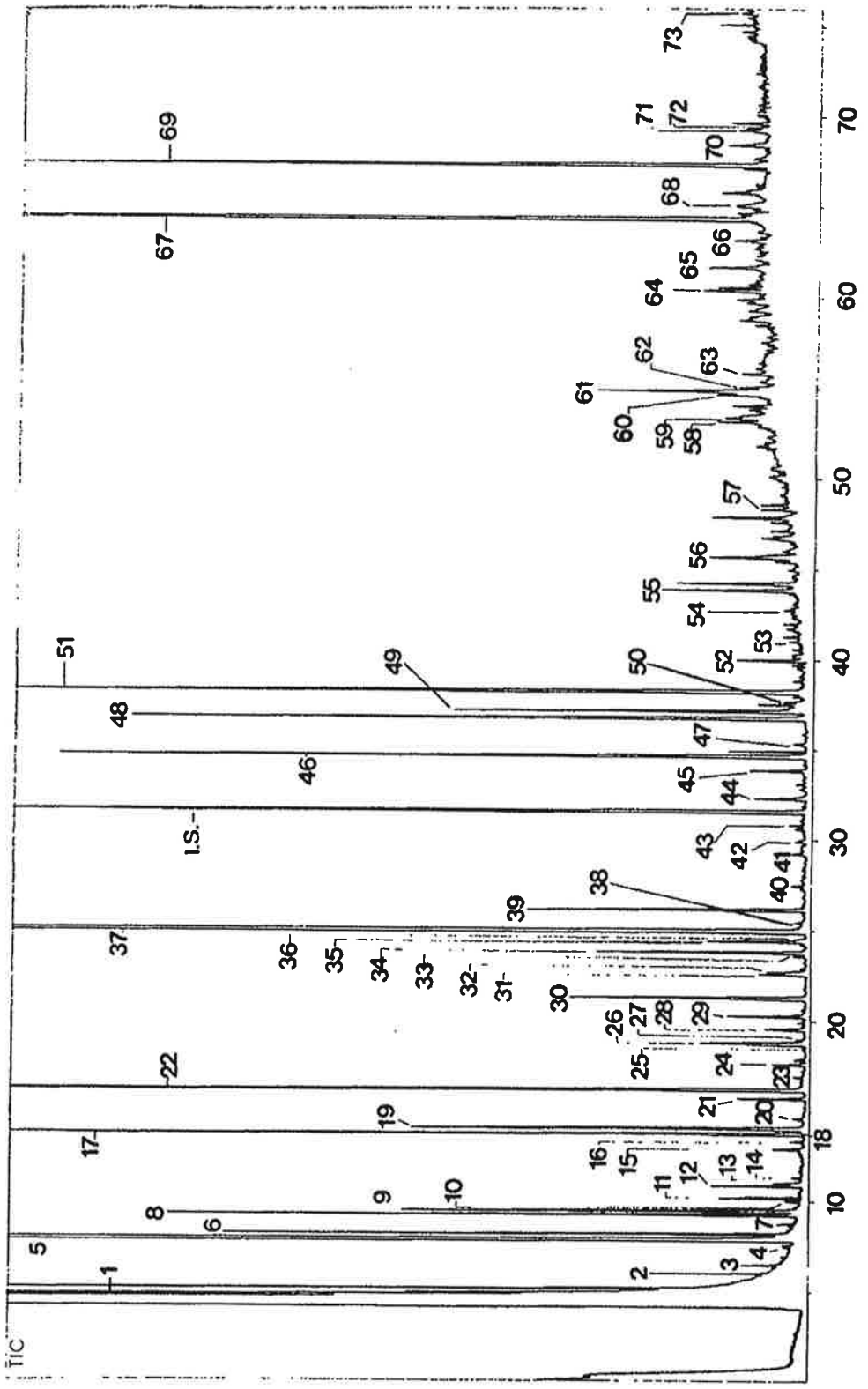

Fig. 15. GC chromatogram of volatile flavor components in Campbell grape

Table 19. Volatile flavor components in Campbell grape

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.717	529	$C_5H_{12}O$	88	0.01
2	Octane	6.050	800	C_8H_{18}	114	0.16
3	Ethyl formate	6.500	821	$C_3H_6O_2$	74	0.06
4	Butanal	7.583	875	C_4H_8O	72	0.03
5	Ethyl acetate	7.925	894	$C_4H_8O_2$	88	30.81
6	Isopropyl acetate	8.200	907	$C_5H_{10}O_2$	102	1.04
7	3-Methylbutanal	8.758	917	$C_5H_{10}O$	86	0.02
8	2-Propanol	9.283	936	C_3H_8O	60	1.36
9	Ethanol	9.492	943	C_2H_6O	46	0.92
10	2-Ethylfuran	10.025	952	C_6H_8O	96	0.01
11	Ethyl propanoate	10.217	955	$C_5H_{10}O_2$	102	0.16
12	Propyl acetate	10.892	978	$C_5H_{10}O_2$	102	0.18
13	Pentanal	11.033	981	$C_5H_{10}O$	86	0.10
14	Methyl butanoate	11.333	987	$C_5H_{10}O_2$	102	0.01
15	α-Pinene	12.942	1019	$C_{10}H_{16}$	136	0.05
16	2-Butanol	13.358	1027	$C_4H_{10}O$	74	0.03
17	Ethyl butanoate	13.792	1036	$C_6H_{12}O_2$	116	2.59
18	Isopropyl butanoate	14.017	1044	$C_7H_{14}O_2$	130	0.10
19	Methyl butenol	14.092	1047	$C_5H_{10}O$	86	1.01
20	Ethyl 2-methylbutanoate	14.667	1051	$C_7H_{14}O_2$	130	0.01

(continued)

21	Butyl acetate	15.758	1072	$C_6H_{12}O_2$	116	0.17
22	Hexanal	16.258	1082	$C_6H_{12}O$	100	4.86
23	2-Methylpropanol	16.950	1100	$C_4H_{10}O$	74	0.01
24	2-β-Pinene	17.675	1111	$C_{10}H_{16}$	136	0.05
25	2-Pentanol	18.767	1127	$C_5H_{12}O$	88	0.44
26	3-Penten-2-one	18.833	1128	C_5H_8O	84	0.44
27	(*E*)-2-Pentenal	19.008	1130	C_5H_8O	84	0.01
28	2-Methyl-4-pentenal	19.600	1136	$C_6H_{16}O$	98	0.13
29	Butanol	20.317	1152	$C_4H_{10}O$	74	0.21
30	Ethyl 2-butenoate	21.342	1163	$C_6H_{10}O_2$	114	0.81
31	o-Xylene	22.633	1184	C_8H_{10}	106	0.14
32	Heptanal	22.742	1186	$C_7H_{14}O$	114	0.10
33	α-Limonene	23.625	1201	$C_{10}H_{16}$	136	0.01
34	(*Z*)-3-Hexenal	23.825	1203	$C_6H_{10}O$	98	0.63
35	1,8-Cineole	24.442	1213	$C_{10}H_{18}O$	154	0.27
36	3-Methyl-1-butanol	24.550	1215	$C_5H_{12}O$	88	0.01
37	(*E*)-2-Hexenal	25.050	1224	$C_6H_{10}O$	98	16.08
38	2-Hexanol	25.458	1228	$C_6H_{14}O$	102	0.01
39	Ethyl hexanoate	26.167	1235	$C_8H_{16}O_2$	144	0.82
40	Pentanol	27.500	1259	$C_5H_{12}O$	88	0.01
41	Acetophenone	29.258	1285	C_8H_8O	120	0.01
42	Octanal	29.917	1294	$C_8H_{16}O$	128	0.01

(continued)

43	Ethyl (*Z*)-3-hexenoate	30.850	1308	$C_8H_{14}O_2$	142	0.01
I.S.	Butylbenzene	31.599	1313	$C_{10}H_{14}$	134	5.26
44	(*Z*)-2-Penten-1-ol	32.308	1329	$C_5H_{10}O$	86	0.14
45	Ethyl (*E*)-2-hexenoate	33.875	1346	$C_6H_{14}O_2$	142	0.16
46	Hexanol	34.654	1365	$C_6H_{14}O_2$	102	2.72
47	(*E*)-3-Hexen-1-ol	35.333	1372	$C_6H_{12}O$	100	0.01
48	(*Z*)-3-Hexen-1-ol	36.767	1395	$C_6H_{12}O$	100	2.41
49	Nonanal	37.167	1398	$C_9H_{18}O$	142	1.12
50	(*E*,*E*)-2,4-Hexadienal	37.700	1404	C_6H_8O	96	0.02
51	(*E*)-2-Hexen-1-ol	38.267	1418	$C_6H_{12}O$	100	4.61
52	Ethyl octanoate	39.950	1436	$C_{10}H_{20}O_2$	172	0.18
53	Furfural	41.783	1477	$C_2H_4O_2$	96	0.01
54	Ethyl (*Z*)-4-octenoate	42.800	1492	$C_{10}H_{18}O_2$	170	0.01
55	2-Ethyl hexanol	43.867	1498	$C_8H_{18}O$	130	0.46
56	Ethyl 3-hydroxybutanoate	45.667	1533	$C_6H_{12}O_3$	132	0.41
57	Octanol	48.282	1564	$C_8H_{18}O$	130	0.09
58	Ethyl decanoate	53.167	1651	$C_{12}H_{24}O_2$	200	0.11
59	α-Tolualdehyde	53.367	1653	C_8H_8O	120	0.12
60	Nonanol	54.650	1659	$C_9H_{20}O$	144	0.13
61	Ethyl (*Z*)-4-decenoate	54.867	1665	$C_{12}H_{22}O_2$	198	0.55
62	*p*-Allylanisole	55.075	1667	$C_8H_{16}O_3$	148	0.01
63	Ethyl 3-hydroxyhexanoate	55.825	1681	$C_8H_{16}O_3$	160	0.51

(continued)

64	Ethyl (*E*)-2-decenoate	60.383	1764	$C_{12}H_{22}O_2$	198	0.20
65	Ethyl phenylacetate	61.667	1790	$C_{10}H_{12}O_2$	164	0.16
66	β-Phenethyl acetate	63.158	1824	$C_{10}H_{12}O_2$	164	0.06
67	Ethyl (*E*,*E*)-2,4-decadienoate	64.350	1853	$C_{12}H_{20}O_2$	196	7.96
68	Guaiacol	65.100	1872	$C_7H_8O_2$	124	0.18
69	Phenethyl alcohol	67.358	1929	$C_8H_{10}O$	122	2.66
70	β-Ionone	68.467	1951	$C_{13}H_{20}O$	192	0.07
71	Dodecanol	69.292	1961	$C_{12}H_{26}O$	186	0.04
72	1-Phenyl-1-butanol	69.417	1962	$C_{10}H_{14}O$	150	0.02
73	Tetradecanol	75.742	2179	$C_{14}H_{30}O$	214	0.01
	Total					94.30

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

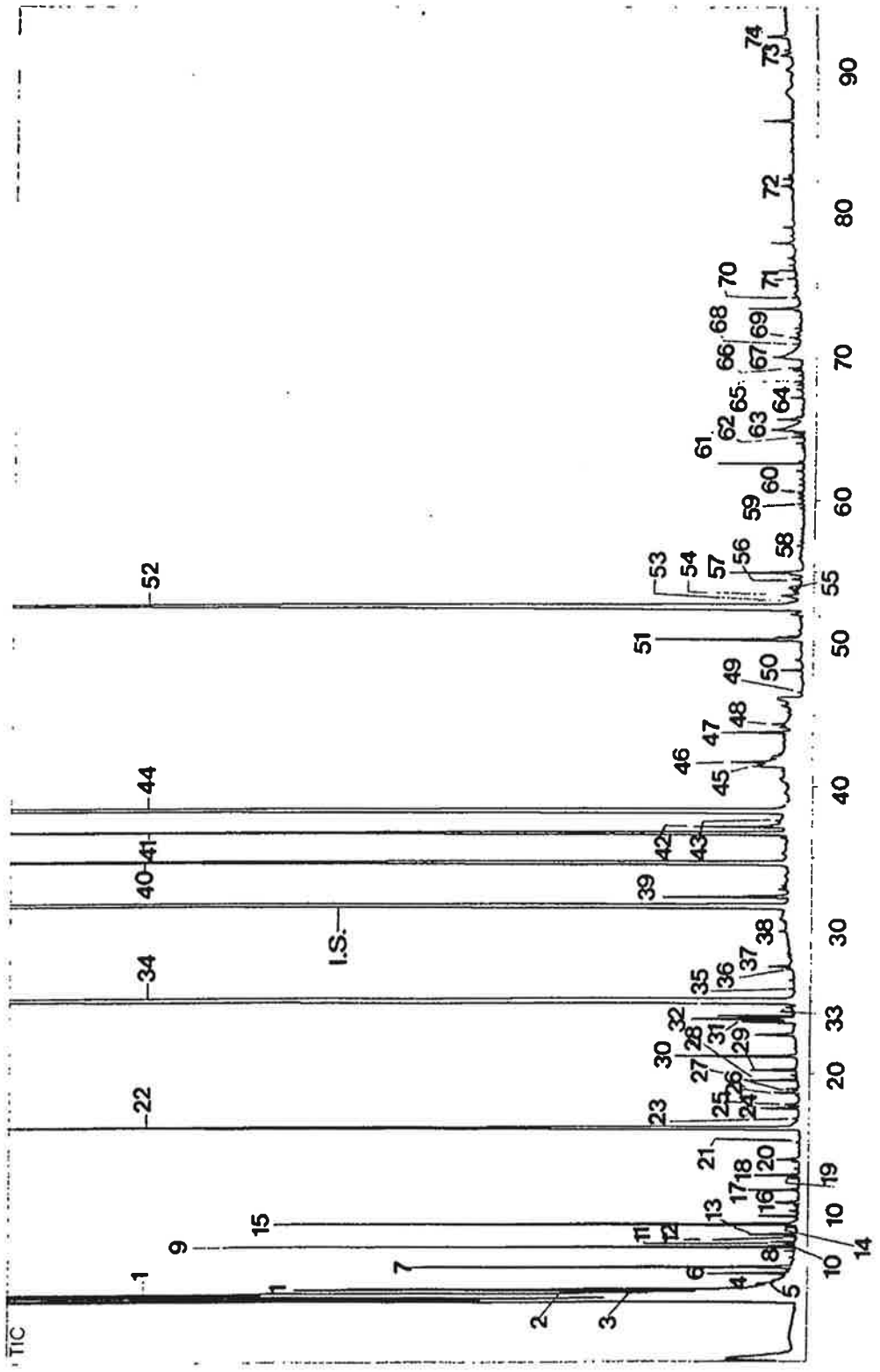

Fig. 16. GC chromatogram of volatile flavor components in Delaware grape

Table 20. Volatile flavor components in Delaware grape

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.683	527	$C_5H_{12}O$	88	1.17
2	3-Methyl-2-pentene	4.800	592	C_6H_{12}	84	0.14
3	2,3-Dimethyl-2-butene	4.892	650	C_6H_{12}	84	0.06
4	sec-Butyl ethyl ether	5.267	705	$C_6H_{14}O$	102	0.01
5	Propanal	5.800	771	C_3H_6O	58	0.01
6	Octane	6.008	794	C_8H_{18}	114	0.13
7	Ethyl formate	6.467	823	$C_3H_6O_2$	74	0.69
8	Butanal	7.550	867	C_4H_8O	72	0.02
9	Ethyl acetate	7.850	879	$C_4H_8O_2$	88	1.22
10	Nonane	8.133	890	C_9H_{20}	128	0.01
11	Methanol	8.192	892	CH_4O	32	0.06
12	2-Methylbutanal	8.583	908	$C_5H_{10}O$	86	0.02
13	3-Methylbutanal	8.717	918	$C_5H_{10}O$	86	0.10
14	2-Propanol	9.242	936	C_3H_8O	60	0.02
15	Ethanol	9.458	944	C_2H_6O	46	1.21
16	Pentanal	10.983	997	$C_5H_{10}O$	86	0.10
17	Decane	11.850	1006	$C_{10}H_{22}$	142	0.11
18	α-Pinene	12.900	1014	$C_{10}H_{16}$	136	0.13
19	2-Butanol	13.308	1034	$C_4H_{10}O$	74	0.01
20	Propanol	13.992	1047	C_3H_8O	60	0.08

(continued)

21	Camphene	15.192	1068	$C_{10}H_{16}$	136	0.01
22	Hexanal	16.267	1086	$C_6H_{12}O$	100	5.34
23	2-Methylpropanol	16.908	1094	$C_4H_{10}O$	74	0.01
24	2-β-Pinene	17.633	1102	$C_{10}H_{16}$	136	0.11
25	1-Isopropoxy-2-propanol	17.867	1106	$C_6H_{14}O_2$	118	0.06
26	2-Pentanol	18.725	1130	$C_5H_{12}O$	88	0.05
27	(*E*)-2-Pentenal	18.983	1137	C_5H_8O	84	0.03
28	2-Methyl-4-pentenal	19.575	1145	$C_6H_{10}O$	98	0.15
29	Butanol	20.258	1154	$C_4H_{10}O$	74	0.13
30	1-Penten-3-ol	21.208	1166	$C_5H_{10}O$	86	0.37
31	α-Limonene	23.592	1192	$C_{10}H_{16}$	136	0.18
32	(*Z*)-3-Hexenal	23.792	1203	$C_6H_{10}O$	98	0.40
33	3-Methyl-1-butanol	24.608	1220	$C_5H_{12}O$	88	0.01
34	(*E*)-2-Hexenal	25.167	1232	$C_6H_{10}O$	98	21.07
35	2-Pentylfuran	25.883	1241	$C_9H_{14}O$	138	0.01
36	3-Methyl-3-buten-1-ol	27.258	1258	$C_5H_{10}O$	86	0.01
37	Pentanol	27.442	1260	$C_5H_{12}O$	88	0.06
38	Octanal	29.883	1276	$C_8H_{16}O$	128	0.01
I.S.	Butylbenzene	31.767	1320	$C_{10}H_{14}$	134	15.22
39	(*Z*)-2-Penten-1-ol	32.267	1331	$C_5H_{10}O$	86	0.43
40	Hexanol	34.733	1370	$C_6H_{14}O_2$	102	9.78
41	(*Z*)-3-Hexen-1-ol	36.783	1400	$C_6H_{12}O$	100	5.64

(continued)

42	Nonanal	37.192	1407	$C_9H_{18}O$	142	0.26
43	*(E,E)*-2,4-Hexadienal	37.633	1415	C_6H_8O	96	0.01
44	(*E*)-2-Hexen-1-ol	38.425	1430	$C_6H_{12}O$	100	19.43
45	Acetic acid	41.442	1456	$C_2H_4O_2$	60	0.05
46	Furfural	41.730	1466	$C_5H_4O_2$	96	0.12
47	2-Ethyl-1-hexanol	43.825	1505	$C_8H_{18}O$	130	0.23
48	Benzaldehyde	45.717	1536	C_7H_6O	106	0.04
49	(*E*)-2-Nonenal	46.617	1568	$C_9H_{16}O$	140	0.01
50	Octanol	48.208	1573	$C_{10}H_{18}O_2$	170	0.06
51	1,2-Propanediol	50.367	1617	$C_3H_8O_2$	76	0.63
52	1,2-Ethanediol	52.758	1669	$C_2H_6O_2$	62	10.48
53	Benzeneacetaldehyde	53.300	1670	C_7H_6O	106	0.01
54	(*E*)-2-Decenal	53.417	1671	$C_{10}H_{18}O$	154	0.03
55	Acetophenone	53.867	1680	C_8H_8O	120	0.01
56	Nonanol	54.567	1692	$C_9H_{20}O$	144	0.02
57	Estragole	55.025	1712	$C_{10}H_{12}O$	148	0.26
58	α-Terpineol	56.867	1733	$C_{10}H_{16}O$	152	0.01
59	*(E)*-2-Undecenal	59.825	1762	$C_{11}H_{20}O$	168	0.01
60	β-Citronellol	60.667	1770	$C_{10}H_{20}O$	156	0.01
61	(*E,E*)-2,4-Decadienal	62.792	1810	$C_{10}H_{16}O$	152	0.01
62	Geraniol	64.525	1848	$C_{10}H_{18}O$	154	0.01
63	Hexanoic acid	65.025	1859	$C_6H_{12}O_2$	116	0.15

(continued)

64	Phenethyl alcohol	67.283	1930	$C_8H_{10}O$	122	0.03
65	β-Ionone	68.400	1958	$C_{13}H_{20}O$	192	0.01
66	1-Phenyl-1-butanol	69.367	1983	$C_{10}H_{14}O$	150	0.04
67	(Z)-2-Hexenoic acid	70.042	1993	$C_6H_{10}O_2$	114	0.04
68	2-Tetradecanol	71.017	2018	$C_{14}H_{30}O$	214	0.02
69	Methylethyl tetradecanoate	71.492	2047	$C_{17}H_{34}O_2$	270	0.03
70	Hexahydrofarnesyl acetone	74.308	2137	$C_{18}H_{36}O$	568	0.01
71	Tetradecanol	75.658	2180	$C_{14}H_{30}O$	314	0.02
72	Hexadecanol	82.142	2394	$C_{16}H_{34}O$	242	0.04
73	Octadecanol	91.267	2585	$C_{18}H_{38}O$	270	0.01
74	Phytol	92.575	2609	$C_{20}H_{40}O$	296	0.08
	Total					96.56

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 21. Relative content of functional groups in Grapes

Peak area%

Functional group	Neo muscat	Blackolympia	Campbell	Delaware
Aldehydes	19.35	44.21	23.24	27.75
Alcohols	23.84	9.73	17.77	49.31
Esters	26.11	25.73	47.08	1.94
Terpenes	0.03	0.04	0.11	0.43
Acids	0.54	1.01	-	0.24
Ketones	0.5	0.07	0.52	0.03
Ethers	1.14	0.67	0.01	1.18
Miscellaneous	0.29	0.35	0.31	0.46
T o t a l	71.80	81.81	89.04	81.34

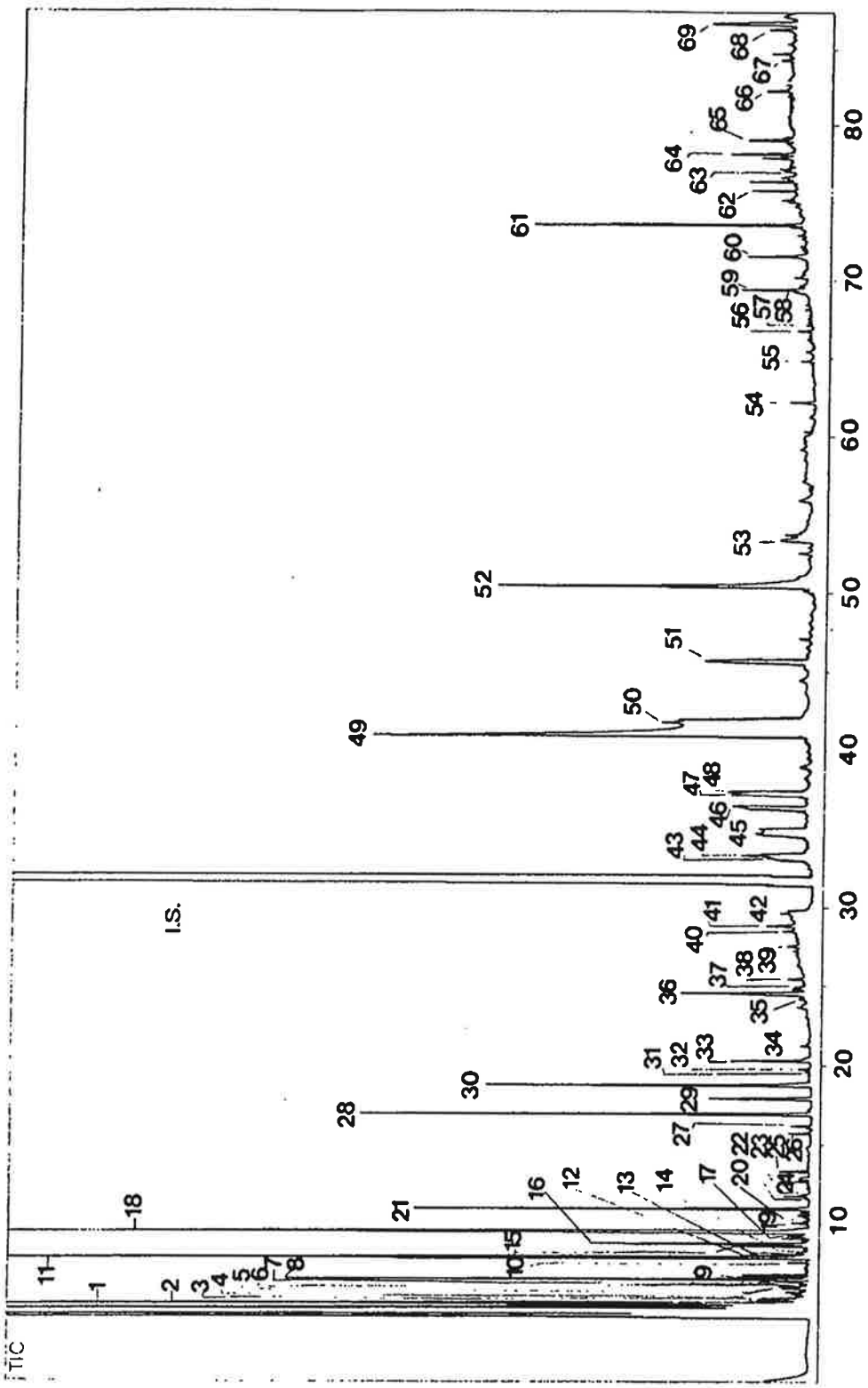

Fig. 17. GC chromatogram of volatile flavor components in Buyu persimmon

Table 22. Volatile flavor components in Buyu persimmon

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.708	529	$C_5H_{12}O$	88	1.80
2	Acetaldehyde	4.975	696	C_2H_4O	44	3.91
3	sec-Butyl ethyl ether	5.292	706	$C_6H_{14}O$	102	0.09
4	Propanal	5.925	787	C_3H_6O	58	0.05
5	Octane	6.042	794	C_8H_{18}	114	0.07
6	2-Methylpropanal	6.267	807	C_4H_8O	72	0.02
7	2-Propanone	6.342	812	C_3H_6O	58	0.09
8	Ethyl formate	6.492	821	$C_3H_6O_2$	74	1.22
9	2-Methyl-2-butene oxide	6.650	829	$C_5H_{10}O$	86	0.15
10	Butanal	7.575	874	C_4H_8O	72	0.05
11	Ethyl acetate	7.892	889	$C_4H_8O_2$	88	7.41
12	Diethylacetal	8.025	892	$C_6H_{14}O_2$	118	0.19
13	Nonane	8.175	896	C_9H_{20}	128	0.03
14	2-Butanone	8.242	898	C_4H_8O	72	0.02
15	2-Methylbutanal	8.617	907	$C_5H_{10}O$	86	0.20
16	3-Methylbutanal	8.750	916	$C_5H_{10}O$	86	0.61
17	2-Propanol	9.283	936	C_3H_8O	60	0.09
18	Ethanol	9.550	943	C_2H_6O	46	5.68
19	4,5-Dimethyloctane	9.708	947	$C_{10}H_{22}$	142	0.05
20	Ethyl propanoate	10.208	959	$C_5H_{10}O_2$	102	0.02

(continued)

21	2-Pentanone	10.975	978	$C_5H_{10}O$	86	1.38
22	Ethyl 2-propenoate	11.625	992	$C_5H_8O_2$	100	0.02
23	Decane	11.883	998	$C_{10}H_{12}$	142	0.03
24	2-Methyl-2-butanol	12.725	1017	$C_5H_{12}O$	88	0.05
25	2-Butanol	13.358	1030	$C_4H_{10}O$	74	0.10
26	Butyl acetate	15.750	1073	$C_6H_{12}O_2$	116	0.09
27	Hexanal	16.233	1081	$C_6H_{12}O$	100	0.07
28	2-Methylpropanol	16.975	1100	$C_4H_{10}O$	74	1.79
29	3-Pentanol	17.942	1115	$C_5H_{12}O$	88	0.56
30	2-Pentanol	18.775	1128	$C_5H_{12}O$	88	1.41
31	3-Methylhexanal	19.600	1141	$C_7H_{14}O$	114	0.02
32	Benzyl isopropyl ketone	19.783	1144	$C_{11}H_{14}O$	162	0.05
33	Butanol	20.308	1152	$C_4H_{10}O$	74	0.32
34	1-Penten-3-ol	21.250	1167	$C_5H_{10}O$	86	0.03
35	1-Propoxy-2-propanol	24.150	1210	$C_6H_{14}O_2$	118	0.03
36	3-Methyl-1-butanol	24.542	1216	$C_5H_{12}O$	88	0.87
37	*(E)*-2-Hexenal	24.933	1228	$C_6H_{10}O$	98	0.05
38	2-Ethoxyethanol	25.433	1230	$C_4H_{10}O_2$	90	0.07
39	Pentanol	27.517	1238	$C_5H_{12}O$	88	0.07
40	3,4-Epoxy-2-pentanone	28.483	1256	$C_5H_8O_2$	100	0.03
41	3-Methyl-1-hexyn-3-ol	28.833	1262	$C_7H_{12}O$	112	0.14
42	3-Hydroxy-2-butanone	29.633	1300	$C_4H_8O_2$	88	0.05

(continued)

I.S.	Butylbenzene	32.050	1311	$C_{10}H_{14}$	134	54.67
43	1-Methyl-2-propyl benzene	33.183	1333	$C_{10}H_{14}$	134	0.03
44	6-Methyl-5-hepten-2-one	33.342	1336	$C_8H_{14}O$	126	0.15
45	Hexanol	34.717	1362	$C_6H_{14}O$	102	0.03
46	2-Methylindan	36.467	1374	$C_{10}H_{12}$	132	0.09
47	Nonanal	37.192	1387	$C_9H_{18}O$	142	0.07
48	5-Methylindan	37.375	1390	$C_{10}H_{12}$	132	0.09
49	Acetic acid	40.950	1453	$C_2H_4O_2$	60	3.86
50	Furfural	41.783	1458	$C_5H_4O_2$	96	0.10
51	Benzaldehyde	45.758	1520	C_7H_6O	106	0.12
52	1,2-Propanediol	50.450	1607	$C_3H_8O_2$	76	2.55
53	α-Tolualdehyde	53.375	1671	C_8H_8O	120	0.37
54	1-Phenyl-1-butanone	62.217	1863	$C_{10}H_{12}O$	148	0.14
55	Nerylacetone	64.850	1888	$C_{13}H_{22}O$	194	0.03
56	Dimethyl sulfone	66.783	1966	$C_2H_6O_2S$	94	0.09
57	4-Methyl-2,6-di-tert-butylphenol	67.142	1975	$C_{15}H_{24}O$	220	0.02
58	Dodecanol	69.258	2031	$C_{12}H_{26}O$	186	0.03
59	1-Phenyl-1-butanol	69.425	2036	$C_{10}H_{14}O$	150	0.27
60	Isopropyl tetradecanoate	71.558	2066	$C_{14}H_{28}O_2$	270	0.24
61	Unknown	73.575	2113			0.95
62	Tetradecanol	75.733	2179	$C_{14}H_{30}O$	214	0.17
63	Methyl hexadecanoate	77.025	2225	$C_{17}H_{34}O_2$	270	0.05

(continued)

64	Ethyl hexadecanoate	78.125	2254	$C_{18}H_{36}O_2$	284	0.22
65	Ethyl 9-hexadecenoate	79.025	2292	$C_{18}H_{34}O_2$	282	0.17
66	Hexadecanol	82.250	2390	$C_{16}H_{34}O$	242	0.10
67	Butyl hexadecanoate	84.333	2450	$C_{28}H_{40}O_2$	312	0.05
68	Ethyl *(Z)*-9-octadecenoate	86.375	2501	$C_{20}H_{38}O_2$	310	0.12
69	Heptadecanol	86.750	2527	$C_{17}H_{36}O$	256	0.70
	Total					94.46

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

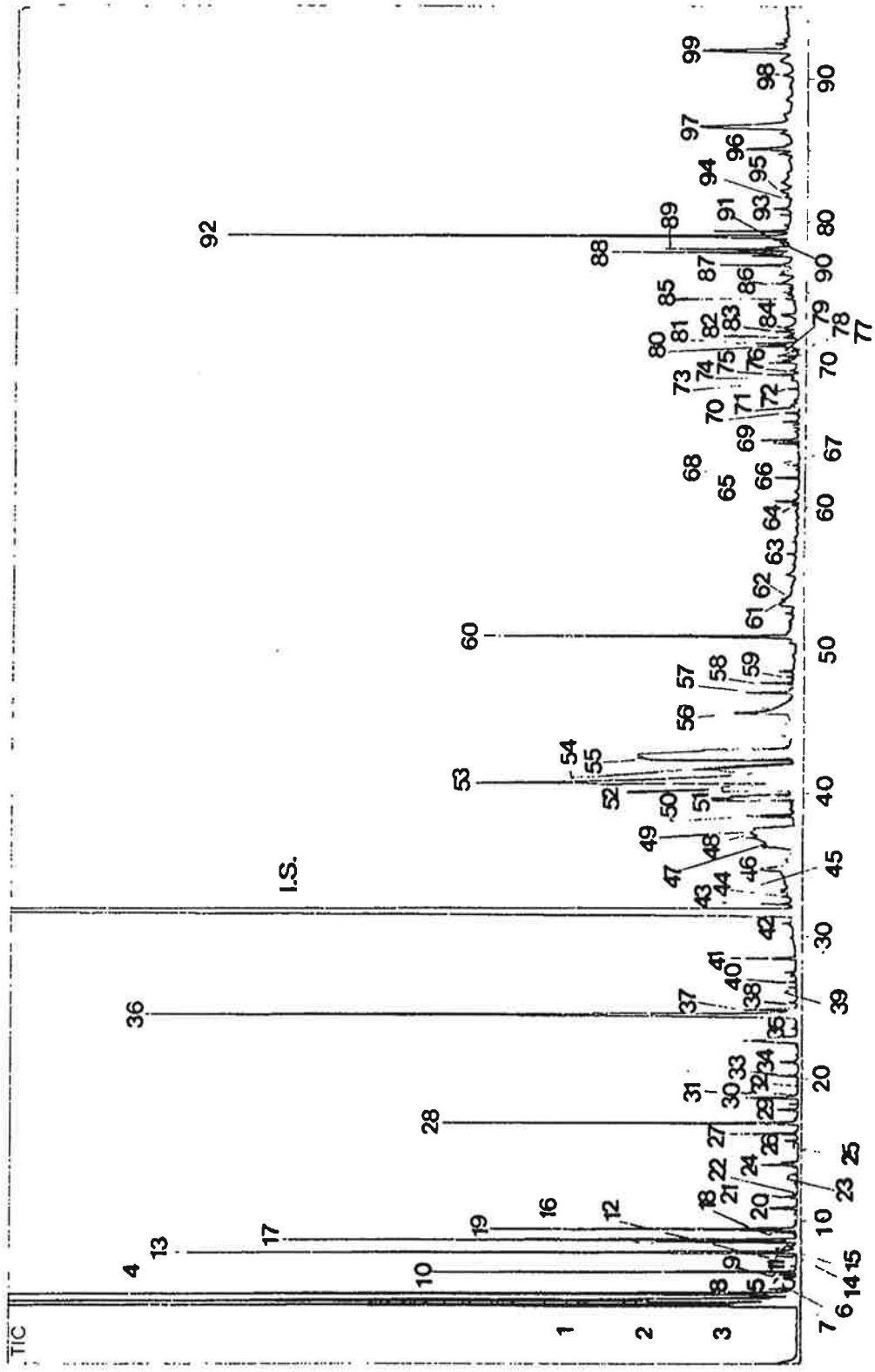

Fig. 18. GC chromatogram of volatile flavor components in Daebong persimmon

Tabke 23. Volatile flavor components in Daebong persimmon

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.700	529	$C_5H_{12}O$	88	0.20
2	3-Methylhexane	4.808	597	C_7H_{14}	100	0.07
3	Ethyl vinyl ether	4.850	623	C_4H_8O	72	0.17
4	Acetaldehyde	4.967	696	C_2H_4O	44	4.65
5	sec-Butyl ethyl ether	5.275	706	$C_6H_{14}O$	102	0.07
6	Propanal	5.908	790	C_3H_6O	58	0.03
7	Octane	6.050	798	C_8H_{18}	114	0.07
8	2-Methylpropanal	6.250	809	C_4H_8O	72	0.07
9	2-Propanone	6.308	812	C_3H_6O	58	0.07
10	Ethyl formate	6.475	821	$C_3H_6O_2$	74	1.55
11	2-Propenal	6.867	840	C_3H_4O	56	0.03
12	Butanal	7.542	874	C_4H_8O	72	0.10
13	Ethyl acetate	7.850	889	$C_4H_8O_2$	88	3.66
14	Diethylacetal	7.992	892	$C_6H_{14}O_2$	118	0.07
15	Nonane	8.175	897	C_9H_{20}	128	0.05
16	2-Methylbutanal	8.575	907	$C_5H_{10}O$	86	0.64
17	3-Methylbutanal	8.717	917	$C_5H_{10}O$	86	2.34
18	2-Propanol	9.225	936	C_3H_8O	60	0.12
19	Ethanol	9.467	942	C_2H_6O	46	1.77
20	2-Pentanone	10.925	978	$C_5H_{10}O$	86	0.23

(continued)

21	Diethoxyethane	11.742	999	$C_6H_{14}O_2$	118	0.07
22	Decane	11.867	1001	$C_{10}H_{12}$	142	0.02
23	2-Butanol	13.350	1032	$C_4H_{10}O$	74	0.03
24	Propanol	13.975	1045	C_3H_8O	60	0.26
25	3-Methylbutyl formate	15.583	1072	$C_6H_{12}O_2$	116	0.02
26	Butyl acetate	15.667	1073	$C_6H_{12}O_2$	116	0.10
27	Hexanal	16.150	1081	$C_6H_{12}O$	100	0.45
28	2-Methylpropanol	16.925	1100	$C_4H_{10}O$	74	2.39
29	3-Pentanol	17.867	1115	$C_5H_{12}O$	88	0.17
30	2-Pentanol	18.692	1128	$C_5H_{12}O$	88	0.45
31	(*E*)-2-Pentenal	18.950	1132	C_5H_8O	84	0.02
32	2-Methyl-4-pentenal	19.525	1141	$C_6H_{10}O$	98	0.02
33	Butanol	20.217	1152	$C_4H_{10}O$	74	0.13
34	1-Penten-3-ol	21.175	1167	$C_5H_{10}O$	86	0.12
35	α-Limonene	23.542	1202	$C_{10}H_{16}$	136	0.03
36	3-Methyl-1-butanol	24.542	1216	$C_5H_{12}O$	88	7.52
37	(*E*)-2-Hexenal	24.875	1228	$C_6H_{10}O$	98	0.45
38	2-Ethoxyethanol	25.367	1230	$C_4H_{10}O_2$	90	0.08
39	γ-Terpinene	26.817	1236	$C_{10}H_{16}$	136	0.05
40	3-Methyl-3-butenol	27.217	1238	$C_5H_{10}O$	86	0.03
41	*p*-Cymene	28.483	1262	$C_{10}H_{14}$	134	0.51
42	Tridecane	30.917	1299	$C_{13}H_{28}$	184	0.05

(continued)

I.S.	Butylbenzene	31.925	1309	$C_{10}H_{14}$	134	36.35
43	(*Z*)-2-Penten-1-ol	32.250	1315	$C_5H_{10}O$	86	0.12
44	2-Butyltetrahydrofuran	32.767	1325	$C_8H_{16}O$	128	0.05
45	6-Methyl-5-hepten-2-one	33.258	1335	$C_8H_{14}O$	126	0.08
46	Hexanol	34.625	1362	$C_6H_{14}O$	102	0.36
47	2-Methylindan	36.367	1387	$C_{10}H_{12}$	132	0.05
48	2-Nonanone	36.942	1395	$C_9H_{18}O$	142	0.05
49	Nonanal	37.150	1398	$C_9H_{18}O$	142	0.07
50	(*E*)-2-Hexen-1-ol	38.275	1415	$C_6H_{12}O$	100	0.13
51	(*E*)-2-Octenal	39.617	1437	$C_8H_{14}O$	126	0.38
52	Ethyl octanoate	40.125	1445	$C_{10}H_{20}O_2$	172	0.33
53	Acetic acid	40.683	1454	$C_2H_4O_2$	60	5.73
54	Furfural	41.667	1465	$C_5H_4O_2$	96	1.34
55	(*E*)-Sabinene hydrate	42.458	1474	$C_{10}H_{18}O$	154	2.31
56	Benzaldehyde	45.667	1520	C_7H_6O	106	0.21
57	(*E*)-2-Nonenal	47.100	1544	$C_9H_{16}O$	140	0.30
58	7-Decen-2-one	47.775	1559	$C_{10}H_{18}O$	154	0.23
59	Octanol	48.225	1565	$C_8H_{18}O$	130	0.05
60	4-Terpineol	51.050	1607	$C_{10}H_{18}O$	154	2.56
61	α-Tolualdehyde	53.350	1635	C_8H_8O	120	0.36
62	1-Phenyl-1-ethanone	53.800	1640	C_8H_8O	120	0.03
63	α-Terpineol	56.792	1676	$C_{10}H_{18}O$	154	0.05

(continued)

64	2-Phenyl-2-propanol	60.217	1786	$C_9H_{12}O$	136	0.05
65	(*Z*)-3-Decenol	60.608	1804	$C_{10}H_{20}O$	156	0.03
66	1-Phenyl-1-butanone	62.100	1863	$C_{10}H_{12}O$	148	0.18
67	Tridecanal	62.975	1871	$C_{13}H_{26}O$	198	0.05
68	*p*-Cymen-8-ol	64.525	1886	$C_{10}H_{14}O$	150	0.15
69	Geranylacetone	64.742	1888	$C_{13}H_{22}O$	194	0.28
70	Dimethyl sulfone	66.667	1966	$C_2H_6O_2S$	94	0.12
71	4-Methyl-2,6-di-tert-butylphenol	67.050	1977	$C_{15}H_{24}O$	220	0.03
72	β-Ionone	68.358	2011	$C_{13}H_{22}O$	192	0.08
73	Heptanoic acid	68.933	2025	$C_7H_{14}O_2$	130	0.10
74	Dodecanol	69.225	2033	$C_{12}H_{26}O$	186	0.03
75	2-Methyl-1-phenylpropanol	69.342	2036	$C_{10}H_{14}O$	150	0.20
76	(*Z*)-2-Hexenoic acid	69.592	2042	$C_6H_{10}O_2$	114	0.03
77	β-Ionon-5,6-epoxide	70.317	2057	$C_{13}H_{20}O_2$	208	0.05
78	Methyl tetradecanoate	70.608	2059	$C_{15}H_{30}O_2$	242	0.10
79	2-Tetradecanone	71.025	2062	$C_{14}H_{28}O$	212	0.03
80	Pentadecanal	71.300	2065	$C_{15}H_{30}O$	226	0.38
81	Isopropyl tetradecanoate	71.483	2066	$C_{17}H_{34}O_2$	270	0.25
82	Ethyl tetradecanoate	71.900	2072	$C_{17}H_{34}O_2$	270	0.25
83	13-Tetradecenal	72.308	2083	$C_{14}H_{26}O$	210	0.23
84	Octanoic acid	72.550	2089	$C_8H_{16}O_2$	144	0.18
85	2,3-Dihydro-2,5-dimethyl-4H-1-benzopyran-4-one	74.600	2146	$C_{11}H_{12}O_2$	176	0.05

(continued)

86	Tetradecanol	75.683	2179	$C_{14}H_{30}O$	214	0.15
87	Methyl hexadecanoate	76.950	2225	$C_{17}H_{34}O_2$	270	0.43
88	Methyl 9-hexadecenoate	77.842	2254	$C_{17}H_{32}O_2$	268	1.17
89	Ethyl hexadecanoate	78.058	2264	$C_{18}H_{36}O_2$	284	0.84
90	2,3-Dihydrofarnesol	78.517	2278	$C_{15}H_{28}O$	224	0.02
91	Pentadecanol	78.717	2283	$C_{15}H_{32}O$	228	0.15
92	Ethyl 9-hexadecenoate	79.000	2292	$C_{18}H_{34}O_2$	282	4.52
93	Methyl-*(E,E)*-9,12-octadecadienoate	80.933	2348	$C_{19}H_{34}O_2$	294	0.12
94	Hexadecanol	82.142	2382	$C_{16}H_{34}O$	242	0.05
95	Dihydroactinidiolide	82.250	2472	$C_{11}H_{16}O_2$	180	0.08
96	Methyl 11-octadecenoate	85.108	2464	$C_{19}H_{36}O_2$	296	0.54
97	Ethyl (*Z*)-9-octadecenoate	86.667	2502	$C_{20}H_{38}O_2$	310	2.13
98	Methyl (*Z,Z,Z*)-9,12,15-octadecatrienoate	90.292	2579	$C_{19}H_{32}O_2$	292	0.13
99	Ethyl (*Z,Z,Z*)-9,12,15-octadecatrienoate	91.975	2613	$C_{20}H_{34}O_2$	306	1.35
	Total					94.60

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 24. Relative content of functional groups in Persimmons

Peak area%

Functional group	Buyu	Daebong
Aldehydes	5.83	12.19
Alcohols	15.08	17.2
Esters	9.61	17.49
Terpenes	-	0.08
Acids	3.86	6.04
Ethers	1.89	0.44
Ketones	2.08	1.31
Miscellaneous	0.49	3.5
T o t a l	38.84	58.25

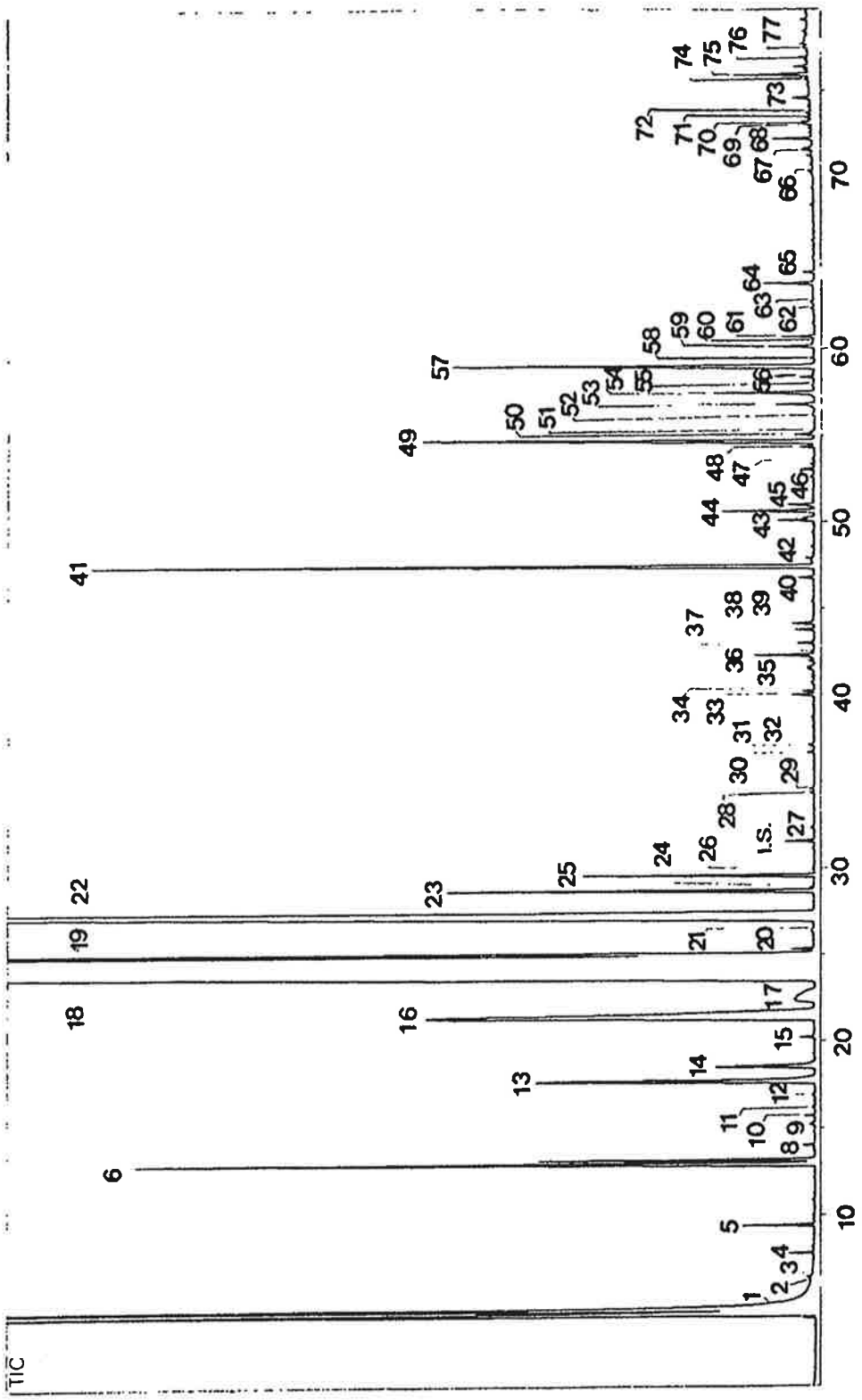

Fig. 19. GC chromatogram of volatile flavor components in Yuzu citrus

Table 25. Volatile flavor components in Yuzu citrus

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Acetaldehyde	4.942	697	C_2H_4O	44	0.01
2	2-Propanone	6.300	812	C_3H_6O	58	0.01
3	Ethyl formate	6.458	822	$C_3H_6O_2$	74	0.01
4	Ethyl acetate	7.825	889	$C_4H_8O_2$	88	0.03
5	Ethanol	9.433	943	C_2H_6O	46	0.11
6	α-Pinene	12.983	1025	$C_{10}H_{16}$	136	1.97
7	α-Thujene	13.192	1029	$C_{10}H_{16}$	136	0.60
8	2-Methyl-3-buten-2-ol	14.025	1043	$C_5H_{10}O$	86	0.02
9	Camphene	15.175	1062	$C_{10}H_{16}$	136	0.01
10	Butyl acetate	15.683	1072	$C_6H_{12}O_2$	116	0.02
11	Hexanal	16.150	1080	$C_6H_{12}O$	100	0.01
12	2-Methylpropanol	16.875	1093	$C_4H_{10}O$	74	0.01
13	2-β-Pinene	17.667	1107	$C_{10}H_{16}$	136	1.14
14	Sabinene	18.500	1117	$C_{10}H_{16}$	136	0.37
15	Butanol	20.225	1143	$C_4H_{10}O$	74	0.03
16	β-Myrcene	21.375	1160	$C_{10}H_{16}$	136	3.39
17	α-Terpinene	22.717	1175	$C_{10}H_{16}$	136	0.14
18	α-Limonene	24.867	1244	$C_{10}H_{16}$	136	68.11
19	β-Phellandrene	25.100	1246	$C_{10}H_{16}$	136	3.19
20	Butyl butanoate	25.325	1249	$C_8H_{16}O_2$	144	0.04

(continued)

21	*(Z)*-β-Ocimene	26.358	1260	$C_{10}H_{16}$	136	0.01
22	γ-Terpinene	27.433	1271	$C_{10}H_{16}$	136	11.96
23	*p*-Cymene	28.717	1283	$C_{10}H_{14}$	134	0.96
24	Hexyl acetate	28.900	1285	$C_8H_{16}O_2$	144	0.01
25	α-Terpinolene	29.592	1292	$C_{10}H_{16}$	136	0.57
26	Octanal	29.908	1296	$C_8H_{16}O$	128	0.01
I.S.	Butylbenzene	31.558	1317	$C_{10}H_{14}$	134	0.06
27	3-Methyl-2-buten-1-ol	32.308	1327	$C_5H_{10}O$	86	0.01
28	Butyl 2-butenoate	34.325	1353	$C_8H_{14}O_2$	142	0.01
29	Hexanol	34.550	1355	$C_6H_{14}O$	102	0.01
30	*(Z)*-3-Hexen-1-ol	36.650	1383	$C_6H_{12}O$	100	0.02
31	Nonanal	37.100	1388	$C_9H_{18}O$	142	0.02
32	Hexyl butanoate	38.667	1405	$C_{10}H_{20}O_2$	172	0.01
33	α-*p*-Dimethylstyrene	39.983	1416	$C_{10}H_{12}$	132	0.05
34	*p*-Mentha-1,5,8-triene	40.192	1435	$C_{10}H_{14}$	134	0.02
35	α-Cubebene	41.475	1471	$C_{15}H_{24}$	204	0.01
36	δ-Elemene	41.950	1477	$C_{15}H_{24}$	204	0.16
37	*(E)*-Linalool oxide	42.508	1482	$C_{10}H_{18}O_2$	170	0.01
38	α-Copaene	43.775	1500	$C_{15}H_{24}$	204	0.04
39	Decanal	44.122	1504	$C_{10}H_{20}O$	156	0.05
40	β-Cubebene	46.783	1534	$C_{15}H_{24}$	204	0.04
41	Linalool	47.467	1559	$C_{10}H_{18}O$	154	2.12

(continued)

42	α-Bergamotene	47.917	1563	$C_{15}H_{24}$	204	0.02
43	β-Elemene	50.100	1581	$C_{15}H_{24}$	204	0.09
44	*(E)*-β-Caryophyllene	50.642	1586	$C_{15}H_{24}$	204	0.26
45	Terpinen-4-ol	51.000	1589	$C_{10}H_{18}O$	154	0.08
46	γ-Elemene	53.050	1604	$C_{15}H_{24}$	204	0.03
47	(*E*)-2-Decenal	53.358	1632	$C_{10}H_{18}O$	154	0.01
48	*(Z)*-β-Farnesene	54.367	1658	$C_{15}H_{24}$	204	0.04
49	*(E)*-β-Farnesene	54.733	1667	$C_{15}H_{24}$	204	1.17
50	α-Humulene	55.075	1671	$C_{15}H_{24}$	204	0.05
51	Citronellyl acetate	55.233	1673	$C_{12}H_{22}O_2$	198	0.01
52	γ-Cadinene	56.217	1683	$C_{15}H_{24}$	204	0.01
53	α-Terpineol	56.808	1690	$C_{10}H_{18}O$	154	0.1
54	Germacrene D	57.492	1705	$C_{15}H_{24}$	204	0.29
55	δ-Guaiene	57.867	1712	$C_{15}H_{24}$	204	0.01
56	α-Amorphene	58.400	1722	$C_{15}H_{24}$	204	0.04
57	Unknown	59.008	1733			0.69
58	*(E,E)*-α-Farnesene	59.483	1741	$C_{15}H_{24}$	204	0.01
59	δ-Cadinene	60.175	1752	$C_{15}H_{24}$	204	0.11
60	γ-Cadinene	60.317	1755	$C_{15}H_{24}$	204	0.01
61	β-Sesquiphellandrene	60.733	1765	$C_{15}H_{24}$	204	0.07
62	Nerol	62.358	1797	$C_{10}H_{18}O$	154	0.01
63	*(E,E)*-2,4-Decadienal	62.750	1805	$C_{10}H_{16}O$	152	0.01

(continued)

64	Germacerene B	63.842	1825	$C_{15}H_{24}$	204	0.12
65	Geraniol	64.483	1850	$C_{10}H_{18}O$	154	0.03
66	Perilla alcohol	70.367	2001	$C_{10}H_{16}O$	152	0.01
67	*(Z)*-Nerolidol	71.575	2011	$C_{15}H_{26}O$	222	0.02
68	*(E)*-Nerolidol	72.258	2061	$C_{15}H_{26}O$	222	0.08
69	α-Cedrol	72.858	2079	$C_{15}H_{26}O$	222	0.01
70	Elemol	73.092	2086	$C_{15}H_{26}O$	222	0.02
71	Globuol	73.200	2089	$C_{15}H_{26}O$	222	0.02
72	Veridiflorol	73.483	2098	$C_{15}H_{26}O$	222	0.02
73	Spathulenol	74.600	2136	$C_{15}H_{26}O$	220	0.04
74	Eugenol	75.708	2174	$C_{10}H_{12}O_2$	164	0.01
75	*p*-Cymen-2-ol	75.983	2183	$C_{10}H_{14}O$	150	0.17
76	δ-Cadinol	76.783	1209	$C_{15}H_{26}O$	222	0.01
77	*(E,E)*-Farnesol	77.558	2233	$C_{15}H_{26}O$	222	0.02
	Total					99.08

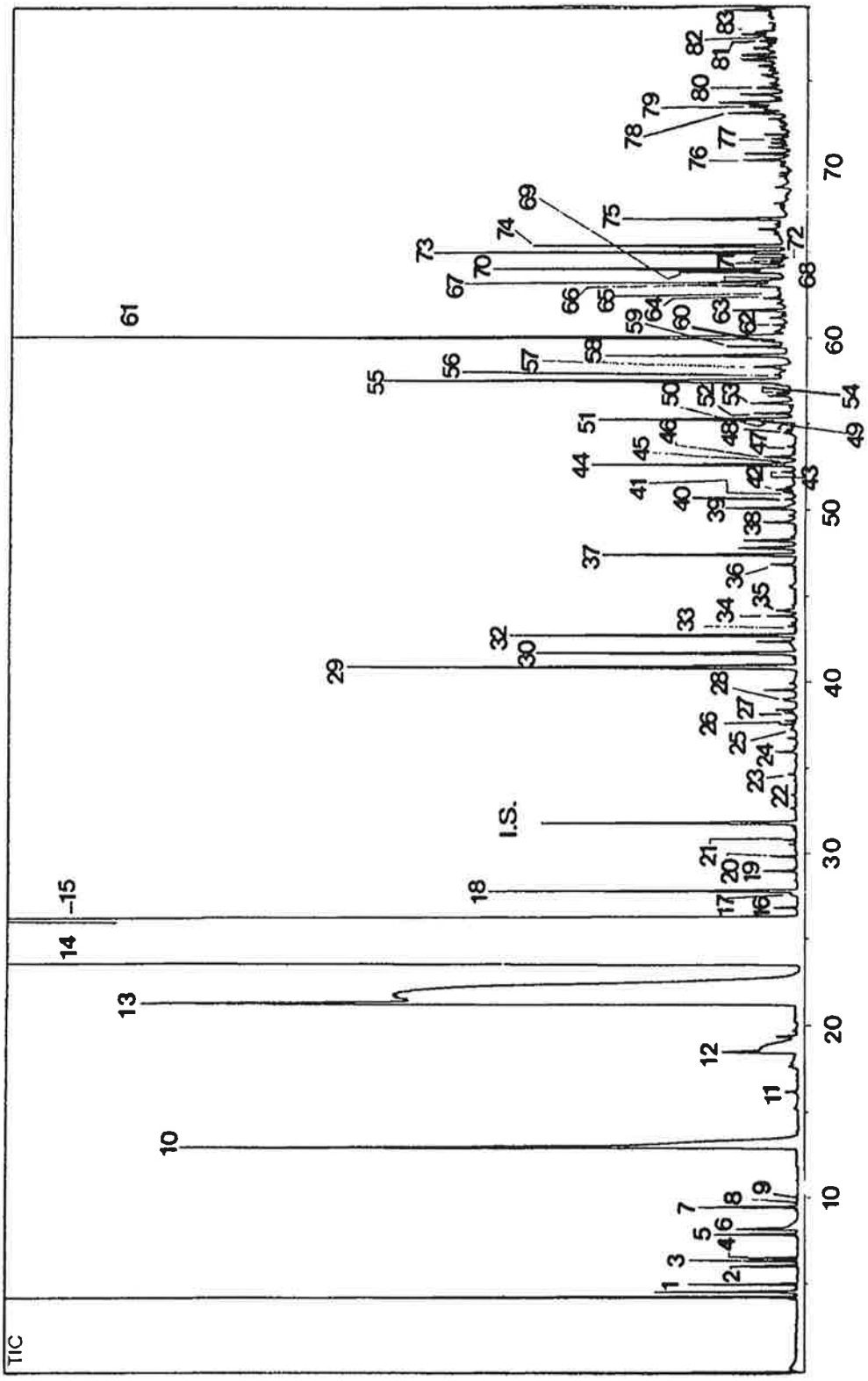

Fig. 20. GC chromatogram of volatile flavor components in Kumquats citrus

Tabke 26. Volatile flavor components in Kumquats citrus

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Acetaldehyde	4.983	697	C_2H_4O	44	0.07
2	Octane	6.033	793	C_8H_{18}	114	0.01
3	2-Propanone	6.325	820	C_3H_6O	58	0.04
4	Ethyl formate	6.492	828	$C_3H_6O_2$	74	0.03
5	Ethyl acetate	7.858	890	$C_4H_8O_2$	88	0.06
6	Nonane	8.150	895	C_9H_{20}	128	0.09
7	Ethanol	9.458	943	C_2H_6O	46	0.09
8	3-Buten-2-one	9.717	949	C_4H_6O	70	0.01
9	3-Methyl-1,3,5-hexatriene	10.025	956	C_7H_{10}	94	0.01
10	α-Pinene	12.958	1025	$C_{10}H_{16}$	136	1.72
11	Hexanal	16.195	1115	$C_6H_{12}O$	100	0.01
12	Sabinene	18.500	1123	$C_{10}H_{16}$	136	0.08
13	β-Myrcene	21.367	1167	$C_{10}H_{16}$	136	8.26
14	α-Limonene	24.667	1248	$C_{10}H_{16}$	136	79.09
15	β-Phellandrene	26.250	1256	$C_{10}H_{16}$	136	0.31
16	*(Z)*-β-Ocimene	26.825	1259	$C_{10}H_{16}$	136	0.02
17	γ-Terpinene	27.517	1263	$C_{10}H_{16}$	136	0.02
18	*(E)*-β-Ocimene	27.800	1264	$C_{10}H_{16}$	136	0.37
19	*p*-Cymene	28.967	1279	$C_{10}H_{14}$	134	0.04
20	α-Terpinolene	29.808	1291	$C_{10}H_{16}$	136	0.02

(continued)

21	Tridecane	30.800	1306	$C_{13}H_{28}$	184	0.01
I.S.	Butylbenzene	31.800	1316	$C_{10}H_{14}$	134	0.36
22	Hexanol	34.642	1360	$C_6H_{14}O$	102	0.01
23	Heptyl acetate	35.933	1378	$C_9H_{18}O_2$	158	0.02
24	*(Z)*-3-Hexen-1-ol	36.725	1392	$C_6H_{12}O$	100	0.01
25	Nonanal	37.217	1399	$C_9H_{18}O$	142	0.02
26	2,3,6-Trimethyl-1,5-heptadiene	37.742	1407	$C_{10}H_{18}$	138	0.02
27	*(E)*-2-Hexen-1-ol	38.208	1414	$C_6H_{12}O$	100	0.01
28	Perillene	38.933	1425	$C_{10}H_{14}O$	150	0.01
29	α-Limonene dioxide	40.900	1450	$C_{10}H_{16}O_2$	168	0.72
30	*(Z)*-2,7-Octadien-1-ol acetate	41.708	1462	$C_{10}H_{16}O_2$	168	0.39
31	δ-Elemene	42.358	1466	$C_{15}H_{24}$	204	0.04
32	Octyl acetate	42.742	1479	$C_{10}H_{20}O_2$	172	0.37
33	α-Ylangene	43.267	1492	$C_{15}H_{24}$	204	0.01
34	α-Copaene	43.858	1507	$C_{15}H_{24}$	204	0.04
35	Decanal	44.200	1516	$C_{10}H_{20}O$	156	0.03
36	β-Cubebene	46.842	1582	$C_{15}H_{24}$	204	0.03
37	Linalool	47.425	1553	$C_{10}H_{18}O$	154	0.26
38	Nonanyl acetate	49.300	1575	$C_{11}H_{22}O_2$	186	0.04
39	β-Elemene	50.108	1584	$C_{15}H_{24}$	204	0.10
40	*(E)*-β-Caryophyllene	50.633	1595	$C_{15}H_{24}$	204	0.01
41	Terpinen-4-ol	51.033	1604	$C_{10}H_{18}O$	154	0.01

(continued)

42	Aristolen	51.200	1607	$C_{15}H_{24}$	204	0.02
43	Calarene	52.225	1629	$C_{15}H_{24}$	204	0.02
44	Unknown	52.658	1637			0.30
45	β-Terpineol	52.792	1640	$C_{10}H_{18}O$	154	0.01
46	γ-Elemene	53.108	1645	$C_{15}H_{24}$	204	0.04
47	Myrcenyl acetate	53.700	1655	$C_{12}H_{22}O_2$	198	0.01
48	Citronellyl acetate	54.492	1668	$C_{12}H_{22}O_2$	198	0.01
49	*(E)*-β-Farnesene	54.658	1671	$C_{15}H_{24}$	204	0.01
50	α-Humulene	55.125	1678	$C_{15}H_{24}$	204	0.05
51	*p*-Mentha-*(E)*-2,8-dien-1-ol	55.283	1681	$C_{10}H_{16}O$	152	0.30
52	Decyl acetate	55.625	1682	$C_{12}H_{24}O_2$	200	0.05
53	*(Z)*-Citral	56.200	1685	$C_{10}H_{16}O$	152	0.07
54	α-Terpineol	56.825	1687	$C_{10}H_{18}O$	154	0.02
55	Germacrene D	57.558	1703	$C_{15}H_{24}$	204	0.78
56	δ-Guaiene	57.867	1708	$C_{15}H_{24}$	204	0.06
57	Neryl acetate	58.358	1716	$C_{12}H_{20}O_2$	196	0.07
58	Carvone	59.017	1726	$C_{10}H_{14}O$	150	0.28
59	*(E,E)*-α-Farnesene	59.525	1733	$C_{15}H_{24}$	204	0.07
60	1.1'-Bicyclopentyl-2-one	59.883	1739	$C_{10}H_{16}O$	152	0.03
61	Geranyl acetate	60.083	1741	$C_{12}H_{20}O_2$	196	1.32
62	β-Maaliene	60.783	1742	$C_{15}H_{24}$	204	0.02
63	Perillaldehyde	61.650	1787	$C_{10}H_{14}O$	150	0.08

(continued)

64	2-Methylen-5-isopropenylcyclo-hexanol	62.333	1792	$C_{10}H_{16}O$	152	0.03
65	Nerol	62.517	1800	$C_{10}H_{18}O$	154	0.01
66	*p*-Menth-8-en-2-ol acetate	63.067	1825	$C_{12}H_{20}O_2$	196	0.09
67	Geranyl propanoate	63.158	1827	$C_{13}H_{22}O_2$	210	0.03
68	*p*-Menth-1-en-9-al	63.333	1832	$C_{10}H_{16}O$	152	0.08
69	Germacrene B	63.867	1846	$C_{15}H_{24}$	204	0.13
70	*(E)*-Carveol	64.042	1851	$C_{10}H_{16}O$	152	0.38
71	*p*-Mentha-1,8-dien-3-one	64.333	1856	$C_{10}H_{14}O$	150	0.03
72	Geraniol	64.517	1858	$C_{10}H_{18}O$	154	0.02
73	*p*-Mentha-1,8-dien-9-ol	65.000	1866	$C_{10}H_{16}O$	152	0.43
74	*(Z)*-Carveol	65.375	1869	$C_{10}H_{16}O$	152	0.32
75	Unknown	66.933	1911			0.19
76	Perilla alcohol	70.392	2005	$C_{10}H_{16}O$	152	0.11
77	*(Z)*-Nerolidol	71.608	2041	$C_{15}H_{26}O$	222	0.03
78	Elemol	73.142	2098	$C_{15}H_{26}O$	222	0.07
79	Veridiflorol	73.508	2111	$C_{15}H_{26}O$	222	0.05
80	Spathulenol	74.633	2149	$C_{15}H_{24}O$	220	0.03
81	Guaiol	77.375	2238	$C_{15}H_{26}O$	222	0.02
82	α-Eudesmol	77.608	2245	$C_{15}H_{26}O$	222	0.02
83	β-Eudesmol	77.917	2254	$C_{15}H_{26}O$	222	0.01
	Total					98.57

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

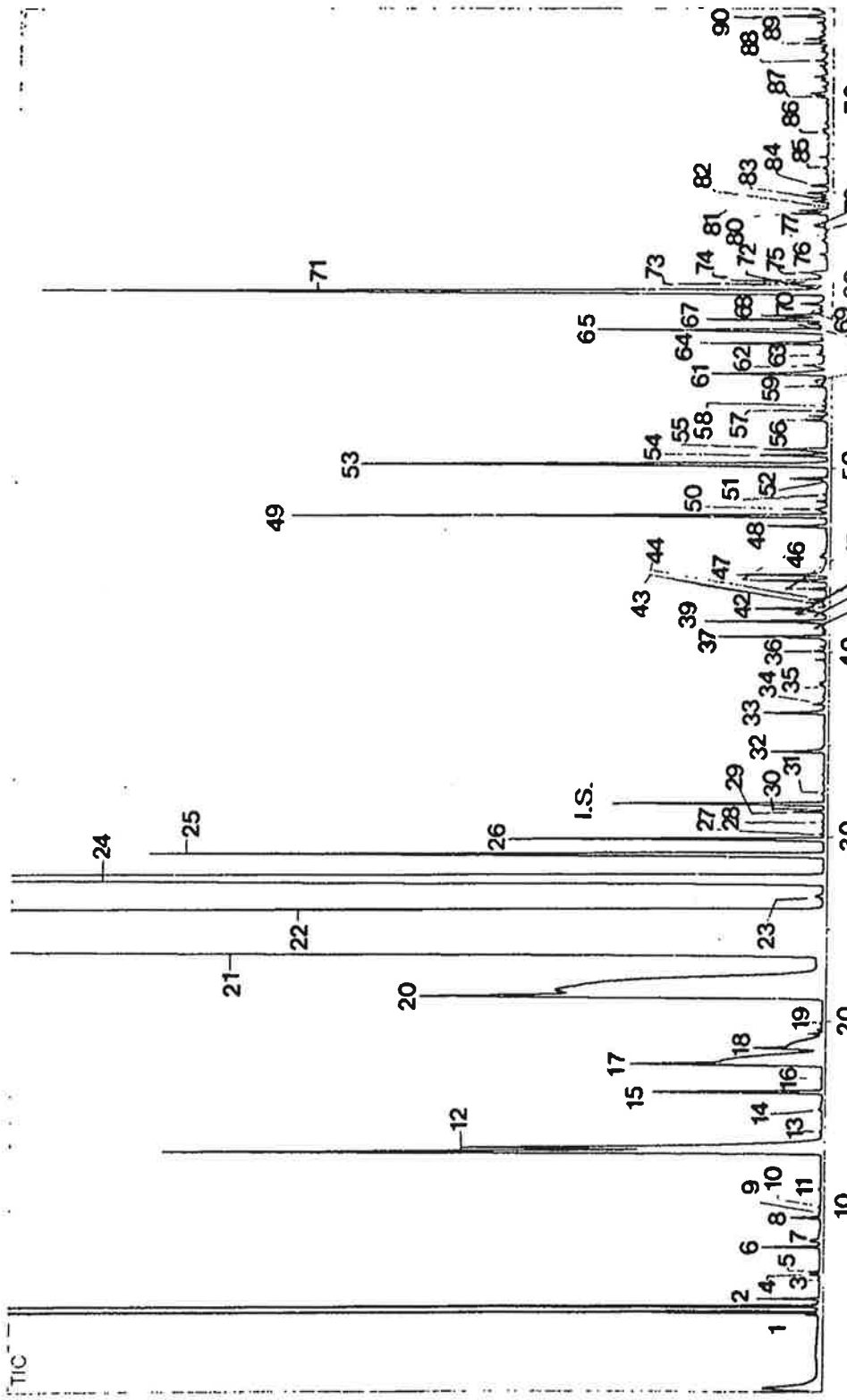

Fig. 21. GC chromatogram of volatile flavor components in Hyangsanchosaeng citrus

Table 27. Volatile flavor components in Hyangsanchosaeng citrus

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.725	530	$C_5H_{12}O$	88	0.01
2	Acetaldehyde	5.000	697	C_2H_4O	44	0.04
3	Octane	6.067	786	C_8H_{18}	114	0.01
4	2-Propanone	6.350	810	C_3H_6O	58	0.01
5	Ethyl formate	6.500	822	$C_3H_6O_2$	74	0.01
6	Ethyl acetate	7.867	890	$C_4H_8O_2$	88	0.05
7	Nonane	8.183	900	C_9H_{20}	128	0.02
8	Ethanol	9.467	943	C_2H_6O	46	0.03
9	3-Buten-2-one	9.733	949	C_4H_6O	70	0.01
10	2-Ethylfuran	10.000	955	C_6H_8O	96	0.01
11	Pentanal	11.000	977	$C_5H_{10}O$	86	0.01
12	α-Pinene	13.242	1028	$C_{10}H_{16}$	136	2.64
13	2-Methyl-3-buten-2-ol	14.058	1042	$C_5H_{10}O$	86	0.01
14	Camphene	15.250	1064	$C_{10}H_{16}$	136	0.01
15	Hexanal	16.200	1082	$C_6H_{12}O$	100	0.20
16	2-Methylpropanol	16.908	1091	$C_4H_{10}O$	74	0.01
17	2-β-Pinene	18.008	1104	$C_{10}H_{16}$	136	1.12
18	Sabinene	18.792	1117	$C_{10}H_{16}$	136	0.37
19	*(Z)*-3-Hexenal	19.892	1165	$C_6H_{10}O$	98	0.01
20	β-Myrcene	21.983	1182	$C_{10}H_{16}$	136	5.07

(continued)

21	α-Limonene	24.417	1248	$C_{10}H_{16}$	136	69.93
22	β-Phellandrene	26.100	1258	$C_{10}H_{16}$	136	0.26
23	*(Z)*-β-Ocimene	26.783	1262	$C_{10}H_{16}$	136	0.02
24	γ-Terpinene	27.942	1269	$C_{10}H_{16}$	136	9.21
25	*p*-Cymene	29.108	1283	$C_{10}H_{14}$	134	1.48
26	α-Terpinolene	29.917	1292	$C_{10}H_{16}$	136	0.49
27	Octanal	30.175	1296	$C_8H_{16}O$	128	0.01
28	Tridecane	30.833	1304	$C_{13}H_{28}$	184	0.01
29	3,6-Dimethyl-1,5-heptadiene	31.375	1312	C_9H_{16}	124	0.04
30	Propenyl acetate	31.475	1313	$C_5H_8O_2$	100	0.01
I.S.	Butylbenzene	31.833	1318	$C_{10}H_{14}$	134	0.35
31	*(Z)*-2-Penten-1-ol	32.325	1326	$C_5H_{10}O$	86	0.01
32	Hexanol	34.667	1365	$C_6H_{14}O$	102	0.09
33	*(Z)*-3-Hexen-1-ol	36.758	1395	$C_6H_{12}O$	100	0.11
34	Nonanal	37.217	1401	$C_9H_{18}O$	142	0.02
35	*(E)*-2-Hexen-1-ol	38.225	1415	$C_6H_{12}O$	100	0.01
36	α-*p*-Dimethylstyrene	40.083	1441	$C_{10}H_{12}$	132	0.02
37	α-Limonene dioxide	40.867	1451	$C_{10}H_{16}O_2$	168	0.16
38	Acetic acid	41.292	1457	$C_2H_4O_2$	60	0.01
39	2,7-Octadiene-1-ol-acetate	41.700	1462	$C_{10}H_{16}O_2$	168	0.19
40	Unknown	42.058	1464			0.01
41	3-Cyclohexen-1-aldehyde	42.250	1465	$C_7H_{10}O$	110	0.03

(continued)

42	δ-Elemene	42.392	1446	$C_{15}H_{24}$	204	0.10
43	Octyl acetate	42.717	1468	$C_{10}H_{20}O_2$	172	0.03
44	β-Citronellal	42.900	1469	$C_{10}H_{18}O$	154	0.03
45	Mytenol	43.467	1472	$C_{10}H_{16}O$	152	0.04
46	α-Copaene	43.908	1475	$C_{15}H_{24}$	204	0.11
47	Decanal	44.217	1486	$C_{10}H_{20}O$	156	0.15
48	β-Cubebene	46.883	1533	$C_{15}H_{24}$	204	0.09
49	Linalool	47.467	1556	$C_{10}H_{18}O$	154	0.86
50	*p*-Mentha-1,8-dien-9-ol	47.800	1559	$C_{10}H_{16}O$	152	0.02
51	*(Z)*-1-Methyl-4-(1-methylethyl)-2-cyclohexen-1-ol	48.600	1566	$C_{10}H_{18}O$	154	0.01
52	Nonanoyl acetate	49.325	1573	$C_{11}H_{22}O_2$	186	0.01
53	β-Elemene	50.267	1588	$C_{15}H_{24}$	204	1.04
54	*(Z)*-β-Caryophyllene	50.725	1600	$C_{15}H_{24}$	204	0.11
55	Terpinen-4-ol	51.042	1608	$C_{10}H_{18}O$	154	0.12
56	*p*-Menth-1-en-9-al	52.642	1632	$C_{10}H_{16}O$	152	0.04
57	γ-Elemene	53.117	1638	$C_{15}H_{24}$	204	0.02
58	*(E)*-2-Decenal	53.392	1641	$C_{10}H_{18}O$	154	0.01
59	Citronellyl acetate	54.475	1655	$C_{12}H_{22}O_2$	198	0.02
60	*(E)*-β-Farnesene	54.658	1657	$C_{15}H_{24}$	204	0.01
61	α-Humulene	55.158	1663	$C_{15}H_{24}$	204	0.22
62	Decyl acetate	55.617	1668	$C_{11}H_{22}O_2$	186	0.03
63	*(Z)*-Citral	56.225	1675	$C_{10}H_{16}O$	152	0.01

(continued)

64	α-Terpineol	56.883	1682	$C_{10}H_{18}O$	154	0.19
65	Germacrene D	57.567	1703	$C_{15}H_{24}$	204	0.48
66	δ-Guaiene	57.900	1708	$C_{15}H_{24}$	204	0.03
67	Valencene	58.133	1712	$C_{15}H_{24}$	204	0.20
68	Neryl acetate	58.342	1717	$C_{12}H_{20}O_2$	196	0.12
69	*(E)*-Citral	58.683	1725	$C_{10}H_{16}O$	152	0.01
70	Carvone	58.992	1733	$C_{10}H_{14}O$	150	0.03
71	*(E,E)*-α-Farnesene	59.700	1750	$C_{15}H_{24}$	204	1.92
72	1,1'-Bicyclopentyl-2-one	59.867	1752	$C_{10}H_{16}O$	152	0.01
73	Geranyl acetate	60.067	1755	$C_{12}H_{20}O_2$	196	0.20
74	δ-Cadinene	60.250	1758	$C_{15}H_{24}$	204	0.15
75	β-Citronellol	60.675	1764	$C_{10}H_{20}O$	156	0.07
76	Perillal	61.658	1779	$C_{10}H_{14}O$	150	0.01
77	Nerol	62.400	1803	$C_{10}H_{18}O$	154	0.01
78	2-Tridecanone	62.675	1811	$C_{13}H_{26}O$	198	0.01
79	Geranyl propanoate	63.142	1826	$C_{13}H_{22}O_2$	210	0.01
80	Germacrene B	63.883	1850	$C_{15}H_{24}$	204	0.05
81	*(E)*-Carveol	64.042	1854	$C_{10}H_{16}O$	152	0.04
82	Ethyl dodecanoate	64.208	1858	$C_{14}H_{28}O_2$	228	0.01
83	Geranylacetone	64.758	1871	$C_{18}H_{22}O$	194	0.02
84	*(Z)*-Carveol	65.375	1886	$C_{10}H_{16}O$	152	0.02
85	Farnesol	66.317	1908	$C_{15}H_{26}O$	222	0.01

(continued)

86	*p*-Menth-1-en-8-ol	68.242	1955	$C_{10}H_{18}O$	154	0.01
87	Caryophyllene oxide	70.225	2003	$C_{15}H_{24}O$	220	0.02
88	Limonene dioxide	72.667	2079	$C_{10}H_{16}O_2$	168	0.01
89	Elemol	73.125	2093	$C_{15}H_{26}O$	222	0.03
90	Spathulenol	74.625	2139	$C_{15}H_{24}O$	220	0.06
	Total					98.93

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

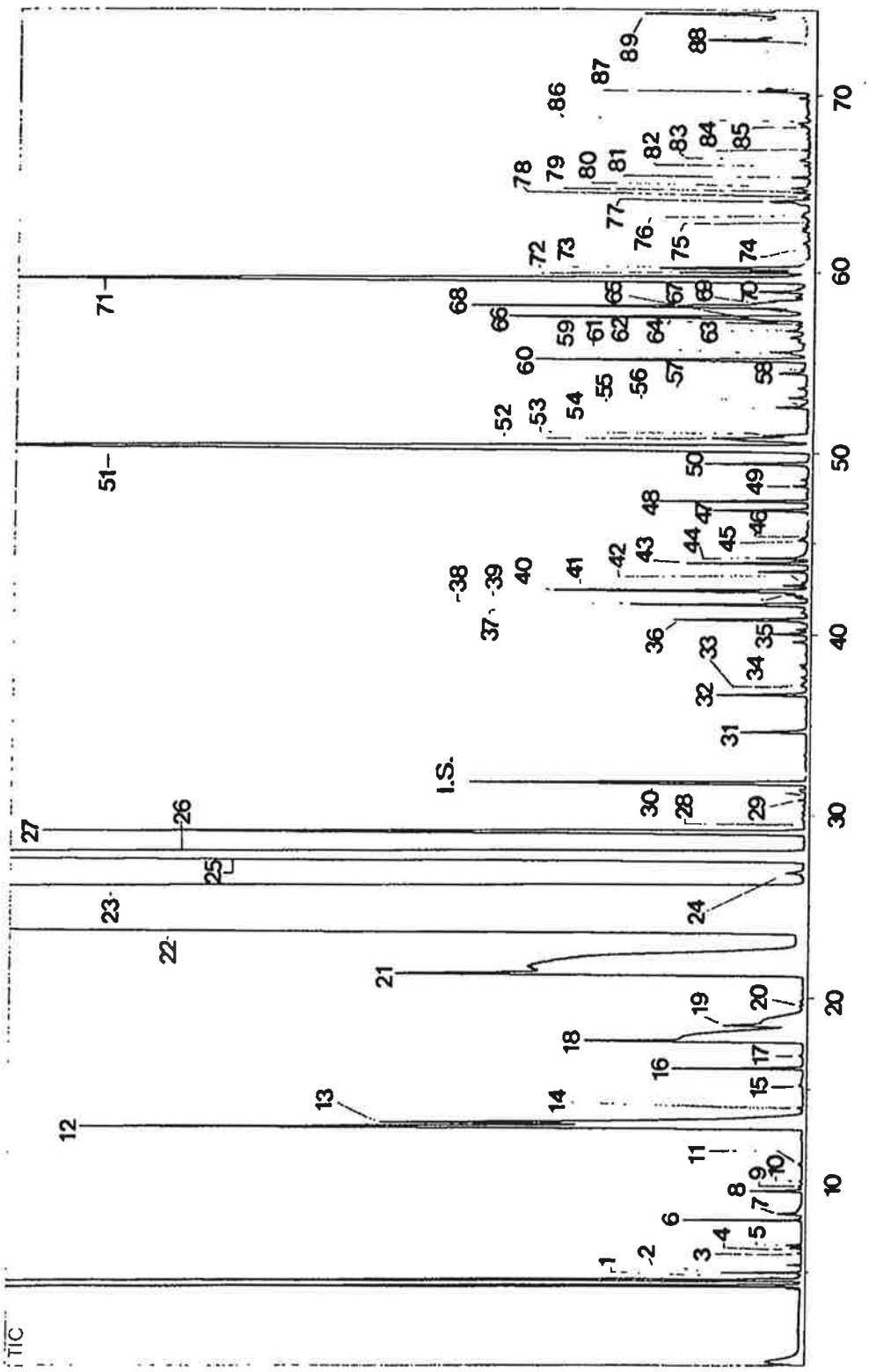

Fig. 22. GC chromatogram of volatile flavor components in Chosaeng citrus

Table 28. Volatile flavor components in Chosaeng citrus

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.717	530	$C_5H_{12}O$	88	0.01
2	Acetaldehyde	4.983	697	C_2H_4O	44	0.04
3	Octane	6.042	800	C_8H_{18}	114	0.01
4	2-Propanone	6.325	814	C_3H_6O	58	0.01
5	Ethyl formate	6.500	823	$C_3H_6O_2$	74	0.01
6	Ethyl acetate	7.850	890	$C_4H_8O_2$	88	0.08
7	Nonane	8.175	900	C_9H_{20}	128	0.03
8	Ethanol	9.450	943	C_2H_6O	46	0.05
9	3-Buten-2-one	9.700	948	C_4H_6O	70	0.01
10	2-Ethylfuran	9.975	954	C_6H_8O	96	0.01
11	2-Pentanone	10.925	975	$C_5H_{10}O$	86	0.01
12	α-Pinene	13.017	1023	$C_{10}H_{16}$	136	1.46
13	α-Thujene	13.225	1032	$C_{10}H_{16}$	136	1.26
14	2-Methyl-3-buten-2-ol	14.025	1046	$C_5H_{10}O$	86	0.01
15	Camphene	15.233	1066	$C_{10}H_{16}$	136	0.01
16	Hexanal	16.167	1082	$C_6H_{12}O$	100	0.14
17	2-Methylpropanol	16.883	1092	$C_4H_{10}O$	74	0.01
18	2-β-Pinene	17.683	1116	$C_{10}H_{16}$	136	1.30
19	Sabinene	18.692	1131	$C_{10}H_{16}$	136	0.44
20	*(Z)*-3-Hexenal	19.850	1156	$C_6H_{10}O$	98	0.01

(continued)

21	β-Myrcene	21.367	1184	$C_{10}H_{16}$	136	5.01
22	α-Limonene	24.483	1197	$C_{10}H_{16}$	136	63.92
23	β-Phellandrene	26.192	1230	$C_{10}H_{16}$	136	0.91
24	*(Z)*-β-Ocimene	26.825	1239	$C_{10}H_{16}$	136	0.03
25	γ-Terpinene	28.000	1255	$C_{10}H_{16}$	136	8.93
26	*(E)*-β-Ocimene	28.058	1256	$C_{10}H_{16}$	136	0.52
27	*p*-Cymene	29.167	1271	$C_{10}H_{14}$	134	1.63
28	α-Terpinolene	29.950	1282	$C_{10}H_{16}$	136	0.48
29	Octanal	30.200	1286	$C_8H_{16}O$	128	0.01
30	Tridecane	30.883	1300	$C_{13}H_{28}$	184	0.01
I.S.	Butylbenzene	31.875	1318	$C_{10}H_{14}$	134	0.59
31	Hexanol	34.667	1357	$C_6H_{14}O$	102	0.11
32	*(Z)*-3-Hexen-1-ol	36.733	1386	$C_6H_{12}O$	100	0.14
33	Nonanal	37.225	1393	$C_9H_{18}O$	142	0.02
34	*(E)*-2-Hexen-1-ol	38.200	1405	$C_6H_{12}O$	100	0.01
35	α-*p*-Dimethylstyrene	40.083	1426	$C_{10}H_{12}$	132	0.05
36	α-Limonene dioxide	40.850	1435	$C_{10}H_{16}O_2$	168	0.19
37	Acetic acid	41.208	1440	$C_2H_4O_2$	60	0.01
38	2,7-Octadiene-1-ol-acetate	41.692	1448	$C_{10}H_{16}O_2$	168	0.25
39	3-Cyclohexen-1-aldehyde	42.225	1456	$C_7H_{10}O$	110	0.03
40	δ-Elemene	42.450	1462	$C_{15}H_{24}$	204	0.39
41	Octyl acetate	42.708	1466	$C_{10}H_{20}O_2$	172	0.03

(continued)

42	β-Citronellal	42.875	1469	$C_{10}H_{18}O$	154	0.01
43	α-Copaene	43.925	1486	$C_{15}H_{24}$	204	0.16
44	Decanal	44.183	1491	$C_{10}H_{20}O$	156	0.07
45	1,4-Dimethyl-3-cyclohexenyl-methyl ketone	45.192	1507	$C_{10}H_{16}O$	152	0.01
46	1-Hydroxy linalool	45.308	1509	$C_{10}H_{18}O_2$	170	0.01
47	β-Cubebene	46.875	1534	$C_{15}H_{24}$	204	0.13
48	Linalool	47.383	1555	$C_{10}H_{18}O$	154	0.18
49	*p*-Mentha-1,8-dien-9-ol	47.775	1559	$C_{10}H_{16}O$	152	0.02
50	Unknown	49.442	1575			0.15
51	β-Elemene	50.450	1592	$C_{15}H_{24}$	204	3.39
52	*(E)*-β-Caryophyllene	50.850	1609	$C_{15}H_{24}$	204	0.29
53	Terpinen-4-ol	51.025	1611	$C_{10}H_{18}O$	154	0.06
54	1-*p*-Menth-1-en-9-al	52.608	1628	$C_{10}H_{16}O$	152	0.05
55	*(E)*-β-Terpineol	52.758	1629	$C_{10}H_{18}O$	154	0.01
56	γ-Elemene	53.125	1633	$C_{15}H_{24}$	204	0.03
57	Junipene	53.650	1641	$C_{15}H_{24}$	204	0.01
58	Citronellyl acetate	54.458	1653	$C_{12}H_{22}O_2$	198	0.04
59	*(E)*-β-Farnesene	54.683	1656	$C_{15}H_{24}$	204	0.01
60	α-Humulene	55.208	1664	$C_{15}H_{24}$	204	0.45
61	Decyl acetate	55.633	1669	$C_{11}H_{22}O_2$	186	0.05
62	*(Z)*-Citral	56.192	1674	$C_{10}H_{16}O$	152	0.01
63	α-Terpineol	56.808	1681	$C_{10}H_{18}O$	154	0.03

(continued)

64	β-Selinene	56.967	1686	$C_{15}H_{24}$	204	0.01
65	β-Chamigrene	57.150	1691	$C_{15}H_{24}$	204	0.01
66	Germacrene D	57.592	1704	$C_{15}H_{24}$	204	0.59
67	δ-Guaiene	57.967	1710	$C_{15}H_{24}$	204	0.05
68	Valencene	58.208	1714	$C_{15}H_{24}$	204	0.62
69	Neryl acetate	58.333	1717	$C_{12}H_{20}O_2$	196	0.08
70	Carvone	58.975	1730	$C_{10}H_{14}O$	150	0.07
71	*(E,E)*-α-Farnesene	59.750	1751	$C_{15}H_{24}$	204	2.47
72	Geranyl acetate	60.050	1756	$C_{12}H_{20}O_2$	196	0.16
73	δ-Cadinene	60.250	1760	$C_{15}H_{24}$	204	0.22
74	Undecyl acetate	61.392	1780	$C_{13}H_{26}O_2$	214	0.01
75	Geranyl propanoate	63.125	1823	$C_{13}H_{22}O_2$	210	0.01
76	Germacrene B	63.883	1850	$C_{15}H_{24}$	204	0.07
77	*(E)*-Carveol	64.017	1852	$C_{10}H_{16}O$	152	0.05
78	Ethyl dodecanoate	64.217	1856	$C_{14}H_{28}O_2$	228	0.01
79	Nerylacetone	64.508	1861	$C_{18}H_{22}O$	194	0.02
80	Geranylacetone	64.742	1865	$C_{18}H_{22}O$	194	0.03
81	*(Z)*-Carveol	65.350	1876	$C_{10}H_{16}O$	152	0.02
82	Dodecyl acetate	66.008	1888	$C_{14}H_{28}O_2$	228	0.01
83	Farnesol	66.300	1893	$C_{15}H_{26}O$	222	0.02
84	*(E)*-Pinocarveyl acetate	66.892	1905	$C_{12}H_{18}O_2$	194	0.01
85	*p*-Menth-1-en-9-ol	68.217	1941	$C_{10}H_{18}O$	154	0.01

(continued)

86	β-Ionone	68.342	1945	$C_{13}H_{20}O$	192	0.01
87	Caryophyllene oxide	70.225	1996	$C_{15}H_{24}O$	220	0.07
88	Elemol	73.125	2094	$C_{15}H_{26}O$	222	0.08
89	Spathulenol	74.617	2141	$C_{15}H_{24}O$	220	0.11
	Total					98.17

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

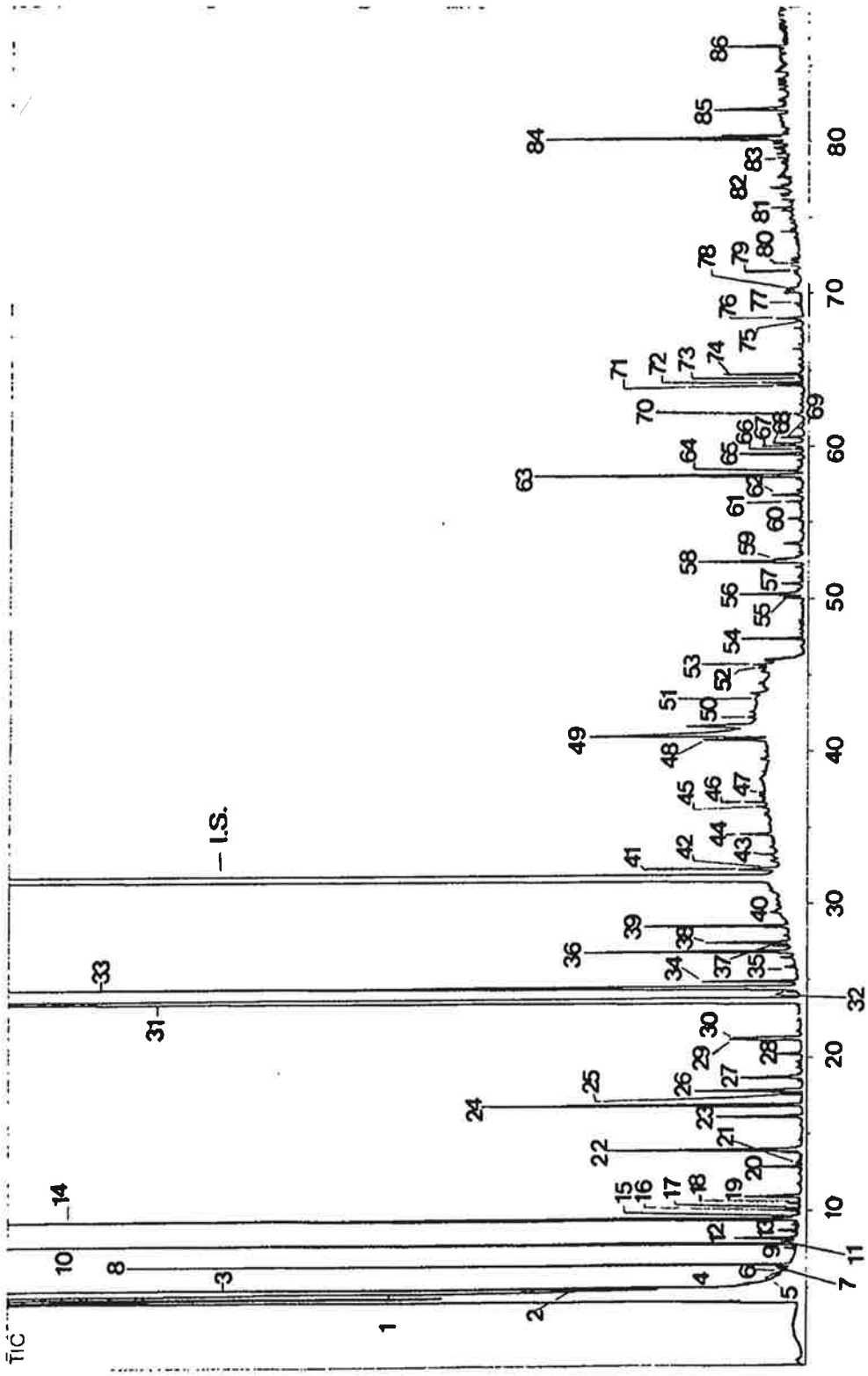

Fig. 23. GC chromatogram of volatile flavor components in Hyangsanchosaengmeat citrus

Table 29. Volatile flavor components in Hyangsanchosaengmeat citrus

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.692	525	$C_5H_{12}O$	88	0.23
2	3-Methyl-2-pentene	4.900	670	C_6H_{12}	84	0.02
3	Acetaldehyde	4.975	696	C_2H_4O	44	1.45
4	sec-Butyl ethyl ether	5.275	706	$C_6H_{14}O$	102	0.02
5	Propanal	5.917	787	C_3H_6O	58	0.02
6	Octane	6.017	800	C_8H_{18}	114	0.02
7	2-Propanone	6.325	814	C_3H_6O	58	0.02
8	Ethyl formate	6.483	821	$C_3H_6O_2$	74	1.59
9	Butanal	7.558	874	C_4H_8O	72	0.04
10	Ethyl acetate	7.858	889	$C_4H_8O_2$	88	3.27
11	Diethylacetal	8.000	896	$C_6H_{14}O_2$	118	0.05
12	Methanol	8.200	907	CH_4O	32	0.21
13	3-Methylbutanal	8.725	917	$C_5H_{10}O$	86	0.05
14	Ethanol	9.475	943	C_2H_6O	46	3.59
15	2,4-Dimethylhexane	9.650	947	C_8H_{18}	114	0.05
16	2-Ethylfuran	9.983	954	C_6H_8O	96	0.04
17	Ethyl propanoate	10.175	958	$C_5H_{10}O_2$	102	0.04
18	Ethyl 2-methylpropanoate	10.508	966	$C_6H_{12}O_2$	116	0.04
19	2-Pentanone	10.942	978	$C_5H_{10}O$	86	0.25
20	α-Pinene	12.900	1033	$C_{10}H_{16}$	136	0.16
21	α-Thujene	13.142	1036	$C_{10}H_{16}$	136	0.04

(continued)

22	Propanol	14.000	1046	C_3H_8O	60	0.84
23	Hexanal	16.183	1081	$C_6H_{12}O$	100	0.30
24	2-Methylpropanol	16.917	1100	$C_4H_{10}O$	74	1.21
25	2-β-Pinene	17.617	1108	$C_{10}H_{16}$	136	0.09
26	Propyl isopropyl ether	17.850	1111	$C_6H_{14}O$	102	0.53
27	2-Pentanol	18.717	1115	$C_5H_{12}O$	88	0.30
28	Butanol	20.250	1128	$C_4H_{10}O$	74	0.09
29	1-Penten-3-ol	21.200	1158	$C_5H_{10}O$	86	0.30
30	β-Myrcene	21.283	1158	$C_{10}H_{16}$	136	0.28
31	α-Limonene	23.808	1197	$C_{10}H_{16}$	136	20.18
32	β-Phellandrene	24.225	1208	$C_{10}H_{16}$	136	0.04
33	3-Methyl-1-butanol	24.542	1217	$C_5H_{12}O$	88	4.46
34	*(E)*-2-hexenal	24.908	1224	$C_6H_{10}O$	98	0.42
35	2-Pentylfuran	25.875	1229	$C_9H_{14}O$	138	0.05
36	γ-Terpinene	26.833	1239	$C_{10}H_{16}$	136	0.91
37	*(E)*-β-Ocimene	27.233	1245	$C_{10}H_{16}$	136	0.07
38	Pentanol	27.425	1247	$C_5H_{12}O$	88	0.37
39	*p*-Cymene	28.500	1263	$C_{10}H_{14}$	134	0.61
40	α-Terpinolene	29.442	1277	$C_{10}H_{16}$	136	0.04
I.S.	Butylbenzene	31.883	1314	$C_{10}H_{14}$	134	40.78
41	*(Z)*-2-Penten-1-ol	32.258	1329	$C_5H_{10}O$	86	0.18
42	3-Methyl-2-buten-1-ol	32.350	1330	$C_5H_{10}O$	86	0.09
43	6-Methyl-5-hepten-2-one	33.242	1343	$C_8H_{14}O$	126	0.05

(continued)

44	Hexanol	34.575	1363	$C_6H_{14}O$	102	0.16
45	2-Methylindan	36.383	1380	$C_{10}H_{12}$	132	0.07
46	*(Z)*-3-Hexen-1-ol	36.692	1384	$C_6H_{12}O$	100	0.11
47	*(E)*-1-Phenyl-1-butene	37.300	1391	$C_{10}H_{12}$	132	0.04
48	α-Limonene dioxide	40.775	1446	$C_{10}H_{16}O_2$	168	0.33
49	Acetic acid	41.458	1451	$C_2H_4O_2$	60	2.14
50	3-Cyclohexen-1-aldehyde	42.208	1471	$C_7H_{10}O$	110	0.05
51	α-Copaene	43.825	1490	$C_{15}H_{24}$	204	0.05
52	Camphor	45.492	1513	$C_{10}H_{16}O$	152	0.02
53	Benzaldehyde	45.692	1516	C_7H_6O	106	0.09
54	Linalool	47.400	1541	$C_{10}H_{18}O$	154	0.28
55	β-Elemene	50.083	1584	$C_{15}H_{24}$	204	0.09
56	1,2-Propanediol	50.325	1588	$C_3H_8O_2$	76	0.35
57	Terpinen-4-ol	51.008	1598	$C_{10}H_{18}O$	154	0.09
58	1,2-Ethanediol	52.467	1624	$C_2H_6O_2$	62	0.67
59	1-*p*-Menthen-9-al	52.650	1625	$C_{10}H_{16}O$	152	0.14
60	*p*-Mentha-*(E)*-2,8-dien-1-ol	55.258	1668	$C_{10}H_{16}O$	152	0.07
61	Caryophyllene	56.400	1686	$C_{15}H_{24}$	204	0.09
62	α-Terpineol	56.825	1693	$C_{10}H_{18}O$	154	0.16
63	Valencene	58.125	1711	$C_{15}H_{24}$	204	1.45
64	β-Chamigrene	58.425	1718	$C_{15}H_{24}$	204	0.05
65	*(E,E)*-α-Farnesene	59.517	1744	$C_{15}H_{24}$	204	0.28
66	1,1'-Bicyclopenty-2-one	59.817	1746	$C_{10}H_{16}O$	152	0.02

(continued)

67	*(E)*-Geranyl acetate	60.017	1753	$C_{12}H_{20}O_2$	196	0.04
68	1,1'-Bicyclopentyl-1-ol	60.117	1755	$C_{10}H_{18}O$	154	0.09
69	δ-Cadinene	60.592	1764	$C_{15}H_{24}$	204	0.11
70	1-Phenyl-1-butanone	62.142	1793	$C_{10}H_{12}O$	148	0.02
71	*(E)*-Carveol	64.033	1842	$C_{10}H_{16}O$	152	0.12
72	Ethyl dodecanoate	64.225	1855	$C_{14}H_{28}O_2$	228	0.16
73	*p*-Cymene-8-ol	64.567	1857	$C_{10}H_{14}O$	150	0.02
74	*(E)*-Geranylacetone	64.775	1863	$C_{18}H_{22}O$	194	0.32
75	*p*-Menth-1-en-8-ol	68.200	1946	$C_{10}H_{18}O$	154	0.02
76	β-Ionone	68.375	1951	$C_{13}H_{20}O$	192	0.12
77	1-Phenyl-1-butanol	69.350	1982	$C_{10}H_{14}O$	150	0.04
78	β-Ionone oxide	70.342	2014	$C_{13}H_{20}O_2$	208	0.07
79	Isopropyl tetradecanoate	71.500	2049	$C_{17}H_{34}O_2$	270	0.04
80	4-Tetradecanol	74.067	2131	$C_{14}H_{30}O$	214	0.05
81	Tetradecanol	75.658	2186	$C_{14}H_{30}O$	214	0.07
82	Pentadecanol	77.192	2229	$C_{15}H_{32}O$	228	0.14
83	Ethyl 9-hexadecenoate	78.958	2289	$C_{18}H_{34}O_2$	282	0.04
84	Hexadecanol	79.958	2316	$C_{16}H_{34}O$	242	1.58
85	Farnesylacetone	82.175	2393	$C_{18}H_{30}O$	262	0.42
86	Ethyl (*Z*)-9-octadecenoate	86.300	2488	$C_{20}H_{38}O_2$	310	0.30
	Total					93.82

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

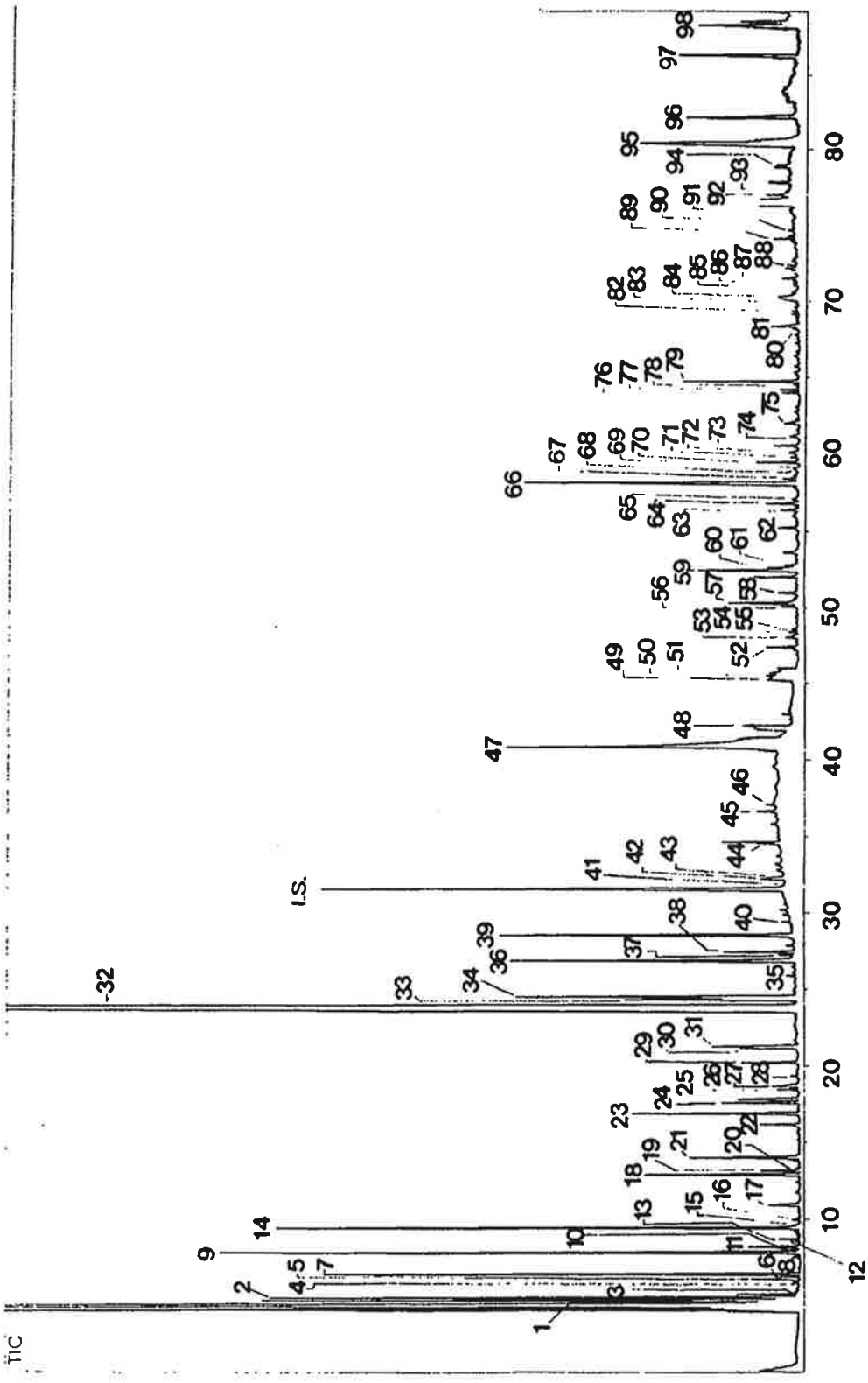

Fig. 24. GC chromatogram of volatile flavor components in Chosaengmeat citrus

Table 30. Volatile flavor components in Chosaengmeat citrus

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.683	520	$C_5H_{12}O$	88	0.59
2	Acetaldehyde	4.967	697	C_2H_4O	44	2.18
3	sec-Butyl ethyl ether	5.267	707	$C_6H_{14}O$	102	0.03
4	Propanal	5.900	792	C_3H_6O	58	0.03
5	Octane	6.008	800	C_8H_{18}	114	0.06
6	2-Propanone	6.317	814	C_3H_6O	58	0.08
7	Ethyl formate	6.475	823	$C_3H_6O_2$	74	2.16
8	Butanal	7.550	875	C_4H_8O	72	0.03
9	Ethyl acetate	7.850	891	$C_4H_8O_2$	88	3.25
10	Diethylacetal	7.983	898	$C_6H_{14}O_2$	118	0.08
11	Methanol	8.192	908	CH_4O	32	0.31
12	2-Methylbutanal	8.583	913	$C_5H_{10}O$	86	0.03
13	3-Methylbutanal	8.717	917	$C_5H_{10}O$	86	0.11
14	Ethanol	9.467	944	C_2H_6O	46	3.22
15	2,4-Diemthylhexane	9.642	948	C_8H_{18}	114	0.03
16	2-Ethylfuran	9.975	956	C_6H_8O	96	0.06
17	2-Pentanone	10.933	979	$C_5H_{10}O$	86	0.25
18	α-Pinene	12.908	1015	$C_{10}H_{16}$	136	0.98
19	α-Thujene	13.150	1020	$C_{10}H_{16}$	136	0.22
20	2-Butanol	13.317	1025	$C_4H_{10}O$	74	0.03

(continued)

21	Propanol	13.992	1046	C_3H_8O	60	0.84
22	Hexanal	16.183	1080	$C_6H_{12}O$	100	0.25
23	2-Methylpropanol	16.908	1100	$C_4H_{10}O$	74	1.09
24	2-β-Pinene	17.625	1112	$C_{10}H_{16}$	136	0.53
25	Propyl isopropyl ether	17.850	1115	$C_6H_{14}O$	102	0.50
26	Sabinene	18.475	1124	$C_{10}H_{16}$	136	0.14
27	2-Pentanol	18.708	1128	$C_5H_{12}O$	88	0.25
28	*p*-Menth-1-ene	19.375	1139	$C_{10}H_{18}$	138	0.06
29	Butanol	20.250	1153	$C_4H_{10}O$	74	0.39
30	1-Penten-3-ol	21.200	1157	$C_5H_{10}O$	86	0.39
31	β-Myrcene	21.300	1158	$C_{10}H_{16}$	136	0.64
32	α-Limonene	23.983	1204	$C_{10}H_{16}$	136	39.00
33	β-Phellandrene	24.342	1214	$C_{10}H_{16}$	136	1.20
34	3-Methyl-1-butanol	24.542	1219	$C_5H_{12}O$	88	2.74
35	2-Pentylfuran	25.875	1231	$C_9H_{14}O$	138	0.06
36	γ-Terpinene	26.892	1241	$C_{10}H_{16}$	136	2.55
37	*(E)*-β-Ocimene	27.250	1245	$C_{10}H_{16}$	136	0.14
38	Pentanol	27.442	1247	$C_5H_{12}O$	88	0.53
39	*p*-Cymene	28.558	1266	$C_{10}H_{14}$	134	2.41
40	α-Terpinolene	29.417	1276	$C_{10}H_{16}$	136	0.06
I.S.	Butylbenzene	31.592	1309	$C_{10}H_{14}$	134	4.51
41	*(E)*-2-Penten-1-ol	31.708	1313	$C_5H_{10}O$	86	0.03

(continued)

42	*(Z)*-2-Penten-1-ol	32.242	1329	$C_5H_{10}O$	86	0.20
43	3-Methyl-2-buten-1-ol	32.342	1331	$C_5H_{10}O$	86	0.11
44	Hexanol	34.575	1365	$C_6H_{14}O$	102	0.28
45	*(Z)*-3-Hexen-1-ol	36.683	1395	$C_6H_{12}O$	100	0.17
46	Nonanal	37.117	1397	$C_9H_{18}O$	142	0.08
47	Acetic acid	40.817	1449	$C_2H_4O_2$	60	4.79
48	3-Cyclohexen-1-aldehyde	42.242	1472	$C_7H_{10}O$	110	0.14
49	1,4-Dimethyl-3-cyclohexenyl-methyl ketone	45.267	1515	$C_{10}H_{16}O$	152	0.11
50	Camphor	45.500	1521	$C_{10}H_{16}O$	152	0.22
51	Benzaldehyde	45.692	1526	C_7H_6O	106	0.14
52	Linalool	47.400	1561	$C_{10}H_{18}O$	154	0.22
53	*p*-Mentha-1,8-dien-9-ol	48.050	1571	$C_{10}H_{16}O$	152	0.11
54	Octanol	48.225	1574	$C_8H_{18}O$	130	0.03
55	Perilla alcohol	48.400	1577	$C_{10}H_{16}O$	152	0.06
56	β-Elemene	50.092	1603	$C_{15}H_{24}$	204	0.11
57	1,2-Propanediol	50.342	1607	$C_3H_8O_2$	76	0.62
58	Terpinen-4-ol	51.000	1620	$C_{10}H_{18}O$	154	0.17
59	1,2-Ethanediol	52.475	1637	$C_2H_6O_2$	62	1.09
60	1-*p*-Menth-1-en-9-al	52.642	1639	$C_{10}H_{16}O$	152	0.25
61	β-Terpineol	52.800	1641	$C_{10}H_{18}O$	154	0.11
62	*p*-Mentha-2,8-dien-1-ol	55.267	1665	$C_{10}H_{16}O$	152	0.17
63	Caryophyllene	56.408	1676	$C_{15}H_{24}$	204	0.14

(continued)

64	α-Terpineol	56.825	1680	$C_{10}H_{18}O$	154	0.31
65	δ-Guaiene	57.108	1687	$C_{15}H_{24}$	204	0.03
66	Valencene	58.183	1714	$C_{15}H_{24}$	204	2.97
67	β-Chamigrene	58.450	1720	$C_{15}H_{24}$	204	0.14
68	Carvone	58.983	1733	$C_{10}H_{14}O$	150	0.03
69	Germacrene B	59.117	1736	$C_{15}H_{24}$	204	0.03
70	*(E,E)*-α-Farnesene	59.517	1745	$C_{15}H_{24}$	204	0.31
71	1,1'-Bicyclopenty-2-one	59.825	1748	$C_{10}H_{16}O$	152	0.06
72	1,1'-Bicyclopentyl-1-ol	60.117	1751	$C_{10}H_{18}O$	154	0.08
73	δ-Cadinene	60.592	1755	$C_{15}H_{24}$	204	0.20
74	Nerol	61.267	1777	$C_{10}H_{18}O$	154	0.03
75	1-Phenyl-1-butanone	62.133	1803	$C_{10}H_{12}O$	148	0.06
76	*(E)*-Carveol	64.033	1850	$C_{10}H_{16}O$	152	0.11
77	Ethyl dodecanoate	64.225	1855	$C_{14}H_{28}O_2$	228	0.11
78	*p*-Cymene-8-ol	64.550	1860	$C_{10}H_{14}O$	150	0.03
79	Geranylacetone	64.775	1864	$C_{18}H_{22}O$	194	0.78
80	*p*-Menth-1-en-9-ol	68.200	1948	$C_{10}H_{18}O$	154	0.03
81	β-Ionone	68.375	1953	$C_{13}H_{20}O$	192	0.22
82	Dodecanol	69.175	1974	$C_{12}H_{26}O$	186	0.06
83	1-Phenyl-1-butanol	69.342	1979	$C_{10}H_{14}O$	150	0.03
84	β-Ionone dioxide	70.333	2007	$C_{13}H_{20}O_2$	208	0.17
85	Methyl tetradecanoate	70.625	2014	$C_{15}H_{30}O_2$	242	0.03

(continued)

86	2-Heptadecanone	71.017	2026	$C_{17}H_{34}O$	254	0.06
87	Isopropyl tetradecanoate	71.492	2041	$C_{17}H_{34}O_2$	270	0.14
88	Tridecanol	72.592	2074	$C_{13}H_{28}O$	200	0.06
89	4-Tetradecanol	74.075	2121	$C_{14}H_{30}O$	214	0.14
90	Tetradecanol	74.258	2127	$C_{14}H_{30}O$	214	0.03
91	Thymol	76.033	2189	$C_{10}H_{14}O$	150	0.03
92	Methyl hexadecanoate	76.967	2218	$C_{17}H_{34}O_2$	270	0.28
93	Pentadecanol	77.208	2225	$C_{15}H_{32}O$	228	0.03
94	Ethyl 9-hexadecenoate	78.967	2275	$C_{18}H_{34}O_2$	282	0.11
95	Hexadecanol	80.467	2318	$C_{16}H_{34}O$	242	3.72
96	Farnesylacetone	82.200	2374	$C_{18}H_{30}O$	262	0.70
97	Ethyl (*Z*)-9-octadecenoate	86.367	2478	$C_{20}H_{38}O_2$	310	1.18
98	Octadecanol	87.950	2515	$C_{18}H_{38}O$	270	1.23
	Total					94.86

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 31. Relative content of functional groups in Citrus

Peak area%

Functional group	Yuzu	Kumquats	Hyangsan chosaeng	Chosaeng	Hyangsan chosaeng meat	Chosaeng meat
Aldehydes	0.12	0.36	0.58	0.39	2.61	3.32
Alcohols	2.98	2.25	1.76	0.93	15.66	19.08
Esters	0.14	2.49	0.69	0.75	5.52	7.26
Terpenes	94.04	91.32	95.13	93.17	23.93	49.39
Acids	-	-	0.01	0.01	2.14	4.79
Ethers	-	-	0.01	0.01	0.78	1.12
Ketones	0.01	0.39	0.09	0.17	1.24	2.54
Miscellaneous	1.04	0.91	0.3	2.0	1.3	2.88
T o t a l	98.33	97.72	98.57	97.43	53.18	90.38

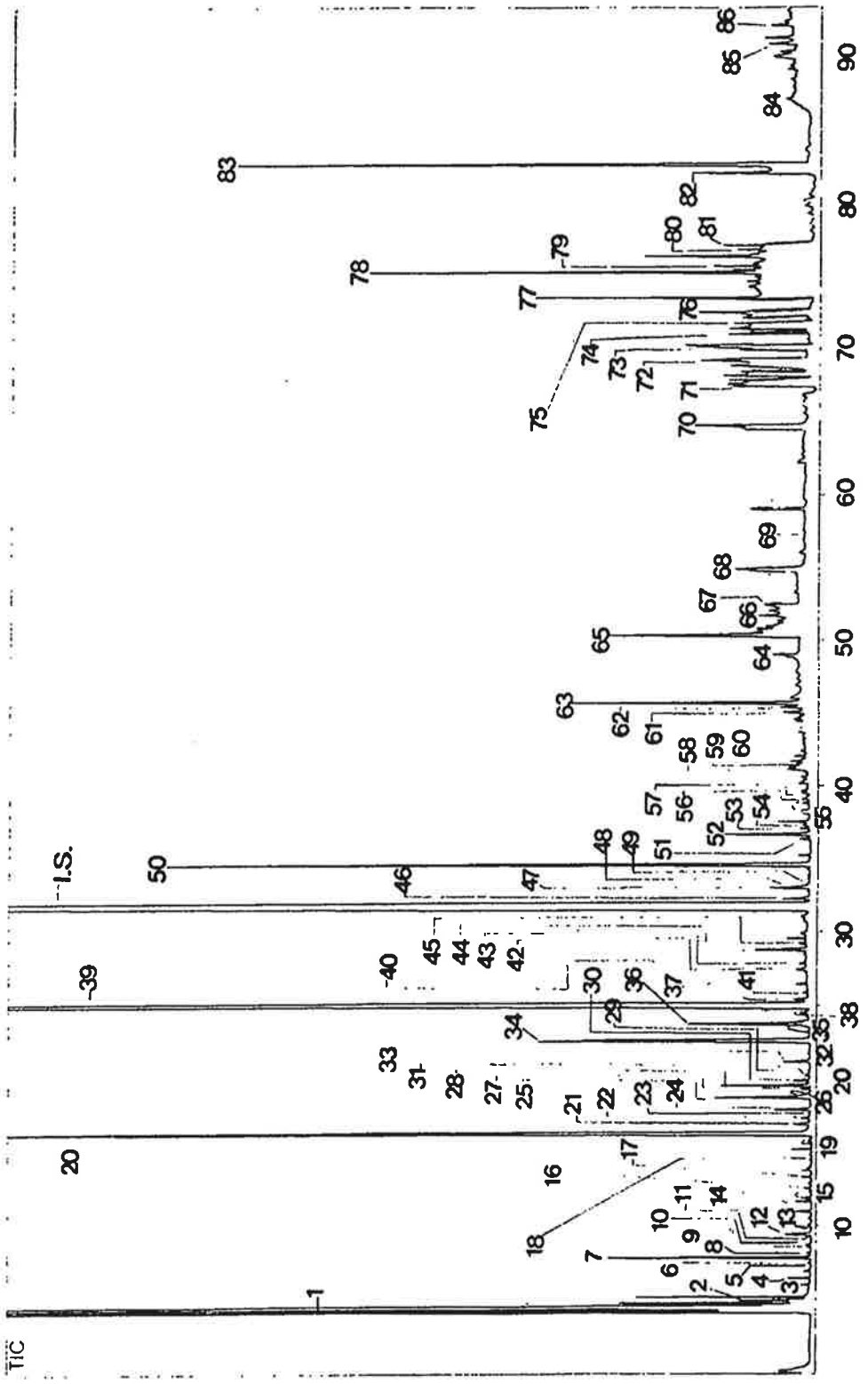

Fig. 25. GC chromatogram of volatile flavor components in Bekdo peach

Table 32. Volatile flavor components in Bekdo peach

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.692	527	$C_5H_{12}O$	88	0.13
2	Ethyl propyl ether	4.974	620	$C_5H_{12}O$	88	0.16
3	Ethyl butyl ether	5.992	750	$C_6H_{14}O$	102	0.02
4	Ethyl formate	6.483	821	$C_3H_6O_2$	74	0.07
5	2-Methyltetrahydrofuran	7.442	868	$C_5H_{10}O$	86	0.01
6	Butanal	7.558	874	C_4H_8O	72	0.01
7	Ethyl acetate	7.850	888	$C_4H_8O_2$	88	0.61
8	Nonane	8.158	900	C_9H_{20}	128	0.01
9	2-Methylbutanal	8.575	911	$C_5H_{10}O$	86	0.01
10	3-Methylbutanal	8.717	915	$C_5H_{10}O$	86	0.02
11	2-Propanol	9.217	934	C_3H_8O	60	0.01
12	Ethanol	9.442	942	C_2H_6O	46	0.09
13	2-Ethylfuran	9.975	955	C_6H_8O	96	0.01
14	Pentanal	10.975	978	$C_5H_{10}O$	86	0.06
15	Decane	11.883	1000	$C_{10}H_{22}$	142	0.03
16	2-Methylpropyl acetate	12.533	1009	$C_6H_{12}O_2$	116	0.02
17	2-Butanol	13.300	1023	$C_4H_{10}O$	74	0.03
18	3-Hexanone	14.483	1039	$C_6H_{12}O$	100	0.01
19	Dimethyl disulfide	15.675	1068	$C_2H_6S_2$	94	0.01
20	Hexanal	16.300	1080	$C_6H_{12}O$	100	10.49
21	2-Methylpropanol	16.900	1097	$C_4H_{10}O$	74	0.07

(continued)

22	Undecane	17.293	1100	$C_{11}H_{24}$	156	0.05
23	2-β-Pinene	17.617	1111	$C_{10}H_{16}$	136	0.01
24	3-Pentanol	17.883	1120	$C_5H_{12}O$	88	0.16
25	2-Pentanol	18.708	1128	$C_5H_{12}O$	88	0.45
26	*(E)*-2-Pentenal	18.958	1133	C_5H_8O	84	0.01
27	*p*-Xylene	19.300	1138	C_8H_{10}	106	0.03
28	*(E)*-Allyl propenyl ether	19.550	1142	$C_6H_{10}O$	98	0.38
29	*m*-Xylene	19.717	1144	C_8H_{10}	106	0.01
30	2-Methyl-4-pentenal	19.875	1146	$C_6H_{10}O$	98	0.07
31	Butanol	20.242	1152	$C_4H_{10}O$	74	0.02
32	3-Heptanone	20.592	1157	$C_7H_{14}O$	114	0.01
33	1-Penten-3-ol	21.183	1165	$C_5H_{10}O$	86	0.14
34	o-Xylene	22.583	1178	C_8H_{10}	106	1.48
35	α-Limonene	23.608	1195	$C_{10}H_{16}$	136	0.05
36	*(Z)*-3-Hexenal	23.775	1198	$C_6H_{10}O$	98	0.66
37	Dodecane	23.933	1200	$C_{12}H_{26}$	170	0.06
38	2-Methyl-1-butanol	24.508	1209	$C_5H_{12}O$	88	0.02
39	*(E)*-2-Hexenal	25.158	1220	$C_6H_{10}O$	98	19.10
40	*p*-Ethyltoluene	25.417	1223	C_9H_{12}	120	0.08
41	2-Pentylfuran	25.867	1228	$C_9H_{14}O$	138	0.01
42	Pentanol	27.417	1241	C_5H_8O	88	0.03
43	*m*-Ethyl toluene	27.850	1245	C_9H_{12}	120	0.02
44	Hexyl acetate	28.775	1253	$C_8H_{16}O_2$	114	0.31

(continued)

45	o -Ethyltoluene	29.217	1272	C_9H_{12}	120	0.05
I.S.	Butylbenzene	31.958	1306	$C_{10}H_{14}$	134	34.52
46	*(Z)*-2-Penten-1-ol	32.258	1323	$C_5H_{10}O$	86	0.16
47	*(E)*-2-Hexenyl acetate	33.025	1335	$C_8H_{14}O_2$	142	0.21
48	*o*-Propyltoluene	33.108	1336	$C_{10}H_{14}$	134	0.01
49	6-Methyl-5-hepten-2-one	33.258	1339	$C_8H_{14}O$	126	0.01
50	Hexanol	34.642	1361	$C_6H_{14}O_2$	102	4.03
51	2-Methylindane	36.392	1387	$C_{10}H_{12}$	132	0.06
52	*(Z)*-3-Hexen-1-ol	36.692	1391	$C_6H_{12}O_2$	100	0.52
53	Nonanal	37.092	1397	$C_9H_{18}O_2$	142	0.05
54	1-Methylindane	37.308	1398	$C_{10}H_{12}$	132	0.02
55	*(E)*-2-Hexen-1-ol	38.217	1414	$C_7H_{12}O_3$	100	3.15
56	Decanal	39.100	1426	$C_{10}H_{20}O$	156	0.01
57	2,6-Dimethyl-2-octanol	39.692	1434	$C_{10}H_{22}O$	158	0.02
58	Acetic acid	41.158	1455	$C_2H_4O_2$	60	0.12
59	Furfural	41.683	1462	$C_5H_4O_2$	96	0.12
60	*(E,E)*-2,4-Heptadienal	41.883	1464	$C_7H_{10}O$	110	0.01
61	3-Nonen-2-one	45.058	1514	$C_9H_{16}O$	140	0.14
62	Benzyl alcohol	45.383	1517	C_7H_8O	108	0.21
63	Benzaldehyde	45.683	1520	C_7H_6O	106	1.54
64	*(E,E)*-3,5-Octadien-2-one	49.050	1575	$C_8H_{12}O$	124	0.10
65	1,2-Propanediol	50.387	1597	$C_3H_8O_2$	76	1.71
66	o-Tolualdehyde	51.733	1610	C_8H_8O	120	0.14

(continued)

67	1,2-Ethanediol	52.517	1623	$C_2H_6O_2$	62	0.20
68	Estragole	54.983	1663	$C_{10}H_{12}O$	148	0.36
69	γ-Hexalactone	56.983	1699	$C_6H_{10}O_2$	114	0.01
70	Nerylacetone	64.775	1863	$C_{13}H_{22}O$	194	0.52
71	γ-Octalactone	67.458	1917	$C_8H_{14}O_2$	142	0.12
72	Dodecanol	69.250	1982	$C_{12}H_{26}O$	186	0.28
73	o-Methylbenzyl alcohol	70.175	1998	$C_8H_{10}O$	122	0.33
74	2-Tetradecanol	71.058	2006	$C_{14}H_{30}O$	242	0.14
75	Isopropyl tetradecanoate	71.542	2033	$C_{17}H_{34}O_2$	270	0.10
76	3-Thujen-2-one	72.545	2066	$C_{10}H_{14}O$	150	0.32
77	Unknown	73.508	2098			1.00
78	γ-Decalactone	75.258	2167	$C_{10}H_{18}O_2$	170	1.98
79	Tetradecanol	75.708	2179	$C_{14}H_{30}O$	242	0.24
80	δ-Undecalactone	76.842	2216	$C_{11}H_{20}O_2$	184	0.17
81	2-Hexadecanol	77.133	2226	$C_{16}H_{34}$	242	0.22
82	Farnesylacetone	82.158	2394	$C_{18}H_{26}O$	262	0.49
83	γ-Dodecalactone	82.742	2405	$C_{12}H_{22}O_2$	198	3.75
84	Phenylketone	87.367	2513	$C_{13}H_{10}O$	182	0.02
85	Octadecanol	91.292	2592	$C_{18}H_{38}$	270	0.10
86	Phytol	92.558	2616	$C_{20}H_{40}O$	296	0.13
	Total					92.44

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

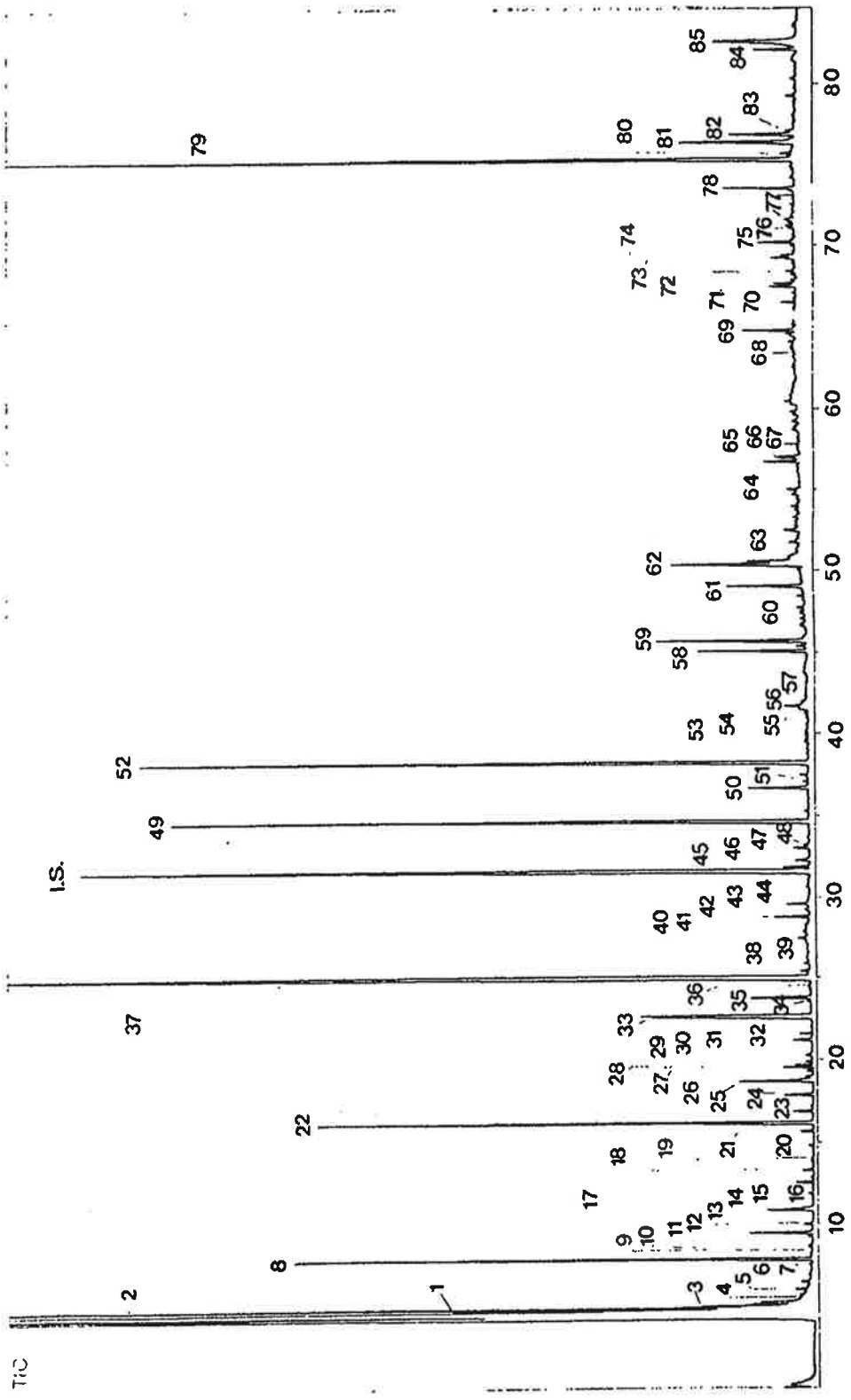

Fig. 26. GC chromatogram of volatile flavor components in Chundo peach

Table 33. Volatile flavor components in Chundo peach

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.700	529	$C_5H_{12}O$	88	2.62
2	2-Methyl-1-pentene	4.833	620	C_6H_{12}	84	5.88
3	Ethyl propyl ether	4.967	696	$C_5H_{12}O$	88	1.04
4	sec-Butyl ethyl ehter	5.283	699	$C_6H_{14}O$	102	0.05
5	Ethyl butyl ether	6.000	790	$C_6H_{14}O$	102	0.07
6	Ethyl formate	6.475	821	$C_3H_6O_2$	74	0.07
7	Butanal	7.550	873	C_4H_8O	72	0.02
8	Ethyl acetate	7.850	888	$C_4H_8O_2$	88	3.67
9	2-Methylbutanal	8.583	913	$C_5H_{10}O$	86	0.02
10	3-Methylbutanal	8.713	917	$C_5H_{10}O$	86	0.02
11	2-Propanol	9.242	935	C_3H_8O	60	0.03
12	Ethanol	9.448	942	C_2H_6O	46	0.48
13	2-Ethylfuran	9.983	953	C_6H_8O	96	0.07
14	2,3-Butanedione	10.867	971	$C_4H_6O_2$	86	0.41
15	Pentanal	10.983	974	$C_5H_{10}O$	86	0.09
16	Decane	11.858	992	$C_{10}H_{22}$	142	0.02
17	2-Methylpropyl acetate	12.550	1006	$C_6H_{12}O_2$	116	0.12
18	2-Butanol	13.308	1022	$C_4H_{10}O$	74	0.09
19	Propanol	13.992	1036	C_3H_8O	60	0.03
20	2,3-Pentanedione	14.833	1053	$C_5H_8O_2$	100	0.03
21	Butyl acetate	15.708	1071	$C_6H_{12}O_2$	116	0.10

(continued)

22	Hexanal	16.217	1081	$C_6H_{12}O$	100	4.44
23	2-Methylpropanol	16.908	1094	$C_4H_{10}O$	74	0.17
24	3-Pentanol	17.982	1114	$C_5H_{12}O$	88	0.26
25	2-Pentanol	18.717	1128	$C_5H_{12}O$	88	0.83
26	2,3-Hexanedione	19.000	1131	$C_6H_{10}O_2$	114	0.09
27	*p*-Xylene	19.308	1134	C_8H_{10}	106	0.05
28	*(E)*-Allyl propenyl ether	19.558	1136	$C_6H_{10}O$	98	0.26
29	*m*-Xylene	19.733	1139	C_8H_{10}	106	0.02
30	2-Methyl-4-pentenal	19.883	1142	$C_6H_{10}O$	98	0.05
31	Butanol	20.267	1149	$C_4H_{10}O$	74	0.03
32	1-Penten-3-ol	21.192	1165	$C_5H_{10}O$	86	0.19
33	o -Xylene	22.579	1184	C_8H_{10}	106	1.67
34	α -Limonene	23.558	1189	$C_{10}H_{16}$	136	0.03
35	*(Z)*-3-Hexenal	23.775	1190	$C_6H_{10}O$	98	0.58
36	2-Methyl-1-butanol	24.458	1205	$C_5H_{12}O$	88	0.02
37	*(E)*-2-Hexenal	25.058	1219	$C_6H_{10}O$	98	16.42
38	*p*-Ethyl toluene	25.408	1224	C_9H_{12}	120	0.09
39	2-Pentylfuran	25.858	1230	$C_9H_{14}O$	138	0.05
40	Pentanol	27.424	1253	C_5H_8O	88	0.10
41	*m*-Ethyl toluene	27.828	1258	C_9H_{12}	120	0.02
42	Hexyl acetate	28.775	1272	$C_8H_{16}O_2$	114	0.32
43	o -Ethyl toluene	29.225	1277	C_9H_{12}	120	0.05

(continued)

44	3-Hydroxy-2-butanone	29.567	1082	$C_4H_8O_2$	88	0.22
I.S.	Butylbenzene	31.658	1307	$C_{10}H_{14}$	134	12.50
45	*(Z)*-3-Hexenyl acetate	31.850	1316	$C_8H_{14}O_2$	142	0.26
46	*(Z)*-2-Penten-1-ol	32.258	1320	$C_5H_{10}O$	86	0.19
47	*(E)*-2-Hexenyl acetate	32.975	1328	$C_8H_{14}O_2$	142	0.19
48	6-Methyl-5-hepten-2-one	33.225	1333	$C_8H_{14}O$	126	0.05
49	Hexanol	34.658	1362	$C_6H_{14}O_2$	102	8.38
50	*(Z)*-3-Hexen-1-ol	36.700	1402	$C_6H_{12}O_2$	100	0.68
51	Nonanal	37.092	1406	C_9H_8O	142	0.03
52	*(E)*-2-Hexen-1-ol	38.275	1415	$C_6H_{12}O$	100	8.77
53	Decanal	39.067	1417	$C_{10}H_{20}O$	156	0.02
54	*(Z)*-2-Octenal	39.517	1418	$C_8H_{14}O$	126	0.02
55	Acetic acid	41.508	1456	$C_2H_4O_2$	60	0.15
56	Furfural	41.708	1464	$C_5H_4O_2$	96	0.29
57	(*E,E*)-2,4-Heptadienal	41.883	1466	$C_7H_{10}O$	110	0.05
58	3-Nonen-2-one	45.100	1514	$C_9H_{16}O$	140	1.16
59	Benzaldehyde	45.708	1520	C_7H_6O	106	1.80
60	Linalool	47.392	1559	$C_{10}H_{18}O$	154	0.03
61	*(E)*-3,8-Nonadien-2-one	49.083	1598	$C_9H_{14}O$	138	0.80
62	1,2-Propanediol	50.383	1615	$C_3H_8O_2$	76	2.01
63	o -Tolualdehyde	51.758	1633	C_8H_8O	120	0.14
64	Estragole	55.008	1676	$C_{10}H_{12}O$	148	0.20

(continued)

65	α-Terpineol	56.842	1703	$C_{10}H_{18}O$	154	0.03
66	γ-Hexalactone	57.008	1710	$C_6H_{10}O_2$	114	0.36
67	4-Methyl-3-pentenoic acid	57.808	1724	$C_6H_{10}O_2$	114	0.03
68	*(E)*-β-Damascenone	63.433	1837	$C_{13}H_{18}O$	190	0.03
69	Nerylacetone	64.783	1876	$C_{13}H_{22}O$	194	0.49
70	γ-Octalactone	67.183	1920	$C_8H_{14}O_2$	142	0.02
71	o-Methylbiphenyl	67.642	1932	$C_{13}H_{12}$	168	0.24
72	β-Ionone	68.392	1955	$C_{13}H_{20}O$	192	0.09
73	Dodecanol	69.233	1980	$C_{12}H_{26}O$	186	0.22
74	Phenylbutanol	69.367	1984	$C_{10}H_{14}O$	150	0.12
75	*o*-Methylbenzyl alcohol	70.175	2006	$C_8H_{10}O$	122	0.34
76	2-Tetradecanol	71.058	2034	$C_{14}H_{30}O$	214	0.05
77	γ-Nonalactone	71.600	2052	$C_9H_{16}O_2$	156	0.15
78	Unknown	73.525	2114			0.54
79	γ-Decalactone	75.317	2170	$C_{10}H_{18}O_2$	170	8.77
80	Tetradecanol	75.892	2176	$C_{14}H_{30}O$	242	0.02
81	1,6-Dimethyl decalin	76.392	2203	$C_{12}H_{22}$	166	1.34
82	δ-Undecalactone	76.875	2216	$C_{11}H_{20}O_2$	184	0.65
83	Megstigmatienone	77.058	2217	$C_{13}H_{18}O$	190	0.14
84	Farnesylacetone	82.167	2405	$C_{18}H_{26}O$	262	0.46
85	γ-Dodecalactone	82.708	2481	$C_{12}H_{22}O_2$	198	1.90
	Total					94.60

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

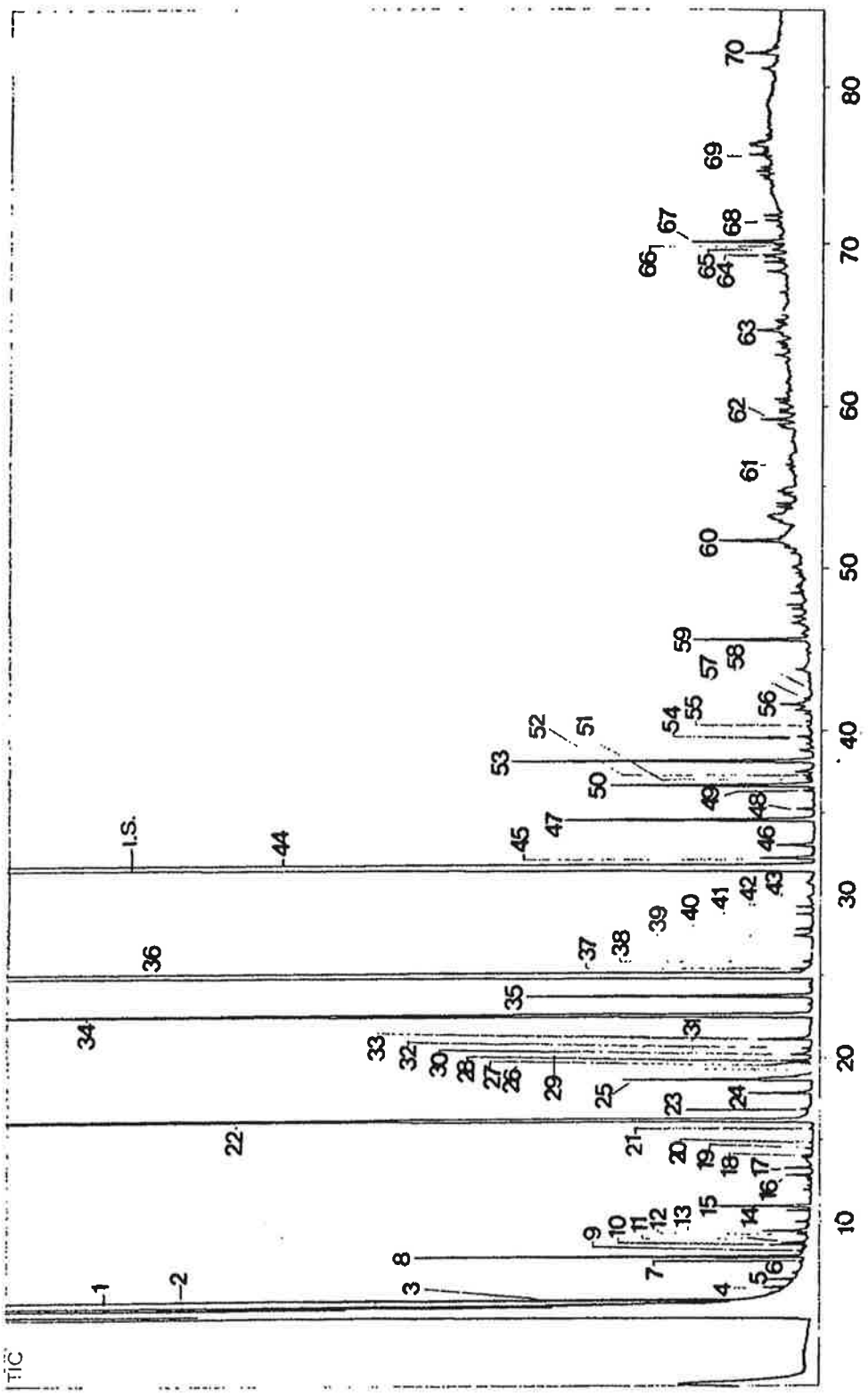

Fig. 27. GC chromatogram of volatile flavor components in Yumungdo peach

Table 34. Volatile flavor components in Yumungdo peach

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.700	529	$C_5H_{12}O$	88	1.00
2	2-Methyl-1-pentene	4.833	620	C_6H_{12}	84	3.81
3	Ethyl propyl ether	4.975	702	$C_5H_{12}O$	88	0.19
4	Ethyl butyl ether	6.000	790	$C_6H_{14}O$	102	0.04
5	Ethyl formate	6.475	821	$C_3H_6O_2$	74	0.05
6	2-Propenal	6.858	840	C_3H_6O	56	0.01
7	Butanal	7.533	873	C_4H_8O	72	0.01
8	Ethyl acetate	7.842	888	$C_4H_8O_2$	88	0.80
9	2-Butanone	8.200	900	C_4H_8O	72	0.01
10	2-Methylbutanal	8.583	913	$C_5H_{10}O$	86	0.08
11	3-Methylbutanal	8.717	918	$C_5H_{10}O$	86	0.05
12	2-Propanol	9.225	935	C_3H_8O	60	0.02
13	Ethanol	9.433	942	C_2H_6O	46	0.13
14	2-Ethylfuran	9.983	955	C_6H_8O	96	0.05
15	Pentanal	10.975	978	$C_5H_{10}O$	86	0.24
16	1-Penten-3-one	12.850	1014	C_5H_8O	84	0.06
17	2-Butanol	13.300	1023	$C_4H_{10}O$	74	0.07
18	Methyl-buten-1-ol	14.033	1037	$C_5H_{10}O$	86	0.03
19	3-Hexanone	14.500	1047	$C_6H_{12}O$	100	0.01
20	2,3-Pentanedione	14.825	1053	$C_2H_6O_2$	100	0.01

(continued)

21	Dimethyl disufide	15.667	1070	$C_2H_6S_2$	94	0.01
22	Hexanal	16.258	1082	$C_6H_{12}O$	100	12.54
23	2-Methylpropanol	16.883	1095	$C_4H_{10}O$	74	0.03
24	3-Pentanol	17.875	1115	$C_5H_{12}O$	88	0.21
25	2-Pentanol	18.700	1128	$C_5H_{12}O$	88	0.72
26	*(E)*-2-Pentenal	18.967	1131	C_5H_8O	84	0.06
27	*p*-Xylene	19.300	1134	C_8H_{10}	106	0.08
28	*(E)*-Allyl propenyl ether	19.542	1136	$C_6H_{10}O$	98	0.38
29	*m*-Xylene	19.717	1139	C_8H_{10}	106	0.04
30	2-Methyl-4-pentenal	19.867	1142	$C_6H_{10}O$	98	0.11
31	Butanol	20.258	1149	$C_4H_{10}O$	74	0.06
32	3-Heptanone	20.600	1155	$C_7H_{14}O$	114	0.02
33	1-Penten-3-ol	21.175	1165	$C_5H_{10}O$	86	0.19
34	o -Xylene	22.600	1178	C_8H_{10}	106	6.63
35	*(Z)*-3-Hexenal	23.767	1190	$C_6H_{10}O$	98	1.07
36	*(E)*-2-Hexenal	25.125	1203	$C_6H_{10}O$	98	31.87
37	*p*-Ethyltoluene	25.408	1223	C_9H_{12}	120	0.08
38	2-Pentylfuran	25.850	1230	$C_9H_{14}O$	138	0.02
39	Pentanol	27.433	1253	$C_5H_{12}O$	88	0.10
40	*m*-Ethyltoluene	27.858	1259	C_9H_{12}	120	0.06
41	Hexyl acetate	28.758	1272	$C_8H_{16}O_2$	144	0.05
42	*o*-Ethyltoluene	29.208	1278	C_9H_{12}	120	0.06

(continued)

43	4-Heptanol	29.742	1284	$C_7H_{16}O$	116	0.01
I.S.	Butylbenzene	31.750	1310	$C_{10}H_{14}$	134	29.32
44	*(Z)*-3-Hexenyl acetate	31.850	1317	$C_8H_{14}O_2$	142	0.20
45	*(Z)*-2-Penten-1-ol	32.242	1321	$C_5H_{10}O$	86	0.25
46	*o*-Propyltoluene	33.058	1328	$C_{10}H_{14}$	134	0.18
47	Hexanol	34.583	1361	$C_6H_{14}O$	102	1.32
48	4-Ethyl-*o*-xylene	35.250	1370	$C_{10}H_{14}$	134	0.06
49	Dimethylstyrene	36.367	1386	$C_{10}H_{12}$	132	0.02
50	*(Z)*-3-hexen-1-ol	36.692	1391	$C_6H_{12}O$	100	1.06
51	Nonanal	37.075	1397	$C_9H_{18}O$	142	0.01
52	2-Methylindane	37.283	1400	$C_{10}H_{12}$	132	0.01
53	*(E)*-2-Hexen-1-ol	38.175	1414	$C_6H_{12}O$	100	1.35
54	2,6-Dimethyl octanol	39.667	1435	$C_{10}H_{22}O$	158	0.05
55	*p*-2-Methylpropyltoluene	40.000	1440	$C_{11}H_{16}$	148	0.01
56	Furfural	41.675	1464	$C_6H_{12}O$	96	0.11
57	*(E,E)*-2,4-Heptadienal	41.825	1469	$C_7H_{10}O$	110	0.01
58	2-Ethyl-1-hexanol	43.808	1495	$C_8H_{18}O$	130	0.01
59	Benzaldehyde	45.658	1520	C_7H_6O	106	0.52
60	*o*-Tolualdehyde	51.733	1612	C_8H_8O	120	0.28
61	γ-Hexalactone	56.925	1710	$C_6H_{10}O_2$	114	0.01
62	Epoxylinalol	59.233	1750	$C_{10}H_{18}O_2$	170	0.17
63	*(Z)*-Geranylacetone	64.758	1853	$C_{13}H_{22}O$	194	0.07

(continued)

64	Dodecanol	69.242	1980	$C_{12}H_{26}O$	186	0.05
65	1-Phenyl-1-butanol	69.350	1983	$C_{10}H_{14}O$	150	0.07
66	2-Hexenoic acid	69.642	1993	$C_6H_{10}O_2$	114	0.01
67	2-Methylbezyl alcohol	70.167	2009	$C_8H_{10}O$	122	0.36
68	Isopropyl tetradecanoate	71.508	2052	$C_{17}H_{34}O_2$	270	0.04
69	Tetradecanol	75.700	2185	$C_{14}H_{30}O$	242	0.07
70	Farnesylacetone	82.142	2389	$C_{18}H_{30}O$	262	0.16
	Total					96.76

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

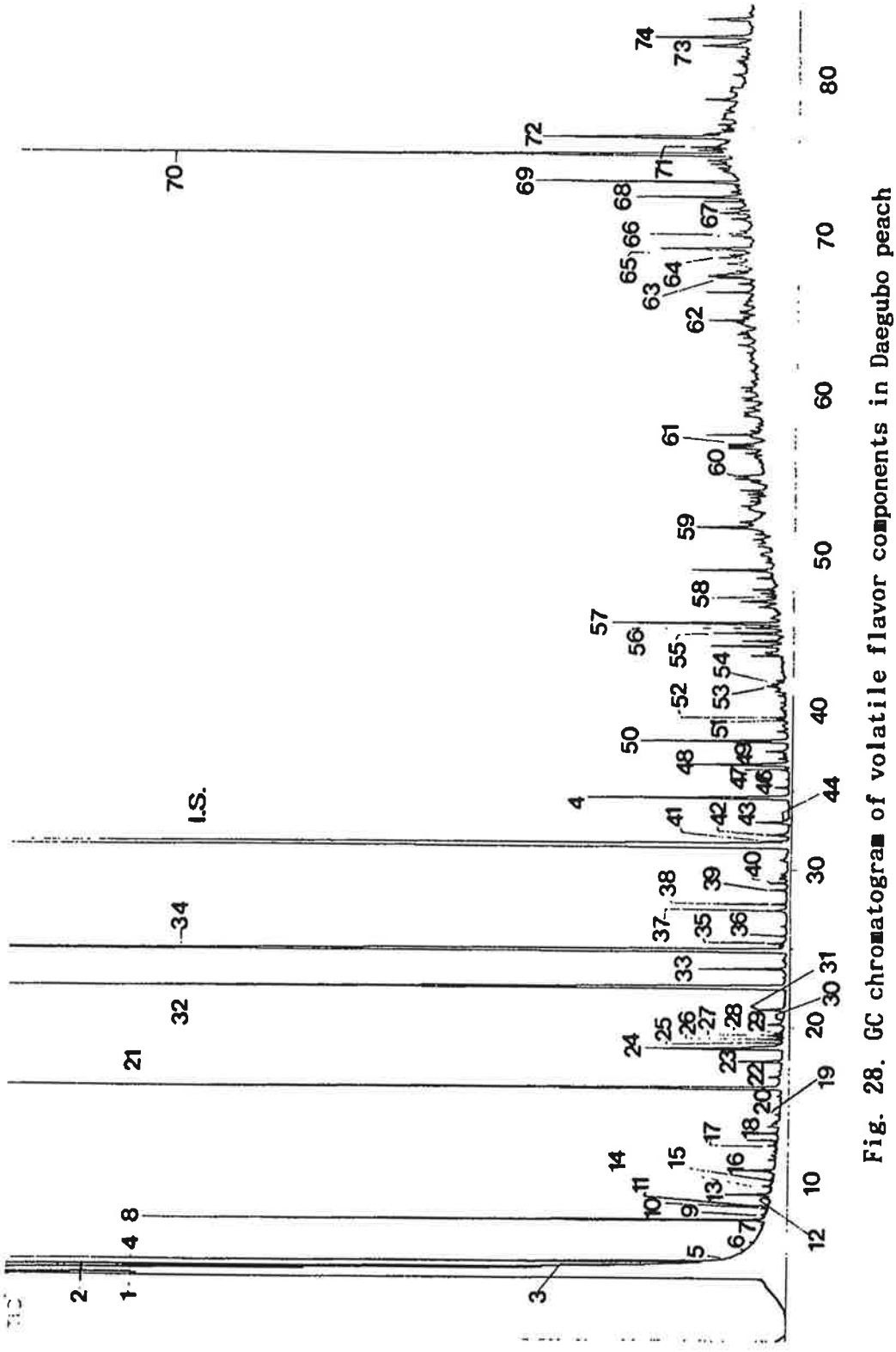

Fig. 28. GC chromatogram of volatile flavor components in Daegubo peach

Table 35. Volatile flavor components in Daegubo peach

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.700	528	$C_5H_{12}O$	88	1.18
2	2-Methyl-1-pentene	4.833	612	C_6H_{12}	84	5.51
3	2,3-Dimethyl-2-butene	4.908	659	C_6H_{12}	84	0.09
4	Ethyl propyl ether	4.975	698	$C_5H_{12}O$	88	0.22
5	sec-Butyl ethyl ether	5.283	707	$C_6H_{14}O$	102	0.01
6	Ethyl butyl ether	5.992	788	$C_6H_{14}O$	102	0.05
7	Ethyl formate	6.467	821	$C_3H_6O_2$	74	0.01
8	Ethyl acetate	7.842	888	$C_4H_8O_2$	88	2.10
9	2-Butanone	8.208	898	C_4H_8O	72	0.01
10	2-Methylbutanal	8.583	911	$C_5H_{10}O$	86	0.02
11	3-Methylbutanal	8.700	915	$C_5H_{10}O$	86	0.02
12	2-Propanol	9.217	934	C_3H_8O	60	0.03
13	Ethanol	9.442	942	C_2H_6O	46	0.23
14	2-Ethylfuran	9.975	955	C_6H_8O	96	0.01
15	Propyl acetate	10.883	976	$C_5H_{10}O_2$	102	0.01
16	Pentanal	10.967	978	$C_5H_{10}O$	86	0.14
17	2-Methylpropyl acetate	12.533	1009	$C_6H_{12}O_2$	116	0.03
18	2-Butanol	13.292	1023	$C_4H_{10}O$	74	0.08
19	3-Hexanone	14.483	1039	$C_6H_{12}O$	100	0.01
20	Dimethyl disulfide	15.675	1068	$C_2H_6S_2$	94	0.01

(continued)

21	Hexanal	16.183	1081	$C_6H_{12}O$	100	5.64
22	2-Methylpropanol	16.883	1097	$C_4H_{10}O$	74	0.06
23	3-Pentanol	17.867	1120	$C_5H_{12}O$	88	0.24
24	2-Pentanol	18.608	1128	$C_5H_{12}O$	88	0.87
25	(*E*)-2-Pentenal	18.942	1133	C_5H_8O	84	0.01
26	*p*-Xylene	19.292	1138	C_8H_{10}	106	0.10
27	2-Methyl-4-pentenal	19.525	1142	$C_6H_{10}O$	98	0.06
28	*m*-Xylene	19.708	1144	C_8H_{10}	106	0.01
29	Butanol	20.233	1152	$C_4H_{10}O$	74	0.09
30	3-Heptanone	20.583	1157	$C_7H_{14}O$	114	0.01
31	1-Penten-3-ol	21.167	1165	$C_5H_{10}O$	86	0.14
32	*o*-Xylene	22.575	1178	C_8H_{10}	106	7.18
33	(*Z*)-3-Hexenal	23.742	1202	$C_6H_{10}O$	98	0.52
34	(*E*)-2-Hexenal	24.967	1220	$C_6H_{10}O$	98	16.15
35	*p*-Ethyltoluene	25.358	1223	C_9H_{12}	120	0.10
36	2-Pentylfuran	25.833	1228	$C_9H_{14}O$	138	0.01
37	Pentanol	27.425	1241	$C_5H_{12}O$	88	0.01
38	*m*-Ethyltoluene	27.833	1245	C_9H_{12}	120	0.08
39	Hexyl acetate	28.750	1253	$C_8H_{16}O_2$	144	0.09
40	*o*-Ethyltoluene	29.192	1272	C_9H_{12}	120	0.09
I.S.	Butylbenzene	31.675	1309	$C_{10}H_{14}$	134	32.49
41	(*Z*)-3-Hexenyl acetate	31.817	1316	$C_8H_{14}O_2$	142	0.17

(continued)

42	(*Z*)-2-Penten-1-ol	32.233	1323	$C_5H_{10}O$	86	0.14
43	*o*-Propyltoluene	33.042	1336	$C_{10}H_{14}$	134	0.23
44	6-Methyl-5-hepten-2-one	33.208	1339	$C_8H_{14}O$	126	0.01
45	Hexanol	34.567	1361	$C_6H_{14}O$	102	1.70
46	4-Ethyl-*o*-xylene	35.233	1370	$C_{10}H_{14}$	134	0.01
47	Dimethylstyrene	36.350	1386	$C_{10}H_{12}$	132	0.01
48	(*Z*)-3-Hexen-1-ol	36.675	1391	$C_6H_{12}O$	100	0.81
49	Nonanal	37.075	1397	$C_9H_{18}O$	142	0.01
50	(*E*)-2-Hexen-1-ol	38.158	1414	$C_6H_{12}O$	100	1.09
51	(*E*)-2-Octenal	39.492	1432	$C_8H_{14}O$	126	0.01
52	2,6-Dimethyl-2-octanol	39.650	1434	$C_{10}H_{22}O$	158	0.08
53	Furfural	41.650	1462	$C_5H_4O_2$	96	0.12
54	(*E*,*E*)-2,4-Heptadienal	41.808	1464	$C_7H_{10}O$	110	0.07
55	3-Nonen-2-one	45.033	1514	$C_9H_{16}O$	140	0.43
56	2-Methyl-1-octen-3-yne	45.367	1517	C_9H_{14}	122	0.26
57	Benzaldehyde	45.650	1520	C_7H_6O	106	1.30
58	Linalool	47.350	1546	$C_{10}H_{18}O$	154	0.09
59	*o*-Touladehyde	51.717	1610	C_8H_8O	120	0.43
60	Estragole	54.942	1663	$C_{10}H_{12}O$	148	0.25
61	γ-Hexalactone	56.942	1695	$C_6H_{10}O_2$	114	0.31
62	Nerylacetone	64.758	1863	$C_{13}H_{22}O$	194	0.24
63	γ-Octalactone	67.450	1917	$C_8H_{14}O_2$	142	0.18

(continued)

64	7,8-Dihydro-β-ionone	68.725	1957	$C_{13}H_{22}O$	194	0.24
65	(*E*)-6-Methyl-6-(5-methyl-2-furanyl)-3-hepten-2-one	68.900	1964	$C_{13}H_{18}O_2$	206	0.12
66	*o*-Methylbenzyl alcohol	70.175	2006	$C_8H_{10}O$	122	0.81
67	Isopropyl tetradecanoate	71.508	2033	$C_{17}H_{34}O_2$	270	0.23
68	4-Keto-α-ionone	72.525	2068	$C_{13}H_{18}O_2$	206	0.68
69	Unknown	73.492	2114			1.02
70	γ-Decalactone	75.242	2168	$C_{10}H_{18}O_2$	170	5.47
71	Tetradecanol	75.700	2179	$C_{14}H_{30}O$	242	0.30
72	1,6-Dimethyldecalin	76.342	2187	$C_{12}H_{22}$	166	1.71
73	Farnesylacetone	82.133	2394	$C_{18}H_{26}O$	262	0.40
74	γ-Dodecalactone	82.667	2406	$C_{12}H_{22}O_2$	198	0.72
	Total					93.37

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

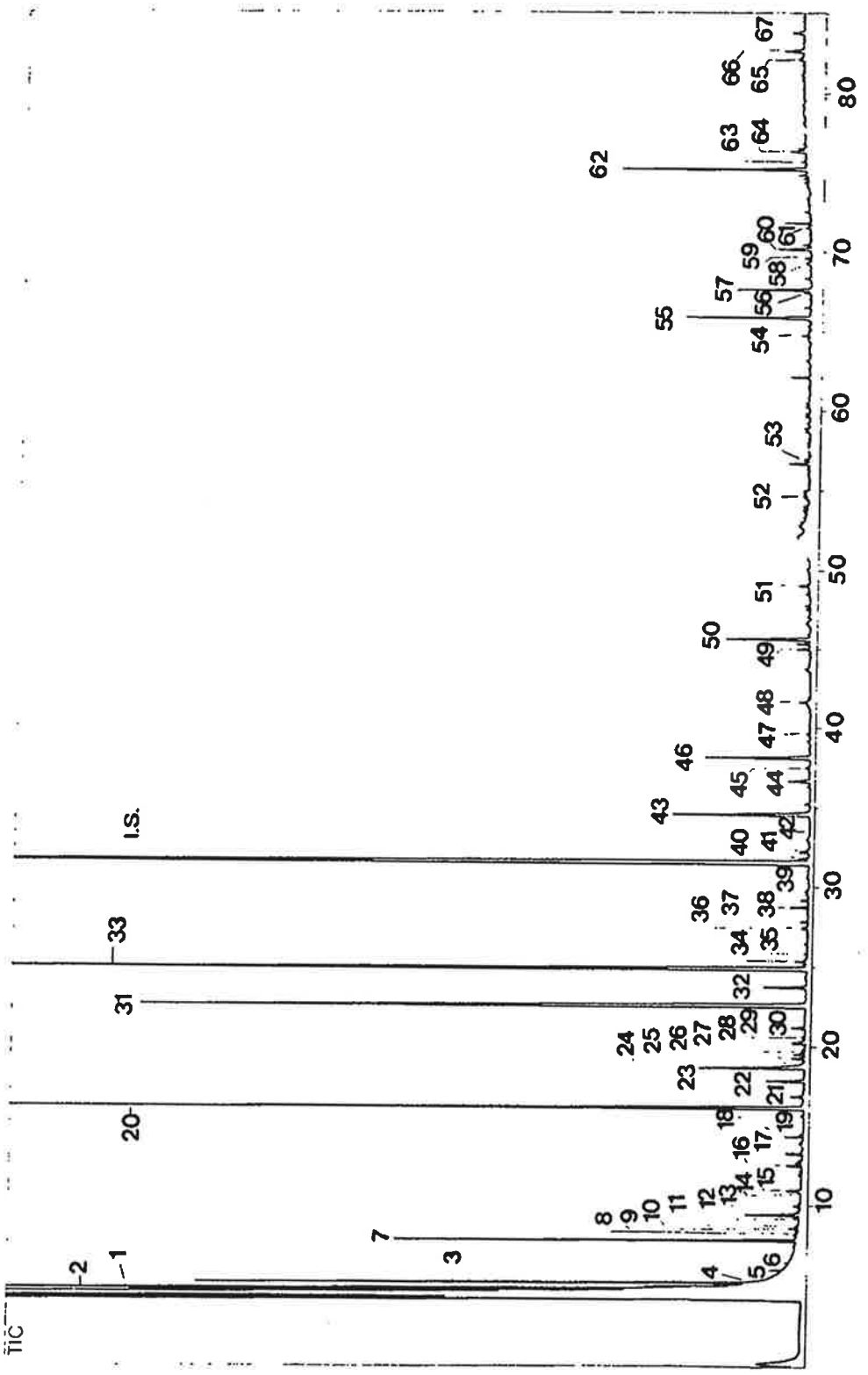

Fig. 29. GC chromatogram of volatile flavor components in Hwangdo peach

Table 36. Volatile flavor components in Hwangdo peach

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.700	529	$C_5H_{12}O$	88	1.88
2	2-Methyl-1-pentene	4.833	620	C_6H_{12}	84	7.77
3	Ethyl propyl ether	4.975	701	$C_5H_{12}O$	88	0.26
4	sec-Butyl ethyl ether	5.283	708	$C_6H_{14}O$	102	0.01
5	Ethyl butyl ether	6.000	798	$C_6H_{14}O$	102	0.08
6	Ethyl formate	6.467	821	$C_3H_6O_2$	74	0.04
7	Ethyl acetate	7.850	887	$C_4H_8O_2$	88	2.66
8	2-Butanone	8.208	898	C_4H_8O	72	0.01
9	2-Methylbutanal	8.575	911	$C_5H_{10}O$	86	0.06
10	3-Methylbutanal	8.717	915	$C_5H_{10}O$	86	0.01
11	2-Propanol	9.225	934	C_3H_8O	60	0.04
12	Ethanol	9.442	942	C_2H_6O	46	0.53
13	2-Ethylfuran	9.983	955	C_6H_8O	96	0.07
14	Propyl acetate	10.883	976	$C_5H_{10}O_2$	102	0.01
15	Cyclopentanol	10.950	977	$C_5H_{10}O$	86	0.18
16	2-Methylpropyl acetate	12.542	1009	$C_6H_{12}O_2$	116	0.14
17	2-Butanol	13.300	1023	$C_4H_{10}O$	74	0.17
18	3-Hexanone	14.483	1049	$C_6H_{12}O$	100	0.01
19	Dimethyl disufide	15.675	1068	$C_2H_6O_2$	94	0.01
20	Hexanal	16.208	1081	$C_6H_{12}O$	100	8.96

(continued)

21	2-Methylpropanol	16.892	1097	$C_4H_{10}O$	74	0.16
22	3-Pentanol	17.875	1120	$C_5H_{12}O$	88	0.41
23	2-Pentanol	18.700	1128	$C_5H_{12}O$	88	1.52
24	*(E)*-2-Pentenal	18.950	1133	C_5H_8O	84	0.01
25	*p*-Xylene	19.300	1138	C_8H_{10}	106	0.14
26	(E)-Allyl propenyl ether	19.533	1142	$C_6H_{10}O$	98	0.12
27	*m*-Xylene	19.717	1144	C_8H_{10}	106	0.04
28	Butanol	20.250	1152	$C_4H_{10}O$	74	0.20
29	3-Heptanone	20.600	1157	$C_7H_{14}O$	114	0.03
30	1-Penten-3-ol	21.175	1165	$C_5H_{10}O$	86	0.16
31	o -Xylene	22.592	1177	C_8H_{10}	106	11.25
32	*(Z)*-3-Hexenal	23.742	1190	$C_6H_{10}O$	98	0.49
33	*(E)*-2-Hexenal	24.950	1219	$C_6H_{10}O$	98	15.10
34	*p*-Ethyltoluene	25.367	1223	C_9H_{12}	120	0.14
35	2-Pentylfuran	25.833	1228	$C_9H_{14}O$	138	0.01
36	Pentanol	27.442	1241	$C_5H_{12}O$	88	0.01
37	*m*-Ethyltoluene	27.842	1245	C_9H_{12}	120	0.11
38	Hexyl acetate	28.750	1253	$C_8H_{16}O_2$	144	0.22
39	*o*-Ethyltoluene	29.200	1272	C_9H_{12}	120	0.11
I.S.	Butylbenzene	31.650	1307	$C_{10}H_{14}$	134	29.05
40	*(Z)*-3-Hexenyl acetate	31.817	1316	$C_8H_{14}O_2$	142	0.11
41	*(Z)*-2-Penten-1-ol	32.233	1323	$C_5H_{10}O$	86	0.14

(continued)

42	6-Methyl-5-hepten-2-one	33.208	1339	$C_8H_{14}O$	126	0.01
43	Hexanol	34.583	1361	$C_6H_{14}O$	102	2.39
44	*(Z)*-3-Hexen-1-ol	36.683	1391	$C_6H_{12}O$	100	0.38
45	Nonanal	37.058	1397	$C_9H_{18}O$	142	0.01
46	*(E)*-2-Hexen-1-ol	38.175	1414	$C_6H_{12}O$	100	1.61
47	2,6-Dimethyl-1-octanol	39.687	1434	$C_{10}H_{22}O$	158	0.03
48	Furfural	41.650	1464	$C_5H_4O_2$	96	0.16
49	3-Nonen-2-one	45.042	1514	$C_9H_{16}O$	140	0.16
50	Benzyladehyde	45.658	1520	C_7H_6O	106	1.27
51	*(E,E)*-3,5-Octadien-2-one	49.033	1577	$C_8H_{12}O$	124	0.14
52	Estragole	54.950	1663	$C_{10}H_{12}O$	148	0.01
53	γ-Hexalactone	56.942	1701	$C_6H_{10}O_2$	114	0.04
54	Nerylacetone	64.750	1863	$C_{13}H_{22}O$	194	0.08
55	2-Ethylbiphenyl	65.858	1876	$C_{14}H_{14}$	182	1.53
56	γ-Octalactone	67.450	1917	$C_8H_{14}O$	142	0.07
57	*o*-Methylbiphenyl	67.617	1920	$C_{13}H_{12}$	168	0.84
58	Dodecanol	69.233	1982	$C_{12}H_{26}O$	186	0.03
59	1-Phenyl-1-butanol	69.350	1985	$C_{10}H_{14}O$	150	0.05
60	*o*-Methylbenzyl alcohol	70.167	2005	$C_8H_{10}O$	122	0.42
61	Isopropyl tetradecanoate	71.500	2033	$C_{14}H_{28}O_2$	228	0.02
62	γ-Decalactone	75.225	2167	$C_{10}H_{18}O_2$	170	2.08
63	Tetradecanol	75.683	2179	$C_{14}H_{30}O$	242	0.06

(continued)

64	1,6-Dimethyldecalin	76.333	2201	$C_{12}H_{22}$	166	0.33
65	Farnesylacetone	82.133	2375	$C_{18}H_{26}O$	262	0.09
66	γ-Dodecalactone	82.658	2390	$C_{12}H_{22}O_2$	198	0.27
67	Dibenzocyclooxepine	83.775	2418	$C_{15}H_{14}O$	210	0.22
	Total					94.73

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 37. Relative content of functional groups in Peaches

Peak area%

Functional group	Bekdo	Chundo	Yumungdo	Daegubo	Hwangdo
Aldehydes	32.3	23.99	46.98	24.5	8.5
Alcohols	12.82	23.27	6.24	7.02	26.07
Esters	1.32	4.73	1.14	2.64	3.2
Terpenes	0.06	0.18	-	-	-
Acids	0.12	0.18	0.01	-	-
Ethers	0.69	4.04	1.61	1.46	2.35
Ketones	7.65	15.82	0.35	2.64	2.29
Miscellaneous	1.95	9.5	11.12	15.41	22.57
T o t a l	56.91	81.71	67.45	53.67	64.98

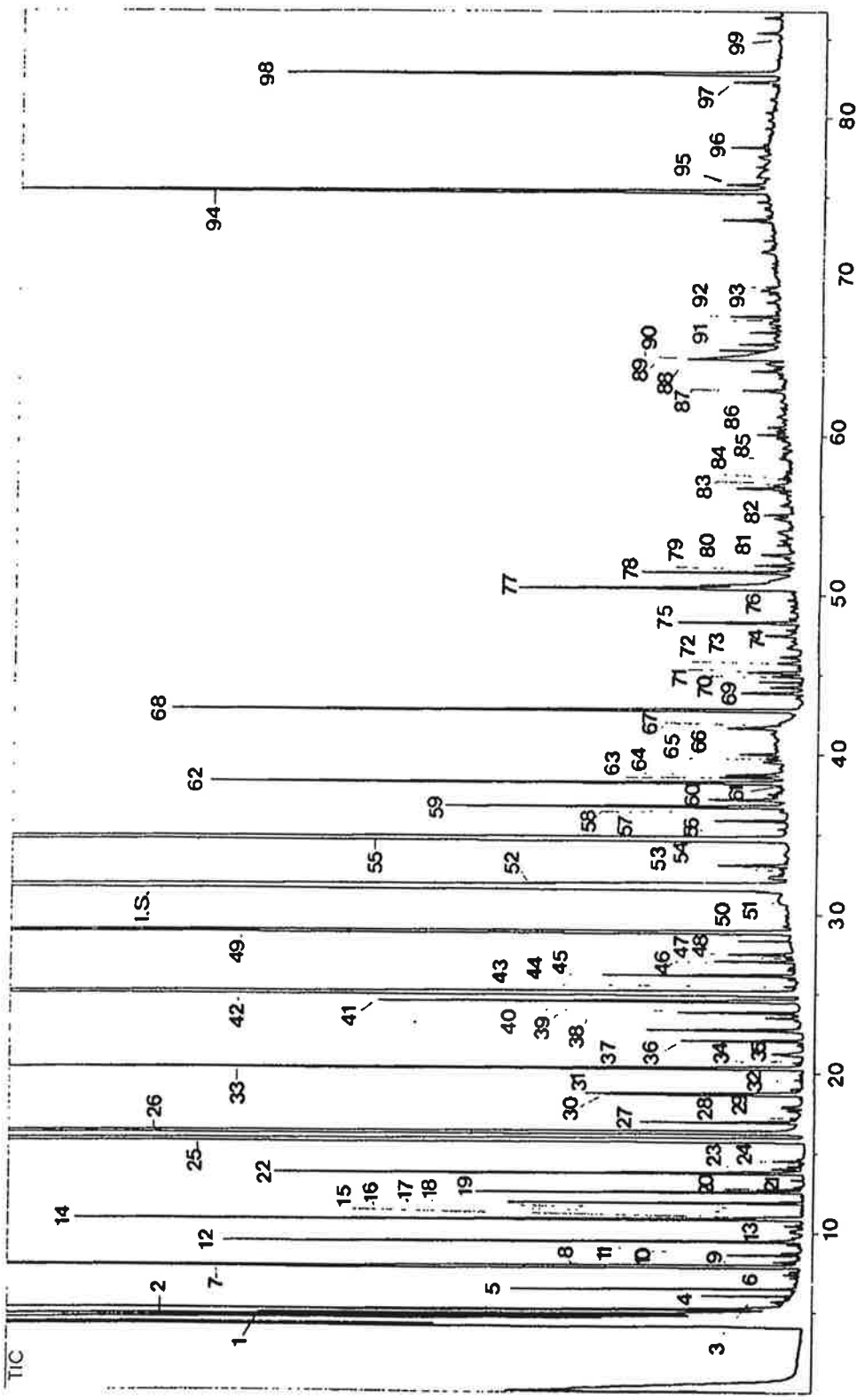

Fig. 30. GC chromatogram of volatile flavor components in Beauty plum

Table 38. Volatile flavor components in Beauty plum

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.717	689	$C_5H_{12}O$	88	0.89
2	2-Methyl-1-pentane	4.850	696	C_6H_{12}	84	3.86
3	sec-Butyl ethyl ether	5.308	706	$C_6H_{14}O$	102	0.03
4	Octane	6.028	805	C_8H_{18}	114	0.09
5	Ethyl formate	6.500	821	$C_3H_6O_2$	74	0.34
6	Butanal	7.592	872	C_4H_8O	72	0.01
7	Ethyl acetate	7.942	888	$C_4H_8O_2$	88	7.78
8	Nonane	8.192	897	C_9H_{20}	128	0.01
9	2-Methylbutanal	8.625	912	$C_5H_{10}O$	86	0.09
10	3-Methylbutanal	8.758	916	$C_5H_{10}O$	86	0.03
11	2-Propanol	9.283	934	C_3H_8O	60	0.01
12	Ethanol	9.508	942	C_2H_6O	46	0.94
13	Ethyl propanoate	10.225	951	$C_5H_{10}O_2$	102	0.01
14	Propyl acetate	10.900	960	$C_5H_{10}O_2$	102	1.08
15	Pentanal	11.033	965	$C_5H_{10}O$	86	0.14
16	Methyl butanoate	11.350	978	$C_5H_{10}O_2$	102	0.01
17	Methyl isopropenyl ketone	11.575	986	C_5H_8O	84	0.01
18	Decane	11.945	1001	$C_{10}H_{22}$	142	0.44
19	2-methylpropyl acetate	12.608	1006	$C_6H_{12}O_2$	116	0.50
20	2-Allyl-1,3-dioxolane	12.775	1007	$C_6H_{10}O_2$	114	0.07

(continued)

21	2-Butanol	13.367	1101	$C_4H_{10}O$	74	0.03
22	Ethyl butanoate	13.808	1014	$C_6H_{12}O_2$	116	0.89
23	Propanol	14.042	1016	C_3H_8O	60	0.07
24	Ethyl 2-methylbutanoate	14.683	1044	$C_7H_{14}O_2$	130	0.01
25	Butyl acetate	15.933	1073	$C_6H_{12}O_2$	116	11.19
26	Hexanal	16.408	1083	$C_6H_{12}O$	100	8.15
27	2-Methylpropanol	16.922	1096	$C_4H_{10}O$	74	0.28
28	4-Methyl-1-penten-3-one	17.233	1104	$C_6H_{10}O$	98	0.01
29	Ethyl carbonate	17.692	1116	$C_5H_{10}O_3$	118	0.01
30	2-Methylbutyl acetate	18.708	1127	$C_7H_{14}O_2$	130	0.36
31	3-Methylbutyl acetate	18.775	1128	$C_7H_{14}O_2$	130	0.38
32	*(E)*-2-Pentenal	19.033	1132	C_5H_8O	84	0.01
33	Butanol	20.367	1152	$C_4H_{10}O$	74	1.90
34	3-Heptanone	20.708	1155	$C_7H_{14}O$	114	0.01
35	1-penten-3-ol	21.258	1160	$C_5H_{10}O$	86	0.07
36	Pentyl acetate	22.067	1172	$C_7H_{14}O_2$	130	0.23
37	2-Heptanone	22.592	1178	$C_7H_{14}O$	114	0.01
38	4-Penten-1-ol acetate	23.508	1187	$C_7H_{12}O_2$	128	0.07
39	Limonene	23.658	1189	$C_{10}H_{16}$	136	0.01
40	*(Z)*-2-Hexenal	23.842	1191	$C_6H_{10}O$	98	0.26
41	2-Methyl-1-butanol	24.542	1214	$C_5H_{12}O$	88	0.98
42	*(E)*-2-Hexenal	25.133	1218	$C_6H_{10}O$	98	8.18

(continued)

43	2-hexanol	25.483	1223	$C_6H_{14}O$	102	0.03
44	2-Pentylfuran	25.942	1226	$C_9H_{14}O$	138	0.01
45	Ethyl hexanoate	26.192	1233	$C_8H_{16}O_2$	144	0.38
46	2-Methoxyacetyl-1-butene	27.058	1246	$C_7H_{12}O_2$	128	0.16
47	3-Methyl-3-buten-1-ol	27.317	1250	$C_5H_{10}O$	86	0.01
48	Pentanol	27.525	1253	$C_5H_{12}O$	88	0.14
49	Hexyl acetate	28.967	1273	$C_8H_{16}O_2$	144	5.99
50	Acetophenone	29.300	1277	C_8H_8O	120	0.01
51	*(Z)*-3-Hexenyl acetate	31.433	1307	$C_8H_{14}O_2$	142	0.04
I.S.	Butylbenzene	31.875	1309	$C_{10}H_{14}$	134	14.24
52	*(Z)*-2-Hexenyl acetate	31.958	1310	$C_5H_{10}O$	142	0.45
53	Tetrahydrofurfuryl alcohol	32.850	1325	$C_5H_{10}O_2$	102	0.01
54	*(E)*-2-Hexenyl acetate	33.092	1327	$C_8H_{14}O_2$	142	0.14
55	Hexanol	34.842	1364	$C_5H_{10}O_2$	102	11.08
56	*(E)*-3-Hexen-1-ol	35.387	1370	$C_6H_{12}O$	100	0.01
57	Heptyl acetate	35.892	1374	$C_9H_{16}O_2$	158	0.14
58	*p*-Allyltoluene	36.467	1386	$C_{10}H_{12}$	132	0.01
59	*(Z)*-3-Hexen-1-ol	36.783	1392	$C_6H_{12}O$	100	0.77
60	Nonanal	37.200	1395	$C_9H_{18}O$	142	0.16
61	*(E),(E)*-2,4-Hexadienal	37.625	1399	C_6H_8O	96	0.01
62	*(E)*-2-Hexen-1-ol	38.283	1404	$C_6H_{12}O$	100	1.35
63	Butyl hexanoate	38.617	1406	$C_{10}H_{22}O_2$	172	0.10

(continued)

64	Hexyl butanoate	38.775	1408	$C_{10}H_{22}O_2$	172	0.10
65	2,6-Dimethyl-2-octanol	39.786	1423	$C_{10}H_{22}O$	158	0.04
66	Ethyl octanoate	40.050	1435	$C_{10}H_{22}O_2$	172	0.09
67	Furfural	41.792	1459	$C_6H_{10}O$	96	0.03
68	Octyl acetate	42.792	1476	$C_{10}H_{20}O_2$	172	1.45
69	2-Ethyl hexanol	43.883	1498	$C_8H_{18}O$	130	0.14
70	3-Octen-1-ol, acetate	44.933	1508	$C_{10}H_{18}O_2$	170	0.09
71	3-Nonen-2-one	45.175	1514	$C_9H_{16}O$	140	0.13
72	Benzaldehyde	45.767	1519	C_7H_6O	106	0.07
73	2-Cyclohexyl ethyl acetate	46.150	1521	$C_{10}H_{18}O_2$	170	0.04
74	Linalool	47.467	1528	$C_{10}H_{18}O$	154	0.06
75	Octanol	48.283	1537	$C_8H_{18}O$	130	0.27
76	*(Z)*-Pent-2-enyl hexanoate	49.733	1553	$C_{11}H_{20}O_2$	184	0.01
77	1,2-Propanediol	50.442	1568	$C_3H_8O_2$	76	0.87
78	Hexyl hexanoate	51.458	1602	$C_{12}H_{24}O_2$	200	0.33
79	Butyl octanoate	51.642	1606	$C_{12}H_{24}O_2$	200	0.01
80	Octyl butanoate	51.908	1612	$C_{12}H_{24}O_2$	200	0.08
81	Ethyl decanoate	53.175	1638	$C_{12}H_{24}O_2$	200	0.01
82	Estragole	55.092	1667	$C_{10}H_{12}O$	148	0.07
83	Decenyl acetate	56.983	1713	$C_{12}H_{22}O_2$	198	0.06
84	Butyl 3-hydroxybutanoate	57.367	1731	$C_8H_{10}O_3$	160	0.01
85	Benzyl acetate	58.642	1744	$C_9H_{10}O_2$	150	0.01

(continued)

86	Neryl acetate	60.108	1760	$C_{12}H_{20}O_2$	196	0.07
87	Heptyl hexanoate	62.900	1817	$C_{13}H_{26}O_2$	214	0.09
88	β-Methylionone	64.108	1839	$C_{14}H_{22}O$	206	0.07
89	Geraniol	64.600	1857	$C_{10}H_{18}O$	154	0.01
90	Hexanoic acid	64.883	1864	$C_6H_{12}O_2$	116	0.37
91	Phenethyl alcohol	67.358	1948	$C_8H_{10}O$	122	0.01
92	γ-Octalactone	67.550	1963	$C_8H_{14}O_2$	142	0.11
93	1-Phenyl-1-butanol	69.425	1979	$C_{10}H_{14}O$	150	0.03
94	γ-Decalactone	75.367	2171	$C_{10}H_{18}O_2$	170	3.58
95	*(E)*-Isoeugenol	75.792	2181	$C_{10}H_{12}O_2$	164	0.11
96	Ethyl hexadecanoate	78.133	2266	$C_{18}H_{36}O_2$	284	0.07
97	Farnesyl acetone	82.250	2340	$C_{18}H_{30}O$	262	0.11
98	γ- Dodecalactone	82.825	2398	$C_{12}H_{22}O_2$	198	1.52
99	Ethyl octadecanoate	85.392	2428	$C_{20}H_{40}O_2$	312	0.01
	Total					94.91

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

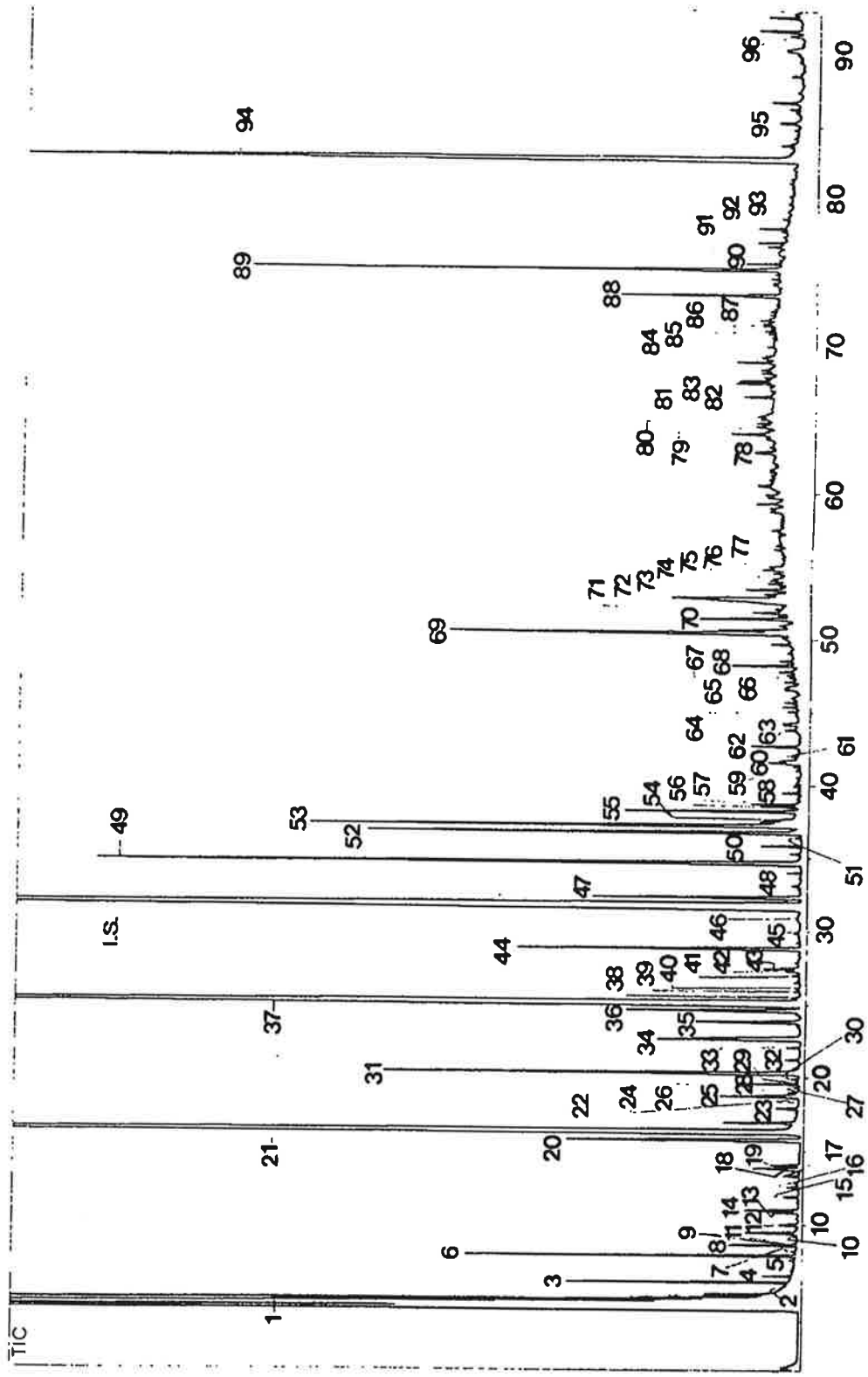

Fig. 31. GC chromatogram of volatile flavor components in Pomosa plum

Table 39. Volatile flavor components in Pomosa plum

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.697	529	$C_5H_{12}O$	88	0.46
2	sec-Butyl ethyl ether	5.292	708	$C_5H_{12}O$	88	0.01
3	Octane	6.042	800	C_8H_{18}	114	0.42
4	Ethyl formate	6.483	820	$C_3H_6O_2$	74	0.08
5	Butanal	7.567	872	C_4H_8O	72	0.02
6	Ethyl acetate	7.867	887	$C_4H_8O_2$	88	0.97
7	Nonane	8.167	900	C_9H_{20}	128	0.01
8	2-Methylbutanal	8.600	912	$C_5H_{10}O$	86	0.19
9	3-Methylbutanal	8.733	916	$C_5H_{10}O$	86	0.01
10	2-Propanol	9.242	934	C_3H_8O	60	0.02
11	Ethanol	9.467	942	C_2H_6O	46	0.17
12	2-Ethylfuran	9.992	949	C_6H_8O	96	0.05
13	Propyl acetate	10.858	960	$C_5H_{10}O_2$	102	0.08
14	Pentanal	11.000	965	$C_5H_{10}O$	86	0.18
15	Decane	11.908	1000	$C_{10}H_{22}$	142	0.05
16	2-Methylpropyl acetate	12.567	1006	$C_6H_{12}O_2$	116	0.03
17	2-Butanol	13.333	1011	$C_4H_{10}O$	74	0.04
18	Ethyl butanoate	13.750	1014	$C_6H_{12}O_2$	116	0.05
19	2-Methyl-3-buten-2-ol	14.067	1023	$C_5H_{10}O$	86	0.15
20	Butyl acetate	15.767	1073	$C_6H_{12}O_2$	116	1.27

(continued)

21	Hexanal	16.442	1080	$C_6H_{12}O$	100	16.05
22	2-Methylpropanol	16.950	1096	$C_4H_{10}O$	74	0.25
23	3-Pentanol	17.925	1122	$C_5H_{12}O$	88	0.08
24	2-Methylbutyl acetate	18.650	1127	$C_7H_{14}O_2$	130	0.01
25	2-Pentanol	18.742	1128	$C_5H_{12}O$	88	0.34
26	*(E)*-2-Pentenal	19.000	1132	C_5H_8O	84	0.05
27	*p*-Xylene	19.342	1137	C_8H_{10}	106	0.02
28	*(E)*-Allyl propenyl ether	19.592	1141	$C_6H_{10}O$	98	0.16
29	*m*-Xylene	19.742	1143	C_8H_{10}	106	0.01
30	2-Methyl-4-pentenal	19.917	1146	$C_6H_{10}O$	98	0.03
31	Butanol	20.333	1152	$C_4H_{10}O$	74	2.11
32	1-Penten-3-ol	21.225	1160	$C_5H_{10}O$	86	0.05
33	Pentyl acetate	22.033	1172	$C_7H_{14}O_2$	130	0.05
34	*o*-Xylene	22.603	1178	C_8H_{10}	106	0.65
35	*(Z)*-3-Hexenal	23.817	1191	$C_6H_{10}O$	98	0.46
36	2-Methyl-1-butanol	24.600	1214	$C_5H_{12}O$	88	0.96
37	*(E)*-2-Hexenal	25.250	1217	$C_6H_{10}O$	98	15.67
38	2-Hexanol	25.458	1223	$C_6H_{14}O$	102	0.04
39	2-Pentylfuran	25.908	1226	$C_9H_{14}O$	138	0.02
40	Ethyl hexanoate	26.133	1233	$C_8H_{16}O_2$	144	0.03
41	2-Methylacetyl-1-butene	27.018	1246	$C_7H_{12}O_2$	128	0.03
42	2-Methyl-1-buten-4-ol	27.283	1250	$C_5H_{10}O$	86	0.06

(continued)

43	Pentanol	27.458	1253	$C_5H_{12}O$	88	0.17
44	Hexyl acetate	28.850	1271	$C_8H_{16}O_2$	144	1.42
45	Octanol	29.917	1286	$C_8H_{16}O$	128	0.01
46	Tridecane	30.925	1300	$C_{13}H_{28}$	184	0.01
I.S.	Butylbenzene	31.900	1305	$C_{10}H_{14}$	134	18.94
47	2-Methyl-2-buten-1-ol	32.325	1307	$C_5H_{10}O$	86	1.09
48	*(E)*-2-Hexenyl acetate	33.050	1310	$C_8H_{14}O_2$	142	0.02
49	Hexanol	34.725	1364	$C_5H_{10}O_2$	102	4.24
50	Heptyl acetate	35.842	1374	$C_9H_{16}O_2$	158	0.16
51	2,5-Dimethylstyrene	36.425	1385	$C_{10}H_{12}$	132	0.03
52	*(Z)*-3-Hexen-1-ol	36.792	1392	$C_6H_{12}O$	100	2.51
53	Nonanal	37.275	1395	$C_9H_{18}O$	142	2.91
54	*(E,E)*-2,4-Hexadienal	37.658	1399	C_6H_8O	96	0.17
55	*(E)*-2-Hexen-1-ol	38.242	1404	$C_6H_{12}O$	100	0.80
56	Butyl hexanoate	38.558	1406	$C_{10}H_{20}O_2$	172	0.14
57	Hexyl butanoate	38.733	1408	$C_{10}H_{20}O_2$	172	0.17
58	Hexyl 2-methyl butanoate	39.492	1425	$C_{11}H_{22}O_2$	186	0.11
59	Ethyl octanoate	39.967	1435	$C_{10}H_{22}O_2$	172	0.03
60	3-Methylbutyl hexanoate	41.592	1457	$C_{11}H_{22}O_2$	186	0.21
61	Furfural	41.725	1459	$C_6H_{10}O$	96	0.11
62	Octyl acetate	42.692	1476	$C_{10}H_{20}O_2$	172	0.19
63	2-Ethylhexanol	43.833	1498	$C_8H_{18}O$	130	0.06

(continued)

64	Pentyl hexanoate	45.100	1511	$C_{11}H_{22}O_2$	186	0.04
65	Benzaldehyde	45.708	1519	C_7H_6O	106	0.07
66	*(E)*-2-Nonenal	46.592	1523	$C_9H_{16}O$	140	0.06
67	Linalool	47.408	1528	$C_{10}H_{18}O$	154	0.04
68	Octanol	48.242	1537	$C_8H_{18}O$	130	0.28
69	1,2-Propanediol	50.475	1568	$C_3H_8O_2$	76	2.34
70	Hexyl hexanoate	51.433	1602	$C_{12}H_{24}O_2$	200	0.44
71	Butyl octanoate	51.617	1606	$C_{12}H_{24}O_2$	200	0.05
72	Octyl butanoate	51.858	1612	$C_{12}H_{24}O_2$	200	0.21
73	1,2-Ethanediol	52.867	1653	$C_2H_6O_2$	62	1.54
74	Ethyl decanoate	53.100	1638	$C_{12}H_{24}O_2$	200	0.18
75	*(E)*-2-Decenal	53.442	1643	$C_{10}H_8O$	154	0.24
76	*(Z)*-3-Hexenyl hexanoate	54.217	1655	$C_{12}H_{22}O_2$	198	0.05
77	Estragole	55.008	1667	$C_{10}H_{12}O$	148	0.11
78	*(E,E)*-2,4-Decadienal	62.800	1812	$C_{10}H_{16}O_2$	152	0.14
79	Geraniol	64.550	1857	$C_{10}H_{18}O$	154	0.11
80	Nerylacetone	64.800	1860	$C_{13}H_{22}O$	194	0.06
81	Hexanoic acid	65.067	1864	$C_6H_{12}O_2$	116	0.07
82	γ-Octalactone	67.500	1963	$C_8H_{14}O_2$	142	0.16
83	β-Ionone	68.408	1971	$C_{13}H_{20}O$	192	0.08
84	Dodecanol	69.250	1978	$C_{12}H_{26}O$	186	0.02
85	1-Phenyl-1-butanol	69.383	1979	$C_{10}H_{14}O$	150	0.02

(continued)

86	2-Tetradecanol	71.058	2026	$C_{14}H_{30}O$	214	0.03
87	Isopropyl tetradecanoate	71.558	2041	$C_{17}H_{34}O_2$	270	0.06
88	Unknown	73.542				0.55
89	γ-Decalactone	75.308	2171	$C_{10}H_{18}O_2$	170	2.36
90	Tetradecanol	75.717	2181	$C_{14}H_{30}O$	242	0.13
91	δ-Undecalactone	76.875	2220	$C_{11}H_{20}O_2$	184	0.11
92	2-Hexadecanol	77.150	2230	$C_{16}H_{34}O$	242	0.12
93	Ethyl hexadecanoate	78.108	2266	$C_{18}H_{36}O_2$	284	0.11
94	γ-Dodecalactone	82.908	2398	$C_{12}H_{22}O_2$	198	9.06
95	Ethyl octadecanoate	85.317	2428	$C_{20}H_{40}O_2$	312	0.08
96	Octadecanol	91.317	2590	$C_{18}H_{38}O$	270	0.06
	Total					93.90

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 40. Relative content of functional groups in Plums

Peak area%

Functional group	Beauty	Pomosa
Aldehydes	17.14	36.36
Alcohols	19.29	17.95
Esters	32.63	6.24
Terpenes	0.01	-
Acids	0.37	0.07
Ethers	0.92	0.63
Ketones	5.57	11.83
Miscellaneous	4.65	1.3
T o t a l	80.58	74.38

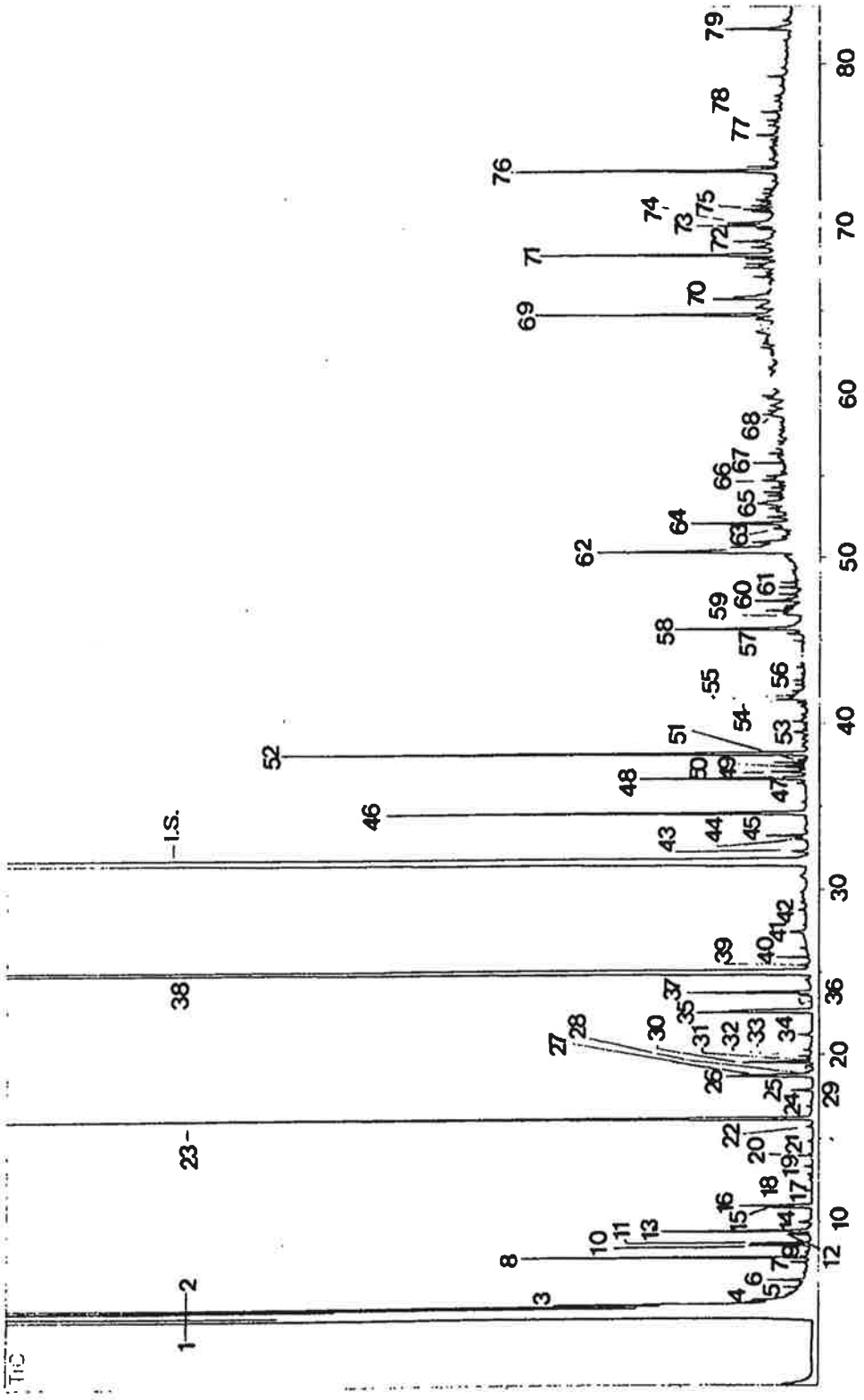

Fig. 32. GC chromatogram of volatile flavor components in Apricot

Table 41. Volatile flavor components in Apricot

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.700	529	$C_5H_{12}O$	88	1.65
2	2-Methyl-1-pentene	4.833	612	C_6H_{12}	84	5.60
3	Ethyl propyl ether	4.975	702	$C_5H_{12}O$	88	0.64
4	sec-Butyl ethyl ether	5.283	709	$C_6H_{14}O$	102	0.02
5	Ethyl butyl ether	6.008	790	$C_6H_{14}O$	102	0.09
6	Ethyl formate	6.483	821	$C_3H_6O_2$	74	0.14
7	Butanal	7.558	873	C_4H_8O	72	0.06
8	Ethyl acetate	7.858	888	$C_4H_8O_2$	88	1.12
9	Nonane	8.167	900	C_9H_{20}	128	0.01
10	2-Methylbutanal	8.600	907	$C_5H_{10}O$	86	0.22
11	3-Methylbutanal	8.733	916	$C_5H_{10}O$	86	0.22
12	2-Propanol	9.250	933	C_3H_8O	60	0.10
13	Ethanol	9.467	942	C_2H_6O	46	0.68
14	2-Ethylfuran	9.992	954	C_6H_8O	96	0.05
15	2,3-Butanedione	10.892	975	$C_4H_6O_2$	86	0.19
16	Pentanal	11.000	978	$C_5H_{10}O$	86	0.32
17	Decane	11.875	1000	$C_{10}H_{22}$	142	0.03
18	3-Penten-3-one	12.483	1012	$C_6H_{12}O_2$	116	0.01
19	2-Methylpropyl acetate	12.558	1013	$C_6H_{12}O_2$	116	0.01
20	2-Butanol	13.333	1034	$C_4H_{10}O$	74	0.03

(continued)

21	2,3-Pentanedione	14.858	1056	$C_5H_8O_2$	100	0.02
22	Butyl acetate	15.725	1071	$C_6H_{12}O_2$	116	0.03
23	Hexanal	16.242	1081	$C_6H_{12}O$	100	4.91
24	2-Methylpropanol	16.908	1099	$C_4H_{10}O$	74	0.01
25	3-Pentanol	17.908	1113	$C_5H_{12}O$	88	0.11
26	2-Pentanol	18.733	1125	$C_5H_{12}O$	88	0.46
27	3-Penten-2-one	18.800	1131	C_5H_8O	84	0.34
28	3-Methyl-2-butenal	18.983	1133	C_5H_8O	84	0.01
29	*p*-Xylene	19.325	1139	C_8H_{10}	106	0.01
30	*(E)*-Allyl propenyl ether	19.575	1143	$C_6H_{10}O$	98	0.35
31	*m*-Xylene	19.742	1146	C_8H_{10}	106	0.01
32	2-Methyl-4-pentenal	19.908	1149	$C_6H_{10}O$	98	0.06
33	Butanol	20.283	1151	$C_4H_{10}O$	74	0.01
34	1-Penten-3-ol	21.208	1165	$C_5H_{10}O$	86	0.05
35	o -Xylene	22.583	1177	C_7H_8	106	0.72
36	α -Limonene	23.608	1191	$C_{10}H_{16}$	136	0.07
37	*(Z)*-3-Hexenal	23.800	1202	$C_6H_{10}O$	98	0.74
38	*(E)*-2-Hexenal	25.100	1218	$C_6H_{10}O$	98	19.60
39	2-Hexanol	25.425	1223	$C_6H_{14}O$	102	0.06
40	2-Pentylfuran	25.892	1226	$C_9H_{14}O$	138	0.05
41	Pentanol	27.458	1258	$C_5H_{12}O$	88	0.11
42	Hexyl acetate	28.808	1279	$C_8H_{16}O_2$	144	0.03

(continued)

I.S.	Butylbenzene	31.867	1308	$C_{10}H_{14}$	134	36.37
43	*(Z)*-2-Heptenal	32.333	1330	$C_7H_{12}O$	112	0.12
44	2-Phenylpropanal	33.092	1337	$C_9H_{10}O$	134	0.11
45	6-Methyl-5-Hepten-2-one	33.267	1338	$C_8H_{14}O$	126	0.24
46	Hexanol	34.633	1362	$C_6H_{14}O$	102	2.72
47	2-Methylindan	36.417	1387	$C_{10}H_{12}$	132	0.02
48	*(Z)*-3-Hexen-1-ol	36.725	1392	$C_6H_{12}O$	100	1.05
49	Nonanal	37.117	1396	$C_9H_{18}O$	142	0.21
50	1-Methylindan	37.333	1398	$C_{10}H_{12}$	132	0.01
51	α-Isophorone	37.850	1407	$C_9H_{14}O$	138	0.04
52	*(E)*-2-Hexen-1-ol	38.242	1414	$C_6H_{12}O$	100	3.48
53	*(E)*-2-Octenal	38.667	1433	$C_8H_{14}O$	126	0.01
54	2-Octanol	41.467	1456	$C_8H_{18}O$	130	0.26
55	Furfural	41.725	1460	$C_5H_4O_2$	96	0.12
56	*(E)*-2-Hexenyl butanoate	42.625	1475	$C_{10}H_{18}O_2$	170	0.06
57	2,3-Butanediol diacetate	43.425	1487	$C_8H_{14}O_4$	174	0.04
58	Benzaldehyde	45.725	1520	C_7H_6O	106	0.85
59	*(E)*-2-Nonenal	46.593	1533	$C_9H_{16}O$	140	0.11
60	Linalool	47.417	1541	$C_{10}H_{18}O$	154	0.27
61	Octanol	48.242	1556	$C_8H_{18}O$	130	0.11
62	1,2-Propanediol	50.400	1591	$C_3H_8O_2$	76	1.97
63	4-Methylbenzaldehyde	51.800	1614	C_8H_8O	120	0.15

(continued)

64	β-Cyclocitral	52.142	1619	$C_{10}H_{16}O$	152	0.78
65	α-Tolualdehyde	53.342	1641	C_8H_8O	120	0.25
66	Estragole	55.017	1671	$C_{10}H_{12}O$	148	0.18
67	α-Ionene	56.375	1695	$C_{13}H_{18}$	174	0.09
68	4-Ethylbenzaldehyde	58.625	1737	$C_9H_{10}O$	134	0.05
69	Nerylacetone	64.808	1863	$C_{13}H_{22}O$	194	1.25
70	Unknown	65.767	1886			0.31
71	β-Ionone	68.425	1951	$C_{13}H_{20}O$	192	1.33
72	Dodecanol	69.242	1964	$C_{12}H_{26}O$	186	0.18
73	Methylbenzyl alcohol	70.200	1980	$C_8H_{10}O$	122	0.48
74	β-Ionone dioxide	70.367	1984	$C_{13}H_{20}O_2$	208	0.30
75	2-Tetradecanol	71.050	2002	$C_{14}H_{30}O$	214	0.10
76	Unknown	73.533	2114			1.29
77	Tetradecanol	75.692	2181	$C_{14}H_{30}O$	214	0.10
78	Pentadecanol	76.592	2209	$C_{15}H_{32}O$	228	0.06
79	Farnesylacetone	82.175	2389	$C_{18}H_{30}O$	262	0.43
	Total					94.45

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 42. Relative content of functional groups in Apricot

	Peak area%
Functional group	Apricot
Aldehydes	28.9
Alcohols	12.58
Esters	1.43
Terpenes	1.4
Acids	-
Ethers	2.75
Ketones	2.52
Miscellaneous	6.9
T o t a l	56.48

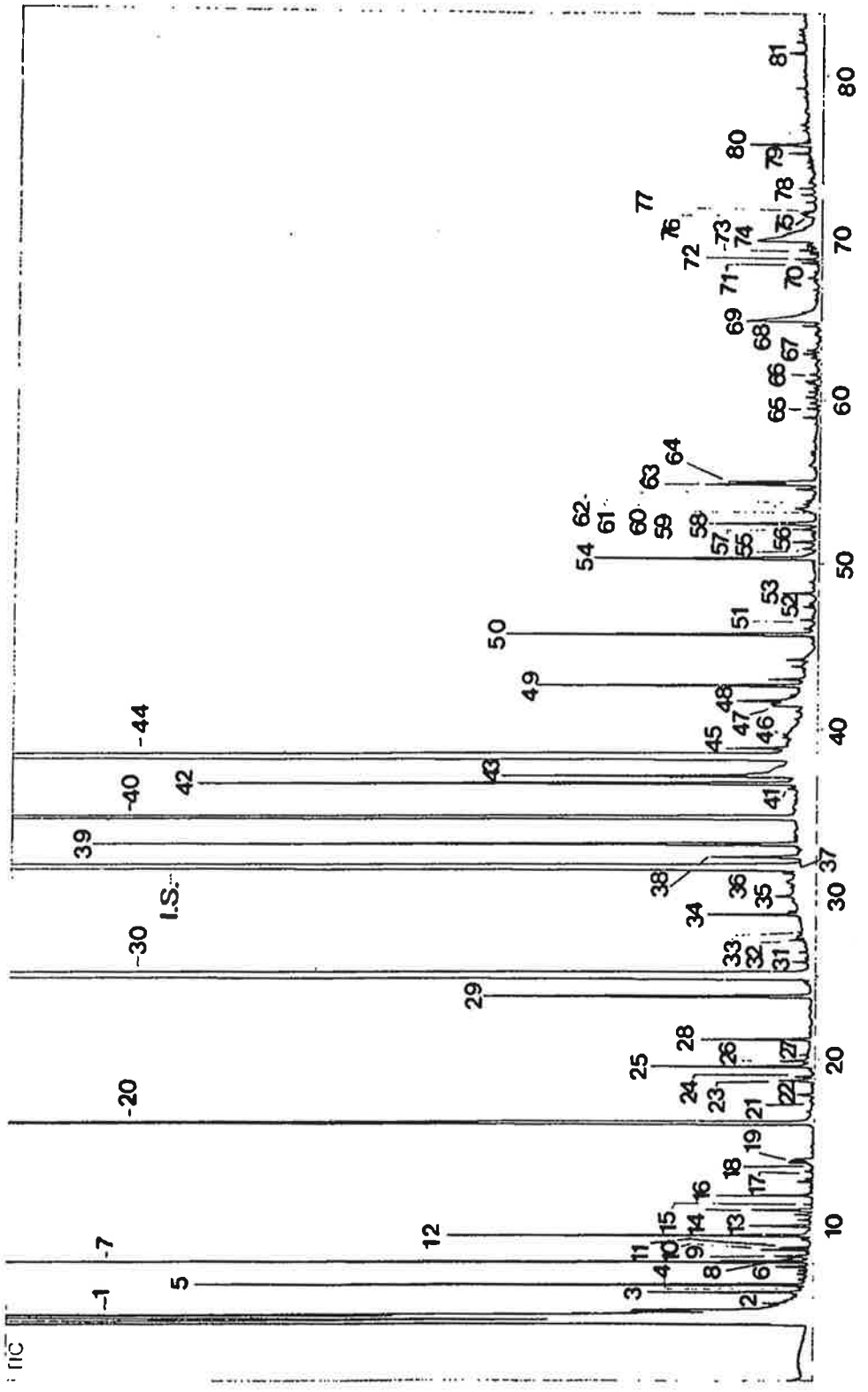

Fig. 33. GC chromatogram of volatile flavor components in Japanese apricot

Table 43. Volatile flavor components in Japanese apricot

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.683	525	$C_5H_{12}O$	88	1.49
2	sec-Butyl ethyl ether	5.267	705	$C_6H_{14}O$	102	0.01
3	Octane	6.017	800	C_8H_{10}	114	0.15
4	2-Propanone	6.317	813	C_3H_6O	58	0.01
5	Ethyl formate	6.475	823	$C_3H_6O_2$	74	0.71
6	Butanal	7.550	876	C_4H_8O	72	0.05
7	Ethyl acetate	7.850	890	$C_4H_8O_2$	88	1.07
8	Nonane	8.133	908	C_9H_{20}	128	0.01
9	Methanol	8.200	909	CH_4O	32	0.05
10	2-Methylbutanal	8.583	913	$C_5H_{10}O$	86	0.06
11	3-Methylbutanal	8.717	914	C_5HO	86	0.04
12	Ethanol	9.458	943	C_2H_6O	46	0.57
13	2-Ethylfuran	9.983	955	C_6H_8O	96	0.01
14	Pentanal	10.992	979	$C_5H_{10}O$	86	0.13
15	2-Ethyl-1-butanol	11.325	985	$C_6H_{14}O$	102	0.01
16	Decane	11.858	995	$C_{10}H_{22}$	142	0.15
17	2-Butanol	13.317	1023	$C_4H_{10}O$	74	0.01
18	Ethyl butanoate	13.733	1031	$C_6H_{12}O_2$	116	0.01
19	Prapanol	13.992	1042	C_3H_8O	60	0.04
20	Hexanal	16.283	1087	$C_6H_{12}O$	100	5.31

(continued)

21	2-Methylpropanol	16.908	1098	$C_4H_{10}O$	74	0.01
22	3-Pentanol	17.883	1114	$C_5H_{12}O$	88	0.04
23	2-Pentanol	18.733	1129	$C_5H_{12}O$	88	0.09
24	*(E)*-2-Pentenal	18.983	1131	C_5H_8O	84	0.01
25	2-Methyl-1-penten-1-one	19.583	1137	$C_6H_{10}O$	98	0.030
26	2-Methyl-4-pentenal	19.900	1142	$C_6H_{10}O$	98	0.05
27	Butanol	20.250	1148	$C_4H_{10}O$	74	0.01
28	1-Penten-3-ol	21.217	1165	$C_5H_{10}O$	86	0.22
29	*(Z)*-3-Hexenal	23.817	1205	$C_6H_{10}O$	98	0.84
30	*(E)*-2-Hexenal	25.275	1229	$C_6H_{10}O$	98	27.20
31	2-Pentylfuran	25.900	1239	$C_9H_{14}O$	138	0.03
32	*(E)*-Ocimene	27.275	1260	$C_{10}H_{16}$	136	0.04
33	Pentanol	27.450	1275	$C_5H_{12}O$	88	0.05
34	Hexyl acetate	28.808	1288	$C_8H_{16}O_2$	144	0.20
35	Octanal	29.900	1298	$C_8H_{16}O$	128	0.05
36	4-Methyl-1,5-heptadiene	31.292	1311	$C_8H_{14}O$	110	0.03
I.S.	Butylbenzene	31.808	1316	$C_{10}H_{14}$	134	14.61
37	*(Z)*-3-Hexenyl acetate	31.883	1317	$C_8H_{14}O_2$	142	0.03
38	*(Z)*-2-Penten-1-ol	32.283	1320	$C_5H_{14}O$	86	0.23
39	*(E)*-2-Hexenyl acetate	33.083	1337	$C_8H_{14}O_2$	142	1.54
40	Hexanol	34.742	1368	$C_6H_{14}O$	102	7.77
41	4-Methyl-2-butanol acetate	36.425	1391	$C_{12}H_{16}O_2$	192	0.01

(continued)

42	*(Z)*-3-Hexen-1-ol	36.742	1395	$C_6H_{12}O$	100	1.46
43	Nonanal	37.183	1405	$C_6H_{18}O$	142	0.72
44	(*E*)-2-Hexen-1-ol	38.508	1429	$C_6H_{12}O$	100	24.08
45	Hexyl butanoate	38.858	1432	$C_{10}H_{20}O_2$	172	0.11
46	Hexyl 2-methylbutanoate	39.517	1437	$C_{11}H_{22}O_2$	186	0.01
47	Acetic acid	41.517	1454	$C_2H_4O_2$	60	0.14
48	Furfural	41.733	1464	$C_5H_4O_2$	96	0.15
49	*(E)*-2-Hexenyl butanoate	42.667	1480	$C_{10}H_{18}O_2$	170	0.58
50	Benzaldehyde	45.733	1525	C_7H_6O	106	0.84
51	*(E)*-2-Nonenal	46.600	1542	$C_9H_{16}O$	140	0.04
52	Linalool	47.408	1554	$C_{10}H_{18}O$	154	0.03
53	Octanol	48.217	1568	$C_8H_{18}O$	130	0.08
54	1,2-Propanediol	50.375	1593	$C_3H_8O_2$	76	0.64
55	Undecanal	50.942	1599	$C_{11}H_{22}O$	170	0.01
56	Hexyl hexanoate	51.358	1604	$C_{12}H_{24}O_2$	200	0.05
57	Methyl benzoate	52.117	1613	$C_8H_8O_2$	136	0.04
58	1,2-Ethanediol	52.483	1617	$C_2H_6O_2$	62	0.34
59	α-Tolualdehyde	53.292	1634	C_8H_8O	120	0.03
60	*(E)*-2-Decenal	53.400	1637	$C_{10}H_{18}O$	154	0.04
61	Acetophenone	53.867	1651	C_8H_8O	120	0.01
62	Nonanol	54.575	1664	$C_9H_{20}O$	144	0.04
63	3-Propyloxiranemethanol	54.867	1669	$C_6H_{12}O_2$	116	0.28

(continued)

64	*(E)*-2-Hexeny-1-hexanoate	55.025	1672	$C_{12}H_{22}O_2$	198	0.19
65	*(E,E)*-α-Farnesene	59.529	1713	$C_{15}H_{24}$	204	0.03
66	Methyl 2-hydroxybenzoate	61.142	1739	$C_8H_8O_3$	152	0.04
67	*(E,E)*-2,4-Decadienal	62.800	1762	$C_{10}H_{16}O$	152	0.04
68	Nerol	64.525	1775	$C_{10}H_{18}O$	154	0.04
69	Hexanoic acid	64.825	1817	$C_6H_{12}O_2$	116	0.33
70	Dodecanol	67.442	1889	$C_{12}H_{26}O$	186	0.01
71	β-Ionone	68.392	1915	$C_{13}H_{20}O$	192	0.04
72	*(Z)*-Jasmone	68.633	1921	$C_{11}H_{16}O$	164	0.04
73	3-Hexenoic acid	69.508	1981	$C_6H_{10}O_2$	114	0.03
74	2-Hexenoic acid	69.750	1991	$C_6H_{10}O_2$	114	0.30
75	Pentadecanal	71.300	2030	$C_{15}H_{30}O$	198	0.04
76	Isopropyl tetradecanoate	71.508	2034	$C_{17}H_{34}O_2$	270	0.03
77	*(E)*-Nerolidol	71.625	2036	$C_{15}H_{26}O$	222	0.01
78	Hexyl benzoate	73.033	2064	$C_{13}H_{18}O_2$	206	0.03
79	*(Z)*-Hexenyl benzoate	75.208	2181	$C_{13}H_{16}O_2$	204	0.04
80	Propenylguaiacol	75.750	2191	$C_{10}H_{12}O_2$	164	0.13
81	*(E,E)*-Farnesol	81.450	2412	$C_{15}H_{26}O$	222	0.03
	Total					94.10

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 44. Relative content of functional groups in Japanese apricot

Peak area%

Functional group	Japanese apricot
Aldehydes	35.65
Alcohols	36.27
Esters	4.69
Terpenes	0.07
Acids	0.80
Ethers	1.50
Ketones	0.13
Miscellaneous	0.38
T o t a l	79.49

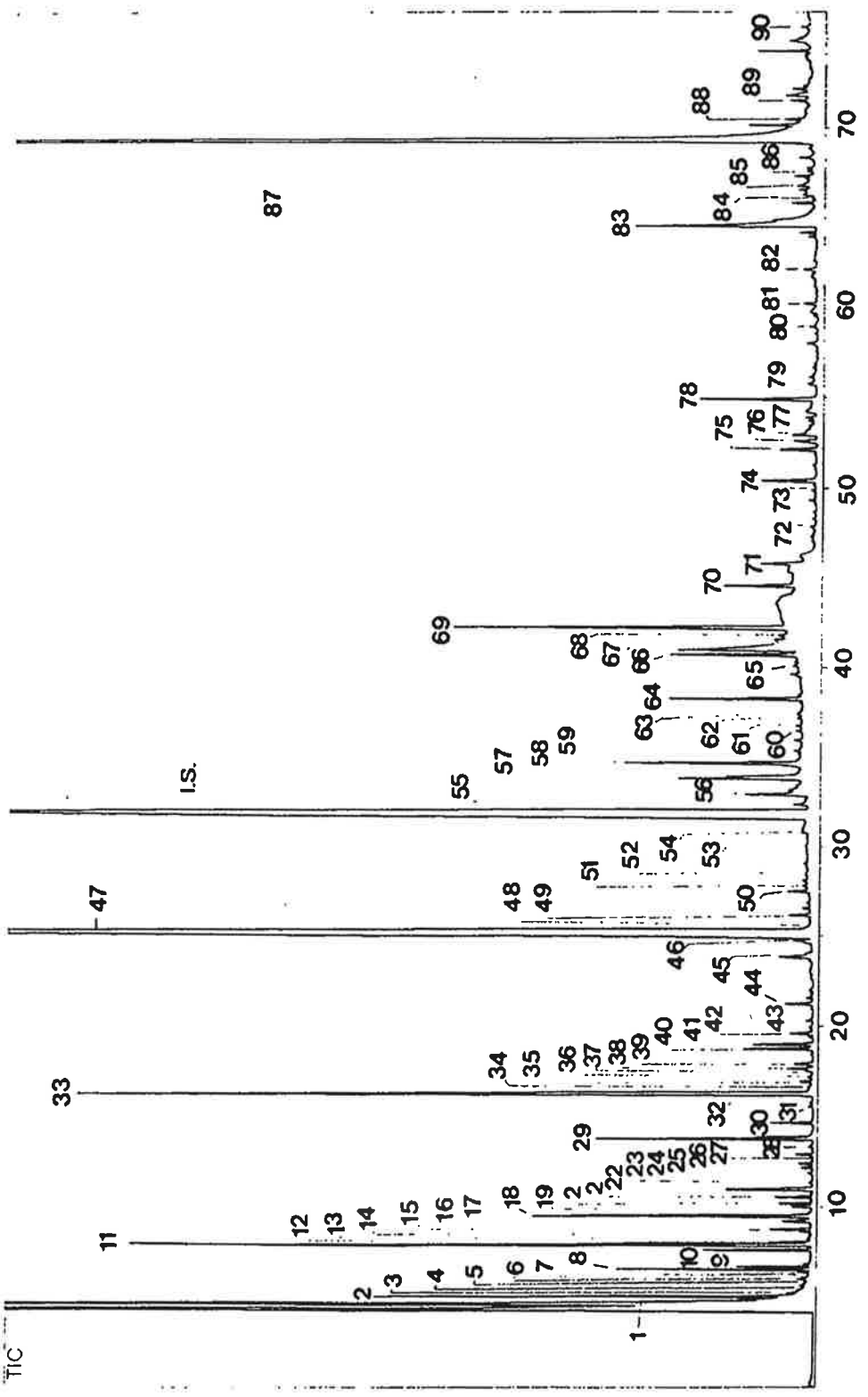

Fig. 34. GC chromatogram of volatile flavor components in Hayward kiwi

자료출처 : 국내산 주요 식물소재의 향기성분 분석에 관한 연구 / 농림부

Table 45. Volatile flavor components in Hayward kiwi

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.700	529	$C_5H_{12}O$	88	0.23
2	Acetaldehyde	4.983	697	C_2H_4O	44	1.50
3	sec-Butyl ethyl ether	5.283	705	$C_6H_{14}O$	102	0.01
4	2,3-Dimethyl hexane	5.575	742	C_8H_{18}	114	0.01
5	Propanal	5.933	787	C_3H_6O	58	0.03
6	Octane	6.042	800	C_8H_{18}	114	0.02
7	2-Propanone	6.342	815	C_3H_6O	58	0.03
8	Ethyl formate	6.500	821	$C_3H_6O_2$	74	0.68
9	2,3-Epoxy-2-methyl butane	6.650	828	$C_5H_{10}O$	86	0.25
10	Butanal	7.583	872	C_4H_8O	72	0.41
11	Ethyl acetate	7.892	888	$C_4H_8O_2$	88	3.32
12	Diethylacetal	8.025	892	$C_6H_{14}O_2$	118	0.14
13	2-Butanone	8.242	898	C_4H_8O	72	0.01
14	2-Methylbutanal	8.617	906	$C_5H_{10}O$	86	0.04
15	3-Methylbutanal	8.750	908	$C_5H_{10}O$	86	0.15
16	Methyl 2-methylpropanoate	8.958	917	$C_5H_{10}O_2$	102	0.01
17	3-Methyl-2-butanone	9.192	927	$C_5H_{10}O$	86	0.12
18	Ethanol	9.517	942	C_2H_6O	46	1.38
19	2-Ethylfuran	10.033	951	C_6H_8O	96	0.13
20	Ethyl propanoate	10.208	955	$C_5H_{10}O_2$	102	0.13

(continued)

21	Ethyl 2-methylpropanoate	10.550	965	$C_6H_{12}O_2$	116	0.15
22	2-Pentanone	10.975	978	$C_5H_{10}O$	86	0.59
23	Methyl butanoate	11.333	984	$C_5H_{10}O_2$	102	0.01
24	2-Butyl acetate	11.417	986	$C_6H_{12}O_2$	116	0.01
25	Decane	11.883	1000	$C_{10}H_{22}$	142	0.01
26	2-Methylpentanal	12.183	1005	$C_6H_{12}O$	100	0.05
27	1-Propoxy-2-propanol	12.725	1013	$C_6H_{14}O_2$	118	0.01
28	2-Butanol	13.350	1023	$C_4H_{10}O$	74	0.02
29	Ethyl butanoate	13.792	1035	$C_6H_{12}O_2$	116	1.07
30	Ethyl 2-methylbutanoate	14.658	1051	$C_7H_{14}O_2$	130	0.18
31	Ethyl 3-methylbutanoate	15.550	1068	$C_7H_{14}O_2$	130	0.02
32	Butyl acetate	15.767	1072	$C_6H_{12}O_2$	116	0.01
33	Hexanal	16.325	1081	$C_6H_{12}O$	100	5.27
34	3-Methyl-2-pentanone	16.633	1086	$C_6H_{12}O$	100	0.01
35	2-Methylpropanol	16.958	1091	$C_4H_{10}O$	74	0.05
36	4-Methyl-1-penten-3-one	17.208	1094	$C_6H_{10}O$	98	0.02
37	2-Methylhexanal	17.550	1097	$C_7H_{14}O$	114	0.03
38	Ethyl carbonate	17.675	1098	$C_5H_{10}O_3$	118	0.14
39	3-Pentanol	17.942	1101	$C_5H_{12}O$	88	0.13
40	2-Pentanol	18.775	1128	$C_5H_{12}O$	88	0.36
41	(*E*)-2-Pentenal	19.025	1133	C_5H_8O	84	0.33
42	2-Methyl-4-pentenal	19.617	1140	$C_6H_{10}O$	98	0.13

(continued)

43	Butanol	20.300	1149	$C_4H_{10}O$	74	0.03
44	1-Penten-3-ol	21.250	1164	$C_5H_{10}O$	86	0.14
45	*(Z)*-3-Henxenal	23.858	1202	$C_6H_{10}O$	98	0.28
46	3-Methyl-1-butanol	24.750	1213	$C_5H_{12}O$	88	0.11
47	(*E*)-2-Hexenal	25.358	1220	$C_6H_{10}O$	98	23.30
48	2-Hexanol	25.500	1227	$C_6H_{14}O$	102	0.02
49	Ethyl hexanoate	26.183	1236	$C_8H_{16}O_2$	144	0.11
50	Pentanol	27.492	1254	$C_5H_{12}O$	88	0.11
51	Ethyl hexylacetal	27.800	1258	$C_{10}H_{22}O_2$	174	0.02
52	4-Methyl-2-penten-1-ol	29.033	1274	$C_6H_{12}O$	100	0.01
53	(*E*)-3-Hepten-2-one	30.792	1298	$C_7H_{12}O$	112	0.01
54	Tridecane	30.958	1300	$C_{13}H_{28}$	184	0.01
I.S.	Butylbenzene	32.006	1308	$C_{10}H_{14}$	134	22.08
55	(*Z*)-2-Penten-1-ol	32.333	1323	$C_5H_{10}O$	86	0.08
56	2-Butyltetrahydrofuran	32.908	1333	$C_8H_{16}O$	128	0.48
57	3-Methyl-3-heptanol	33.808	1348	$C_8H_{18}O$	130	0.79
58	Ethyl 2-hexanoate	33.925	1350	$C_8H_{14}O_2$	142	0.44
59	Hexanol	34.675	1362	$C_6H_{14}O$	102	1.08
60	5-Methylindian	36.450	1388	$C_{10}H_{12}$	132	0.04
61	*(Z)*-3-Hexen-1-ol	36.742	1392	$C_6H_{12}O$	100	0.04
62	Nonanal	37.108	1397	$C_9H_{18}O$	142	0.02
63	1-Methylindian	37.383	1401	$C_{10}H_{12}$	132	0.06

(continued)

64	*(E)*-2-Hexen-1-ol	38.275	1414	$C_6H_{12}O$	100	0.84
65	Ethyl octanoate	40.092	1454	$C_{10}H_{20}O_2$	172	0.03
66	2-Hexanal propylene glycol-acetal	40.717	1468	$C_9H_{16}O_2$	156	0.80
67	Acetic acid	40.950	1473	$C_2H_4O_2$	60	1.73
68	Furfural	41.767	1484	$C_5H_4O_2$	96	0.11
69	2-Propenyl-1,3-dioxolane	42.225	1490	$C_6H_{10}O_2$	114	2.56
70	2-Ethoxy-1-propanol	44.533	1520	$C_5H_{12}O_2$	104	0.48
71	Benzaldehyde	45.758	1536	C_7H_6O	106	0.23
72	Octanol	48.258	1567	$C_8H_{18}O_2$	130	0.01
73	*(E,Z)*-2,6-Nonadienal	49.883	1584	$C_9H_{14}O$	138	0.01
74	1,2-Propanediol	50.408	1604	$C_3H_8O_2$	76	0.37
75	Methyl benzoate	52.142	1626	$C_8H_8O_2$	136	0.26
76	1,2-Ethanediol	52.625	1633	$C_2H_6O_2$	62	0.16
77	Butanoic acid	52.950	1637	$C_4H_8O_2$	88	0.18
78	Ethyl benzoate	54.933	1663	$C_9H_{10}O_2$	150	0.81
79	4-Hydroxy-5-methyl-3-propyl-hexanone	56.167	1683	$C_{10}H_{20}O_2$	172	0.02
80	1,1-Methylethyl-(*Z*)-1,2-hexanediol	59.000	1734	$C_9H_{18}O_2$	158	0.03
81	4-Hydroxy-2-hexenoic acid lactone	60.275	1758	$C_6H_8O_2$	112	0.09
82	Butyrophenone	62.192	1794	$C_{10}H_{12}O$	148	0.10
83	Hexanoic acid	64.550	1849	$C_6H_{12}O_2$	116	2.06
84	2-Methylhexanoic acid	66.050	1884	$C_7H_{14}O_2$	130	0.01
85	3-Hexenoic acid	66.783	1907	$C_6H_{10}O_2$	114	0.04

(continued)

86	Neophytadiene	67.592	1930	$C_{20}H_{38}$	278	0.03
87	2-Hexenoic acid	69.300	1980	$C_6H_{10}O_2$	114	17.02
88	2,3-Epoxy-β-ionone	70.500	2008	$C_{13}H_{20}O_2$	208	0.08
89	Isopropyl tetradecanoate	71.542	2033	$C_{17}H_{34}O_2$	270	0.05
90	6,10,14-Trimethyl-2-pentadecanone	74.358	2131	$C_{18}H_{36}O$	268	0.23
91	Tetradecanol	75.708	2181	$C_{14}H_{30}O$	214	0.04
	Total					94.84

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 46. Relative content of functional groups in Kiwifruit

	Peak area%
Functional group	Hayward
Aldehydes	32.85
Alcohols	6.29
Esters	7.43
Terpenes	-
Acids	21.04
Ethers	0.24
Ketones	1.31
Miscellaneous	3.6
T o t a l	72.76

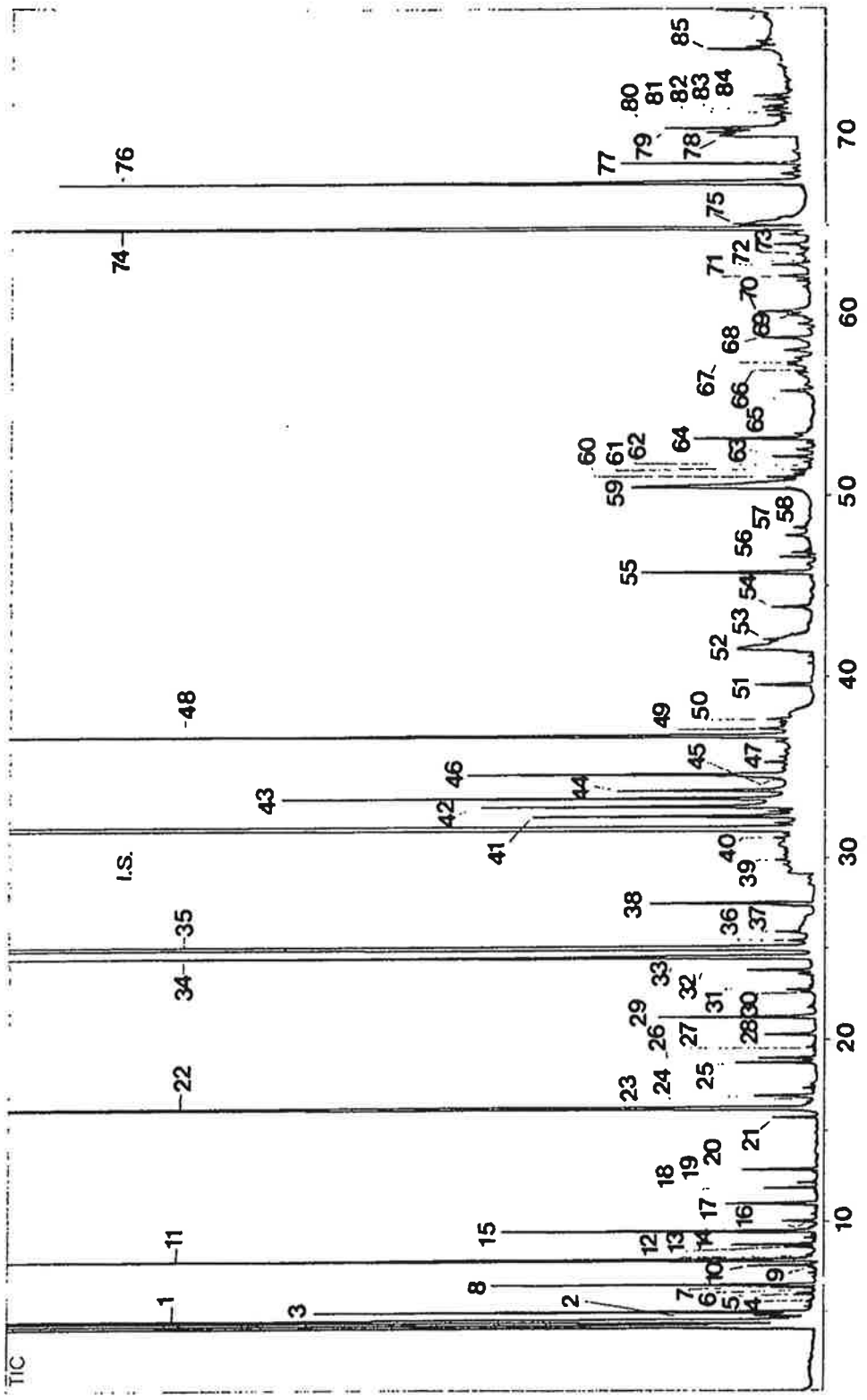

Fig. 35. GC chromatogram of volatile flavor components in Paepae tomato

Table 47. Volatile flavor components in Paepae tomato

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.708	529	$C_5H_{12}O$	88	0.11
2	Ethyl vinyl ether	4.883	623	C_4H_8O	72	0.09
3	Acetaldehyde	5.000	696	C_2H_4O	44	1.61
4	Ethyl sec-butyl ether	5.283	706	C_6H_4O	102	0.02
5	Propanal	5.942	779	C_3H_6O	58	0.04
6	Octane	6.042	800	$C_8H_{18}O$	114	0.04
7	2-Propanone	6.342	811	C_3H_6O	58	0.09
8	Ethyl formate	6.500	821	$C_3H_6O_2$	74	0.72
9	2-Methyltetrahydrofuran	7.458	869	$C_5H_{10}O$	86	0.02
10	Butanal	7.583	875	C_4H_8O	72	0.16
11	Ethyl acetate	7.883	894	$C_4H_8O_2$	88	4.51
12	Diethylacetal	8.017	899	$C_6H_{14}O_2$	118	0.04
13	2-Methylbutanal	8.608	914	$C_5H_{10}O$	86	0.07
14	3-Methylbutanal	8.750	917	$C_5H_{10}O$	86	0.20
15	Ethanol	9.483	943	C_2H_6O	46	0.89
16	2-Ethylfuran	10.000	952	C_6H_8O	96	0.05
17	Pentanal	11.017	981	$C_5H_{10}O$	86	0.38
18	Decane	11.883	1000	$C_{10}H_{22}$	142	0.13
19	2-Methylpentanal	12.175	1004	$C_6H_{12}O$	100	0.02
20	1-Penten-3-one	12.900	1018	C_5H_8O	84	0.22
21	Butyl acetate	15.742	1057	$C_6H_{12}O_2$	116	0.13

(continued)

22	Hexanal	16.267	1066	$C_6H_{12}O$	100	10.55
23	2-Methyl-2-butenal	16.842	1078	C_5H_8O	84	0.05
24	2-Methylpropanol	16.933	1100	$C_4H_{10}O$	74	0.18
25	2-Pentanol	18.758	1128	$C_5H_{12}O$	88	0.27
26	*(E)*-Pentenal	19.008	1130	C_5H_8O	84	0.18
27	2-Methyl 4-pentenal	19.583	1136	$C_6H_{10}O$	98	0.02
28	Butanol	20.292	1152	$C_4H_{10}O$	74	0.16
29	1-Penten-3-ol	21.233	1156	$C_5H_{10}O$	86	0.54
30	2-Heptanone	22.558	1179	$C_7H_{14}O$	114	0.02
31	Heptanal	22.700	1182	$C_7H_{14}O$	114	0.09
32	α-Limonene	23.608	1201	$C_{10}H_{16}$	136	0.04
33	*(Z)*-3-Hexenal	23.808	1203	$C_6H_{10}O$	98	0.24
34	2-Methyl-1-butanol	24.483	1215	$C_5H_{12}O$	88	3.71
35	*(E)*-2-Hexenal	25.058	1224	$C_6H_{10}O$	98	18.48
36	2-Ethoxyethanol	25.433	1228	$C_4H_{10}O_2$	90	0.02
37	2-Pentylfuran	25.908	1232	$C_9H_{14}O$	138	0.04
38	Pentanol	27.475	1259	$C_5H_{12}O$	88	0.56
39	Octanal	29.900	1290	$C_8H_{16}O$	128	0.02
40	*(Z)*-3-Hexenyl ethylacetal	31.117	1306	$C_{10}H_{20}O_2$	172	0.04
I.S.	Butylbenzene	31.700	1313	$C_{10}H_{14}$	134	22.70
41	*(Z)*-2-Penten-1-ol	32.308	1329	$C_5H_{10}O$	86	1.05
42	Tetrahydrofurfuryl alcohol	32.842	1332	$C_5H_{10}O_2$	102	1.36

(continued)

43	6-Methyl-5-hepten-2-one	33.300	1334	$C_8H_{14}O$	126	1.79
44	3-Methyl-3-heptanol	33.733	1344	$C_8H_{18}O$	130	0.60
45	2,6-Dimethyl 5-heptenal	34.350	1358	$C_9H_{16}O$	140	0.02
46	Hexanol	34.633	1365	$C_6H_{14}O$	102	1.23
47	*(E)*-2-Hexen-1-ol	35.317	1372	$C_6H_{14}O$	100	0.05
48	*(Z)*-3-Hexen-1-ol	36.758	1391	$C_6H_{12}O$	100	4.29
49	Nonanal	37.150	1396	$C_9H_{18}O$	142	0.07
50	*(E,E)*-2,4-Hexadienal	37.667	1402	C_6H_8O	96	0.07
51	*(E)*-2-Octenal	39.567	1430	$C_8H_{14}O$	126	0.14
52	Acetic acid	41.467	1454	$C_2H_4O_2$	60	0.02
53	6-Methyl-5-hepten-2-ol	42.058	1465	$C_8H_{16}O$	128	0.02
54	*(E,E)*-2,4-Heptadienal	43.825	1491	$C_7H_{10}O$	110	0.16
55	Benzaldehyde	45.758	1519	C_7H_6O	106	0.76
56	*(E)*-2-Nonenal	46.625	1533	$C_9H_{16}O$	140	0.13
57	Linalool	47.450	1550	$C_{10}H_{18}O$	154	0.14
58	Octanol	48.267	1564	$C_{10}H_{18}O_2$	170	0.02
59	1,2-Propanediol	50.492	1595	$C_3H_8O_2$	76	2.03
60	2,6-Dimethyl cyclohexanol	51.025	1604	$C_8H_{16}O$	128	0.16
61	Hexyl hexanoate	51.417	1611	$C_{12}H_{24}O_2$	200	0.02
62	*(E)*-2-Octen-1-ol	51.883	1618	$C_8H_{16}O$	128	0.02
63	β-Cyclocitral	52.158	1623	$C_{10}H_{16}O$	152	0.18
64	3,4-Epoxy-2-octanone	53.167	1640	$C_8H_{14}O_2$	142	0.43

(continued)

65	*(Z)*-Citral	55.783	1683	$C_{10}H_{16}O$	152	0.11
66	α-Terpineol	56.817	1700	$C_{10}H_{16}O$	152	0.02
67	Ethyl benzaldehyde	57.383	1709	$C_{9}H_{10}O$	134	0.04
68	*(E)*-Citral	58.775	1730	$C_{10}H_{16}O$	152	0.14
69	Geranyl acetate	60.033	1749	$C_{12}H_{20}O_2$	196	0.09
70	5-Ethyl-2-furanone	60.258	1754	$C_{6}H_{8}O_2$	112	0.20
71	1-Phenyl-1-butanone	62.200	1795	$C_{10}H_{12}O$	148	0.36
72	*(E,E)*-2,4-Decadienal	62.833	1811	$C_{10}H_{16}O$	152	0.09
73	Geranyl acetone	63.658	1832	$C_{13}H_{22}O$	194	0.02
74	Neryl acetone	64.867	1863	$C_{13}H_{22}O$	194	6.82
75	Hexanoic acid	65.092	1874	$C_{6}H_{12}O_2$	116	0.14
76	Phenethyl alcohol	67.333	1929	$C_{8}H_{10}O$	122	2.86
77	β-Ionone	68.442	1951	$C_{13}H_{20}O$	192	0.62
78	2-Hexenoic acid	69.958	1981	$C_{6}H_{10}O_2$	114	0.34
79	5,6-Epoxy-β-Ionone	70.392	2007	$C_{13}H_{20}O_2$	208	0.60
80	2-Tetradecanone	71.100	2030	$C_{14}H_{28}O$	212	0.05
81	Pentadecanal	71.358	2039	$C_{15}H_{30}O$	226	0.07
82	Isopropyl tetradecanoate	71.550	2045	$C_{17}H_{34}O_2$	270	0.07
83	*(E)*-Nerolidol	71.658	2048	$C_{15}H_{26}O$	222	0.07
84	3,5-*(E,Z)*-Pseudoionone	71.967	2057	$C_{13}H_{20}O$	192	0.05
85	*(E,E)*-Pseudoionone	74.833	2149	$C_{13}H_{20}O$	192	0.22
	Total					95.19

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

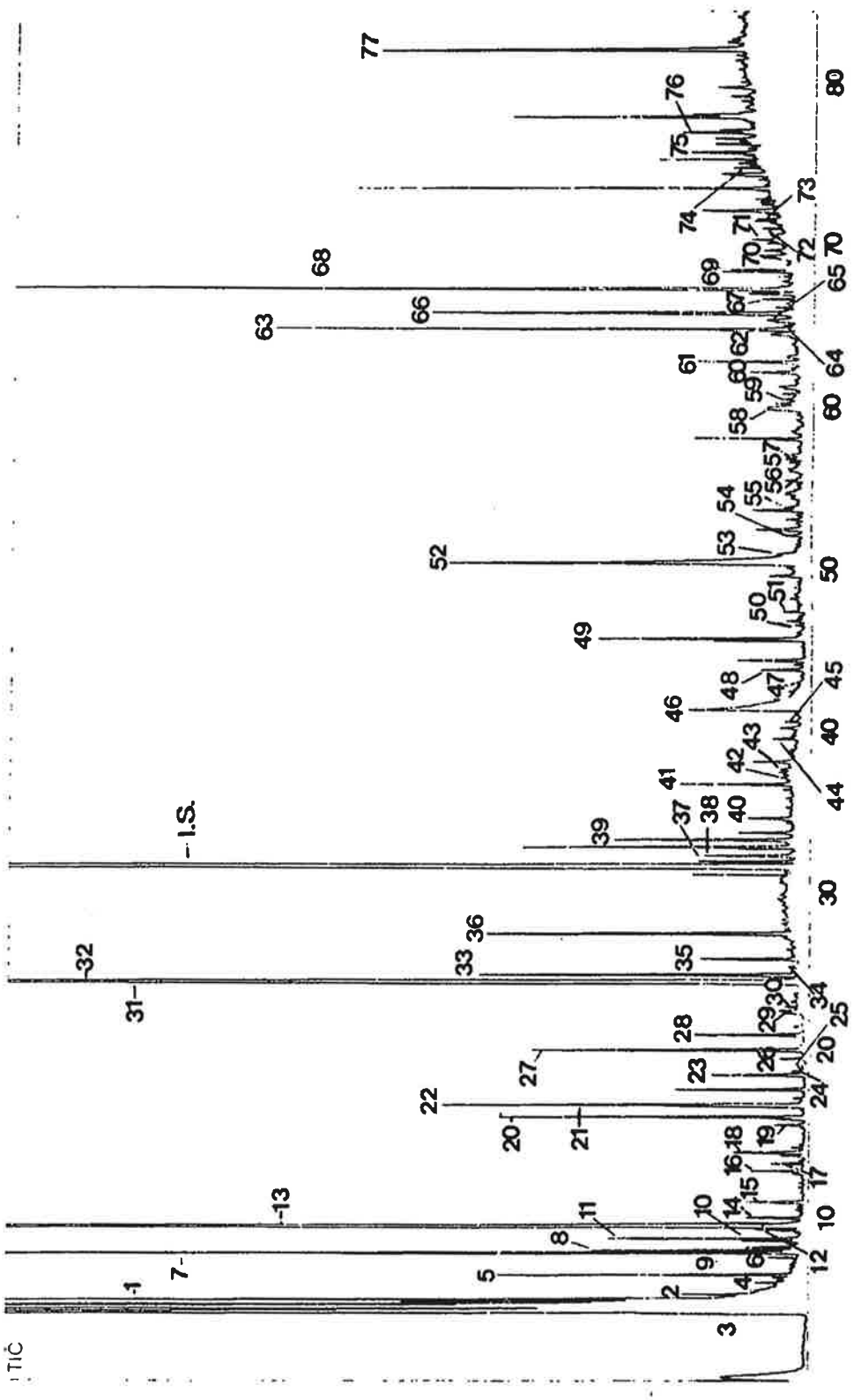

Fig. 36. GC chromatogram of volatile flavor components in Koko tomato

Table 48. Volatile flavor components in Koko tomato

Peak No.	Components	RT[a]	RI[b]	MF[c]	FW[d]	Peak Area (%)
1	Ethyl isopropyl ether	4.700	529	$C_5H_{12}O$	88	2.25
2	sec-Butyl ethyl ether	5.292	707	$C_6H_{14}O$	102	0.11
3	Ethyl butyl ether	6.008	790	$C_6H_{14}O$	102	0.04
4	2-Propanone	6.342	811	C_3H_6O	58	0.02
5	Ethyl formate	6.483	821	$C_3H_6O_2$	74	0.72
6	Butanal	7.567	873	C_4H_8O	72	0.06
7	Ethyl acetate	7.867	888	$C_4H_8O_2$	88	5.52
8	Diethylacetal	8.017	891	$C_6H_{14}O_2$	118	0.50
9	2-Butanone	8.225	896	C_4H_8O	72	0.14
10	2-Methylbutanal	8.608	904	$C_5H_{10}O$	86	0.15
11	3-Methylbutanal	8.742	907	$C_5H_{10}O$	86	0.49
12	2-Propanol	9.283	930	C_3H_8O	60	0.15
13	Ethanol	9.558	942	C_2H_6O	46	16.12
14	2-Ethylfuran	10.008	950	C_6H_8O	96	0.17
15	Pentanal	11.000	969	$C_5H_{10}O$	86	0.24
16	1-Penten-3-one	12.900	1004	C_5H_8O	84	0.17
17	2-Butanol	13.342	1013	$C_4H_{10}O$	74	0.09
18	Propanol	14.017	1025	C_3H_8O	60	0.32
19	Butyl acetate	15.733	1057	$C_6H_{12}O_2$	116	0.07
20	Hexanal	16.217	1066	$C_6H_{12}O$	100	1.03

(continued)

21	2-Methyl-*(E)*-2-butenal	16.850	1078	C_5H_8O	84	0.45
22	2-Methylpropanol	16.950	1080	$C_4H_{10}O$	74	1.35
23	2-Pentanol	18.767	1112	$C_5H_{12}O$	88	0.41
24	(*E*)-2-Pentenal	19.000	1116	C_5H_8O	84	0.01
25	2-Carene	19.167	1119	$C_{10}H_{16}$	136	0.01
26	*m*-Xylene	19.750	1130	C_8H_{10}	106	0.01
27	Butanol	20.292	1139	$C_4H_{10}O$	74	1.07
28	1-Penten-3-ol	21.233	1156	$C_5H_{10}O$	86	0.39
29	2-Heptanone	22.558	1179	$C_7H_{14}O$	114	0.05
30	α-Limonene	23.592	1198	$C_{10}H_{16}$	136	0.01
31	2-Methyl-1-butanol	24.475	1213	$C_5H_{12}O$	88	7.13
32	3-Methyl-1-butanol	24.567	1215	$C_5H_{12}O$	88	4.53
33	(*E*)-2-Hexenal	24.933	1220	$C_6H_{10}O$	98	1.29
34	2-Ethoxyethanol	25.417	1228	$C_4H_{10}O_2$	90	0.01
35	2-Pentylfuran	25.900	1235	$C_9H_{14}O$	138	0.34
36	Pentanol	27.475	1258	$C_5H_{12}O$	88	1.31
I.S.	Butylbenzene	31.708	1306	$C_{10}H_{14}$	134	27.22
37	4-Methyl-1-pentanol	31.942	1311	$C_6H_{14}O$	102	0.39
38	(*Z*)-2-Penten-1-ol	32.300	1317	$C_5H_{10}O$	86	0.40
39	6-Methyl-5-hepten-2-one	33.283	1334	$C_8H_{14}O$	126	0.71
40	Hexanol	34.617	1353	$C_6H_{14}O$	102	0.17
41	(*Z*)-3-Hexen-1-ol	36.725	1391	$C_6H_{12}O$	100	0.45

(continued)

42	Nonanal	37.117	1396	$C_9H_{18}O$	142	0.01
43	(*E*,*E*)-2,4-Hexadienal	37.675	1404	C_6H_8O	96	0.01
44	(*E*)-2-Octenal	39.550	1430	$C_8H_{14}O$	126	0.11
45	1-Propoxy-2-propanol	40.617	1445	$C_6H_{14}O_2$	118	0.04
46	Acetic acid	41.311	1455	$C_2H_4O_2$	60	0.68
47	6-Methyl-5-hepten-2-ol	42.025	1465	$C_8H_{16}O$	128	0.01
48	(*E*,*E*)-2,4-Heptadienal	43.817	1491	$C_7H_{10}O$	110	0.19
49	Benzaldehyde	45.742	1519	C_7H_6O	106	1.05
50	(*E*)-2-Nonenal	46.592	1533	$C_9H_{16}O$	140	0.01
51	Linalool	47.433	1546	$C_{10}H_{18}O$	154	0.01
52	1,2-Propanediol	50.400	1595	$C_3H_8O_2$	76	3.20
53	2,6-Dimethylcyclohexanol	51.008	1604	$C_8H_{16}O$	128	0.01
54	β-Cyclocitral	52.150	1623	$C_{10}H_{16}O$	152	0.01
55	Acetophenone	53.875	1651	C_8H_8O	120	0.01
56	2-Hydroxybenzaldehyde	55.533	1678	$C_7H_6O_2$	122	0.01
57	α-Terpineol	56.883	1700	$C_{10}H_{18}$	154	0.01
58	Geranyl acetate	59.892	1749	$C_{12}H_{20}O_2$	196	0.35
59	(*E*,*Z*)-2,4-Decadienal	60.525	1759	$C_{10}H_{16}O$	152	0.03
60	1-Phenyl-1-butanone	62.200	1795	$C_{10}H_{12}O$	148	0.54
61	(*E*,*E*)-2,4-Decadienal	62.833	1811	$C_{10}H_{16}O$	152	0.37
62	Geraniol	64.550	1856	$C_{10}H_{18}O$	154	0.11
63	(*Z*)-Geranylacetone	64.825	1863	$C_{13}H_{22}O$	194	2.05

(continued)

64	Guaiacol	65.075	1870	$C_7H_8O_2$	124	0.01
65	Hexanoic acid	65.300	1876	$C_6H_{12}O_2$	116	0.21
66	Benzyl alcohol	65.850	1890	C_7H_8O	108	2.11
67	2,6-Dimethylphenol	67.067	1921	$C_8H_{10}O$	122	0.22
68	Phenethyl alcohol	67.325	1928	$C_8H_{10}O$	122	4.21
69	β-Ionone	68.433	1950	$C_{13}H_{20}O$	192	0.24
70	1-Phenyl-2-methylpropyl-alcohol	69.400	1979	$C_{10}H_{14}O$	150	0.01
71	β-Ionone epoxide	70.383	2009	$C_{13}H_{20}O_2$	208	0.08
72	2-Tetradecanone	71.083	2030	$C_{14}H_{28}O$	212	0.05
73	(*E*)-Nerolidol	71.650	2047	$C_{15}H_{26}O$	222	0.07
74	(*E*,*E*)-Pseudoinone	74.808	2149	$C_{13}H_{20}O$	192	0.11
75	Tetradecanol	75.750	2182	$C_{14}H_{30}O$	214	0.32
76	Methyl hexadecanoate	77.000	2224	$C_{17}H_{34}O_2$	270	0.24
77	Farnesylacetone	82.225	2386	$C_{18}H_{30}O$	262	1.76
	Total					94.53

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

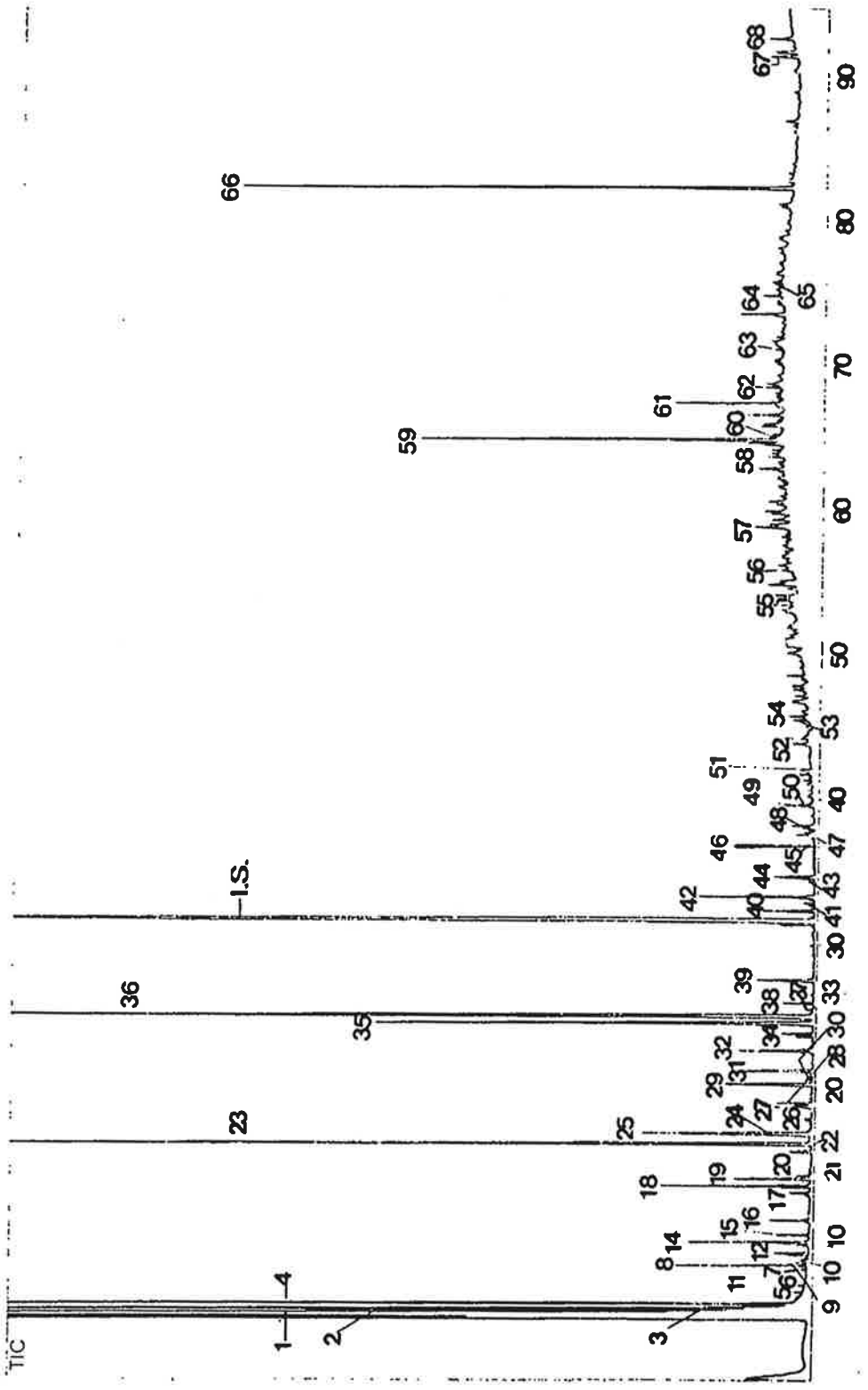

Fig. 37. GC chromatogram of volatile flavor components in Dotaerang tomato

Table 49. Volatile flavor components in Dotaerang tomato

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.725	532	$C_5H_{12}O$	88	1.05
2	2-Methyl-1-pentene	4.858	630	C_6H_{12}	84	10.35
3	2,3-Dimethyl-2-butene	4.933	680	C_6H_{12}	84	0.08
4	Ethyl propyl ether	5.000	699	$C_5H_{12}O$	88	0.24
5	Ethyl butyl ether	6.025	791	$C_6H_{14}O$	102	0.03
6	Ethyl formate	6.517	821	$C_3H_6O_2$	74	0.01
7	Butanal	7.583	873	C_4H_8O	72	0.03
8	Ethyl acetate	7.892	888	$C_4H_8O_2$	88	0.70
9	2-Methylfuran	8.083	893	C_5H_6O	82	0.01
10	2-Butanone	8.242	897	C_4H_8O	72	0.01
11	2-Methylbutanal	8.625	907	$C_5H_{10}O$	86	0.11
12	3-Methylbutanal	8.758	916	$C_5H_{10}O$	86	0.20
13	2-Propanol	9.275	933	C_3H_8O	60	0.07
14	Ethanol	9.500	941	C_2H_6O	46	0.84
15	2-Ethylfuran	10.033	954	C_6H_8O	96	0.20
16	Pentanal	11.033	978	$C_5H_{10}O$	86	0.32
17	1-Penten-3-one	12.917	1020	C_5H_8O	84	0.17
18	2-Butanol	13.367	1032	$C_4H_{10}O$	74	1.11
19	2-Butenal	13.883	1039	C_4H_6O	70	0.58
20	Propanol	14.042	1045	C_3H_8O	60	0.11

(continued)

21	3-Hexanone	14.558	1053	$C_6H_{12}O$	100	0.01
22	Dimethyl disulfide	15.742	1073	$C_2H_6S_2$	94	0.23
23	Hexanal	16.283	1082	$C_6H_{12}O$	100	8.42
24	2-Methyl-*(E)*-2-butenal	16.883	1094	C_5H_8O	84	0.28
25	2-Methylpropanol	16.975	1099	$C_4H_{10}O$	74	1.47
26	3-Pentanol	17.950	1113	$C_5H_{12}O$	88	0.01
27	2-Pentanol	18.783	1125	$C_5H_{12}O$	88	0.48
28	(*E*)-2-Pentenal	19.025	1128	C_5H_8O	84	0.31
29	Butanol	20.325	1151	$C_4H_{10}O$	74	0.83
30	3-Heptanone	20.675	1156	$C_7H_{14}O$	114	0.01
31	1-Penten-3-ol	21.267	1165	$C_5H_{10}O$	86	0.63
32	*o*-Xylene	22.633	1177	C_8H_{10}	106	0.74
33	α-Limonene	23.633	1191	$C_{10}H_{16}$	136	0.14
34	*(Z)*-3-Hexenal	23.833	1202	$C_6H_{10}O$	98	0.29
35	2-Methyl-1-butanol	24.508	1215	$C_5H_{12}O$	88	5.34
36	(*E*)-2-Hexenal	25.058	1220	$C_6H_{10}O$	98	14.89
37	2-Hexanol	25.475	1223	$C_6H_{14}O$	102	0.01
38	2-Pentylfuran	25.942	1226	$C_9H_{14}O$	138	0.28
39	Pentanol	27.508	1258	$C_5H_{12}O$	88	0.67
I.S.	Butylbenzene	31.734	1310	$C_{10}H_{14}$	134	25.14
40	(*Z*)-2-Penten-1-ol	32.333	1328	$C_5H_{10}O$	86	0.58
41	3-Methyl-1-pentanol	32.850	1334	$C_6H_{14}O$	102	0.01

(continued)

42	6-Methyl-5-hepten-2-one	33.317	1338	$C_8H_{14}O$	126	1.03
43	2,6-Dimethyl-5-heptenal	34.392	1356	$C_9H_{16}O$	140	0.01
44	Hexanol	34.658	1361	$C_6H_{14}O$	102	0.37
45	5-Methylindan	36.467	1387	$C_{10}H_{12}$	132	0.01
46	(*Z*)-3-Hexen-1-ol	36.775	1391	$C_6H_{12}O$	100	0.96
47	*(E,E)*-2,4-Hexadienal	37.717	1408	C_6H_8O	96	0.01
48	2-Butoxyethanol	38.008	1411	$C_{10}H_{14}O_2$	118	0.06
49	(E)-2-Octenal	39.592	1428	$C_8H_{14}O$	126	0.29
50	2,6-Dimethyl-2-octanol	39.758	1456	$C_{10}H_{22}O$	158	0.01
51	6-Methyl-5-hepten-2-ol	42.075	1462	$C_8H_{16}O$	128	0.09
52	(*E,E*)-2,4-Heptadienal	43.867	1493	$C_7H_{10}O$	110	0.20
53	2-Nonen-4-yne	45.483	1513	C_9H_{14}	122	0.12
54	Benzaldehyde	45.775	1519	C_7H_6O	106	0.19
55	1-Phenylpropanol	53.733	1650	$C_9H_{12}O$	136	0.18
56	*(Z)*-Citral	55.817	1684	$C_{10}H_{16}O$	152	0.10
57	*(E)*-Citral	58.808	1737	$C_{10}H_{16}O$	152	0.45
58	(*E,E*)-2,4-Decadienal	62.883	1815	$C_{10}H_{16}O$	152	0.25
59	Nerylacetone	64.875	1864	$C_{13}H_{22}O$	194	3.15
60	Guaiacol	65.108	1869	$C_7H_8O_2$	124	0.13
61	Phenethyl alcohol	67.358	1928	$C_8H_{10}O$	122	1.07
62	β-Ionone	68.483	1941	$C_{13}H_{20}O$	192	0.14
63	2-Tetradecanol	71.117	2027	$C_{14}H_{30}O$	214	0.06

(continued)

64	*(E,E)*-Pseudoionone	74.858	2148	$C_{13}H_{20}O$	192	0.11
65	Eugenol	75.808	2181	$C_{10}H_{12}O_2$	164	0.09
66	Farnesylacetone	82.292	2383	$C_{18}H_{30}O$	262	5.81
67	Octadecanol	91.417	2593	$C_{18}H_{38}O$	270	0.33
68	*(E)*-Phytol	92.700	2618	$C_{20}H_{40}O$	296	0.52
	Total					92.73

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 50. Relative content of functional groups in Tomatoes

Peak area%

Functional group	Paepae	Koko	Dotaerang
Aldehydes	34.17	6.02	26.93
Alcohols	20.25	44.63	16.03
Esters	0.22	6.9	0.71
Terpenes	0.04	0.02	0.14
Acids	0.50	2.0	-
Ethers	0.22	2.4	1.32
Ketones	11.49	5.85	10.44
Miscellaneous	0.28	0.6	12.02
T o t a l	67.17	68.42	67.59

Fig. 38. GC chromatogram of volatile flavor components in Suhong strawberry I

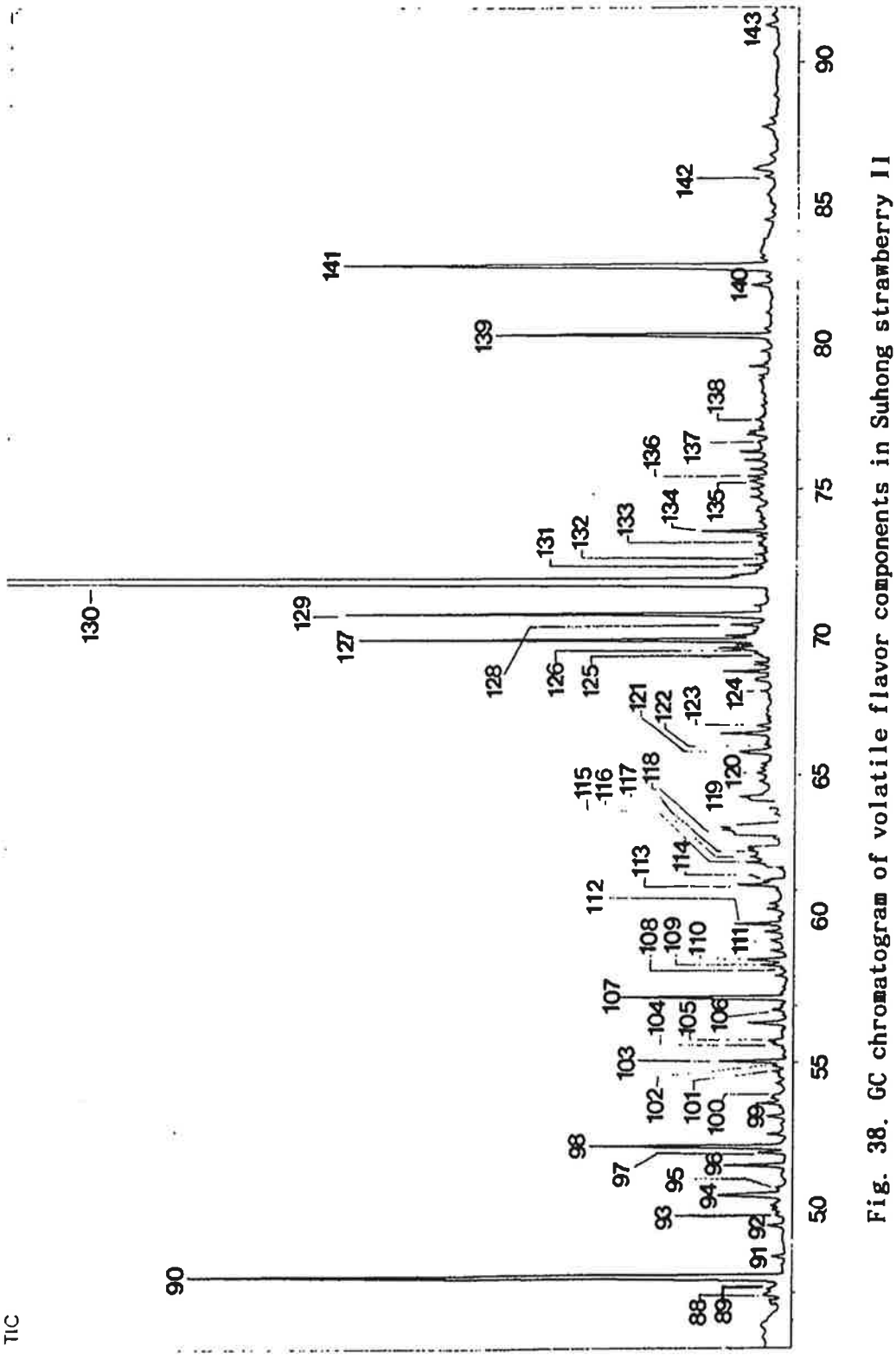

Fig. 38. GC chromatogram of volatile flavor components in Suhong strawberry II

Table 51. Volatile flavor components in Suhong strawberry

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.700	529	$C_5H_{12}O$	88	0.35
2	Acetaldehyde	4.983	696	C_2H_4O	44	1.88
3	sec-Butyl ethyl ether	5.283	708	$C_5H_{12}O$	88	0.03
4	Propanal	5.925	728	C_3H_6O	58	0.03
5	Octane	6.033	731	C_8H_{18}	114	0.05
6	2-Propanone	6.350	791	C_3H_6O	58	0.24
7	Ethyl formate	6.492	822	$C_3H_6O_2$	74	0.86
8	Butanal	7.583	874	C_4H_8O	72	0.05
9	2-Methyl-2-propenal	7.717	882	C_4H_6O	70	0.01
10	Ethyl acetate	7.892	893	$C_4H_8O_2$	88	3.29
11	Diethylacetal	8.017	899	$C_6H_{14}O_2$	118	0.09
12	Isopropyl acetate	8.175	908	$C_5H_{10}O_2$	96	0.16
13	Methyl propanoate	8.408	919	$C_4H_8O_2$	88	0.05
14	2-Methylbutanal	8.608	929	$C_5H_{10}O$	86	0.01
15	3-Methylbutanal	8.742	936	$C_5H_{10}O$	86	0.09
16	3-Methyl-2-butanone	9.175	941	$C_5H_{10}O$	86	0.01
17	2-Propanol	9.267	942	C_3H_8O	60	0.04
18	Ethanol	9.517	945	C_2H_6O	46	1.38
19	3-Buten-2-one	9.750	948	C_4H_6O	70	0.04
20	Ethyl propanoate	10.292	956	$C_5H_{10}O_2$	102	0.18

(continued)

21	Ethyl 2-methylpropanoate	10.533	965	$C_6H_{12}O_2$	116	0.06
22	Propyl acetate	10.875	977	$C_5H_{10}O_2$	102	0.01
23	2-Pentanone	10.958	980	$C_5H_{10}O$	86	0.34
24	Methyl butanoate	11.392	990	$C_5H_{10}O_2$	102	4.14
25	Decane	11.892	1000	$C_{10}H_{12}$	142	0.01
26	4-Methyl-2-pentanone	12.250	1011	$C_6H_{10}O$	100	0.20
27	Methyl 2-methylbutanoate	12.417	1012	$C_6H_{12}O_2$	116	0.20
28	2-Methylpropyl acetate	12.583	1014	$C_6H_{12}O_2$	116	0.03
29	3-Methyl-2-pentanone	12.717	1015	$C_6H_{10}O$	100	0.10
30	Methyl 3-methylbutanoate	12.867	1019	$C_6H_{12}O_2$	116	0.38
31	Ethyl butanoate	13.883	1039	$C_6H_{12}O_2$	116	5.16
32	Isopropyl butanoate	14.017	1040	$C_7H_{14}O_2$	130	0.18
33	4-Methyl-2,3-pentanedione	14.108	1041	$C_6H_{10}O_2$	114	0.03
34	S-Methyl thioacetate	14.325	1045	C_3H_6OS	90	0.04
35	3-Hexanone	14.517	1049	$C_6H_{12}O$	100	0.01
36	Ethyl 2-methylbutanoate	14.658	1052	$C_7H_{14}O_2$	130	0.59
37	Ethyl 3-methylbutanoate	15.525	1068	$C_7H_{14}O_2$	130	0.50
38	Butyl acetate	15.733	1071	$C_6H_{12}O_2$	116	0.14
39	Hexanal	16.342	1081	$C_6H_{12}O$	100	0.38
40	Methyl pentanoate	16.517	1087	$C_6H_{12}O_2$	116	0.03
41	2-Methylpropanol	16.933	1101	$C_4H_{10}O$	74	0.04
42	Methyl *(E)*-2-butenoate	17.633	1107	$C_5H_8O_2$	100	0.05

(continued)

43	Propyl isopropyl ether	17.833	1112	$C_6H_{14}O$	102	0.44
44	3-Penten-2-one	18.908	1131	C_5H_8O	84	3.58
45	*(E)*-2-Pentenal	19.033	1133	C_5H_8O	84	0.01
46	Ethyl pentanoate	19.558	1144	$C_7H_{14}O_2$	130	0.04
47	5-Methyl-2-hexanone	19.875	1150	$C_7H_{14}O$	114	0.04
48	Methyl 4-methylpentanoate	20.067	1153	$C_7H_{14}O_2$	130	0.04
49	Butanol	20.275	1153	$C_4H_{10}O$	74	0.03
50	Ethyl 2-butenoate	21.292	1165	$C_6H_{10}O_2$	114	0.11
51	2-Ethylbutanal	21.400	1166	$C_6H_{12}O$	100	0.01
52	Pentyl acetate	22.025	1172	$C_7H_{14}O_2$	130	0.03
53	2-Heptanone	22.600	1177	$C_7H_{14}O$	114	0.70
54	Methyl hexanoate	23.000	1188	$C_7H_{14}O_2$	130	2.25
55	3-Methyl-1-butanol	24.525	1203	$C_5H_{12}O$	88	0.25
56	*(E)*-2-Hexenal	24.967	1220	$C_6H_{10}O$	98	1.20
57	Butyl butanoate	25.142	1223	$C_8H_{16}O_2$	144	0.03
58	Ethyl hexanoate	26.283	1240	$C_8H_{16}O_2$	144	3.83
59	Pentanol	27.425	1261	$C_5H_{12}O$	88	0.13
60	2-Butyl acetate	28.325	1273	$C_6H_{12}O_2$	116	0.05
61	3-Methylbutyl butanoate	28.483	1273	$C_9H_{18}O_2$	158	0.06
62	Hexyl acetate	28.858	1279	$C_8H_{16}O_2$	144	1.08
63	2,3,4-Trimethyl-3-pentanol	30.092	1294	$C_8H_{18}O$	130	0.01
64	2-Octen-4-one	30.800	1303	$C_8H_{14}O$	126	0.05

(continued)

I.S.	Butylbenzene	32.042	1318	$C_{10}H_{14}$	134	17.54
65	2-Heptanol	32.367	1330	C_7H_6O	116	0.14
66	*(E)*-2-Hexenyl acetate	33.158	1338	$C_8H_{14}O_2$	142	2.20
67	Hexyl propanoate	33.492	1344	$C_9H_{18}O_2$	158	0.01
68	Ethyl 2-hexenoate	33.892	1348	$C_8H_{14}O_2$	142	0.04
69	Hexanol	34.675	1366	$C_6H_{14}O$	102	0.64
70	Ethylidene diacetate	35.875	1381	$C_6H_{10}O_4$	146	0.10
71	1-Propoxy 2-propanol	36.125	1384	$C_6H_{14}O_2$	118	0.09
72	5-Methylindan	36.417	1386	$C_{10}H_{12}$	132	0.04
73	*(Z)*-3-Hexen-1-ol	36.758	1389	$C_6H_{12}O$	100	0.03
74	Methyl octanoate	37.175	1392	$C_9H_{18}O_2$	158	0.16
75	Methyl 2-hydroxy-3-methylbutanoate	37.658	1402	$C_6H_{12}O_3$	132	0.11
76	2-Heptyl butanoate	37.767	1405	$C_{14}H_{30}$	198	0.03
77	*(E)*-2-Hexen-1-ol	38.283	1418	$C_6H_{12}O$	100	0.84
78	Butyl hexanoate	38.683	1422	$C_{10}H_{20}O_2$	172	0.01
79	Hexyl butanoate	38.858	1424	$C_{10}H_{20}O_2$	172	0.23
80	Hexyl 2-methylbutanoate	39.667	1433	$C_{11}H_{22}O_2$	186	0.06
81	Ethyl octanoate	40.150	1440	$C_{10}H_{20}O_2$	172	0.19
82	Acetic acid	40.592	1445	$C_2H_4O_2$	60	2.73
83	*(Z)*-Linalool oxide	40.842	1445	$C_{10}H_{18}O_2$	170	2.11
84	7-Octen-4-ol	41.233	1452	$C_8H_{16}O$	128	0.33
85	Pentyl lactate	41.825	1462	$C_8H_{16}O_3$	160	0.18

(continued)

86	*(E)*-Linalool oxide	42.792	1486	$C_{10}H_{18}O_2$	170	1.08
87	Butandiol diacetate	43.683	1496	$C_8H_{14}O_4$	174	0.09
88	Propanoic acid	46.908	1548	$C_3H_6O_2$	74	0.13
89	*(E)*-2-Nonenal	47.133	1551	$C_9H_{16}O$	140	0.10
90	Linalool	47.558	1558	$C_{10}H_{18}O$	154	3.25
91	Octanol	48.250	1568	$C_8H_{18}O$	130	0.06
92	Nonanyl acetate	49.342	1579	$C_{11}H_{22}O_2$	186	0.06
93	Dimethyl sulfoxide	49.692	1580	C_2H_6OS	78	0.06
94	1,2-Propanediol	50.375	1613	$C_3H_8O_2$	76	0.49
95	2-Undecanone	50.658	1615	$C_{11}H_{22}O$	170	0.05
96	Hexyl hexanoate	51.467	1620	$C_{12}H_{24}O_2$	200	0.26
97	Octyl butanoate	51.858	1627	$C_{12}H_{24}O_2$	200	0.11
98	Butan-3-one-2-yl butanoate	52.067	1631	$C_8H_{14}O_3$	158	0.85
99	Ethyl decanoate	53.125	1640	$C_{12}H_{24}O_2$	200	0.09
100	Methyl 3-hydroxyhexanoate	53.758	1654	$C_7H_{14}O_3$	146	0.09
101	*(Z)*-β-Farnesene	54.692	1664	$C_{15}H_{24}$	204	0.05
102	Ethyl benzoate	54.883	1668	$C_9H_{10}O_2$	150	0.08
103	*(E)*-2-Hexenyl hexanoate	55.050	1672	$C_{12}H_{22}O_2$	198	0.29
104	Decyl acetate	55.658	1691	$C_{12}H_{24}O_2$	200	0.04
105	Ethyl 3-hydroxyhexanoate	55.758	1691	$C_8H_{16}O_3$	160	0.06
106	α-Terpineol	56.850	1714	$C_{10}H_{18}O$	154	0.05
107	Unknown	57.275	1722			0.75

(continued)

108	*(Z,E)*-α-Farnesene	58.242	1730	$C_{15}H_{24}$	204	0.03
109	α-Muurolene	58.400	1731	$C_{15}H_{24}$	204	0.13
110	Benzyl acetate	58.583	1733	$C_9H_{10}O_2$	150	0.19
111	Epoxylinalool	59.267	1755	$C_{10}H_{18}O_2$	170	0.05
112	Butyl butyrolactate	59.883	1775	$C_{11}H_{20}O_4$	216	0.19
113	4-Methyl-5-nonanone	61.200	1789	$C_{10}H_{20}O$	156	0.16
114	2-Heptyl hexanoate	61.317	1791	$C_{13}H_{26}O_2$	214	0.04
115	2-Nonyl butanoate	61.967	1802	$C_{13}H_{26}O_2$	214	0.08
116	1-Phenyl-1-butanone	62.158	1805	$C_{10}H_{12}O$	148	0.06
117	Methyl dodecanoate	62.367	1809	$C_{13}H_{26}O_2$	214	0.04
118	β-Phenethyl acetate	63.092	1824	$C_{12}H_{12}O_2$	164	0.16
119	Ethyl dodecanoate	64.258	1853	$C_{14}H_{28}O_2$	228	0.08
120	Hexanoic acid	65.083	1873	$C_6H_{12}O_2$	116	0.05
121	Benzyl alcohol	65.808	1891	C_7H_8O	108	0.23
122	Dodecyl acetate	66.050	1899	$C_{14}H_{28}O_2$	228	0.01
123	Dimethyl sulfone	66.717	1918	$C_2H_6O_2S$	94	0.06
124	6,7-Dodecanedione	67.942	1942	$C_{12}H_{22}O_2$	198	0.03
125	Heptanoic acid	69.142	1973	$C_7H_{14}O_2$	130	0.04
126	1-Phenyl-1-butanol	69.375	1979	$C_{10}H_{14}O$	150	0.08
127	Unknown	69.733	1992			1.56
128	*(Z)*-Nerolidol	70.275	2009	$C_{15}H_{26}O$	222	0.16
129	Unknown	70.642	2020			1.69

(continued)

130	*(E)*-Nerolidol	71.842	2063	$C_{15}H_{26}O$	222	13.75
131	*(E,E)*-Farnesol	72.350	2072	$C_{15}H_{26}O$	222	0.10
132	3-Methylbutyl dodecanoate	72.533	2084	$C_{17}H_{34}O_2$	270	0.03
133	Methyl cinnamate	73.142	2106	$C_{10}H_{10}O_2$	162	0.04
134	Hexahydrofarnesyl acetate	74.333	2130	$C_{18}H_{36}O$	268	0.19
135	γ-Decalactone	75.258	2160	$C_{10}H_{18}O_2$	170	0.11
136	Tetradecanol	75.675	2181	$C_{14}H_{30}O$	214	0.06
137	δ-Undecalacton	76.883	2213	$C_{11}H_{20}O_2$	184	0.10
138	2-Heptadecanone	77.492	2233	$C_{17}H_{34}O$	254	0.01
139	Unknown	80.375	2321			1.26
140	Hexadecanol	82.158	2375	$C_{16}H_{34}O$	242	0.10
141	γ-Dodecalacton	82.817	2394	$C_{12}H_{22}O_2$	198	2.66
142	*(E,E)*-Farnesyl acetone	85.993	2472	$C_{18}H_{30}O$	262	0.05
143	Octadecanol	91.275	2590	$C_{18}H_{38}O$	270	0.06
	Total					94.97

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

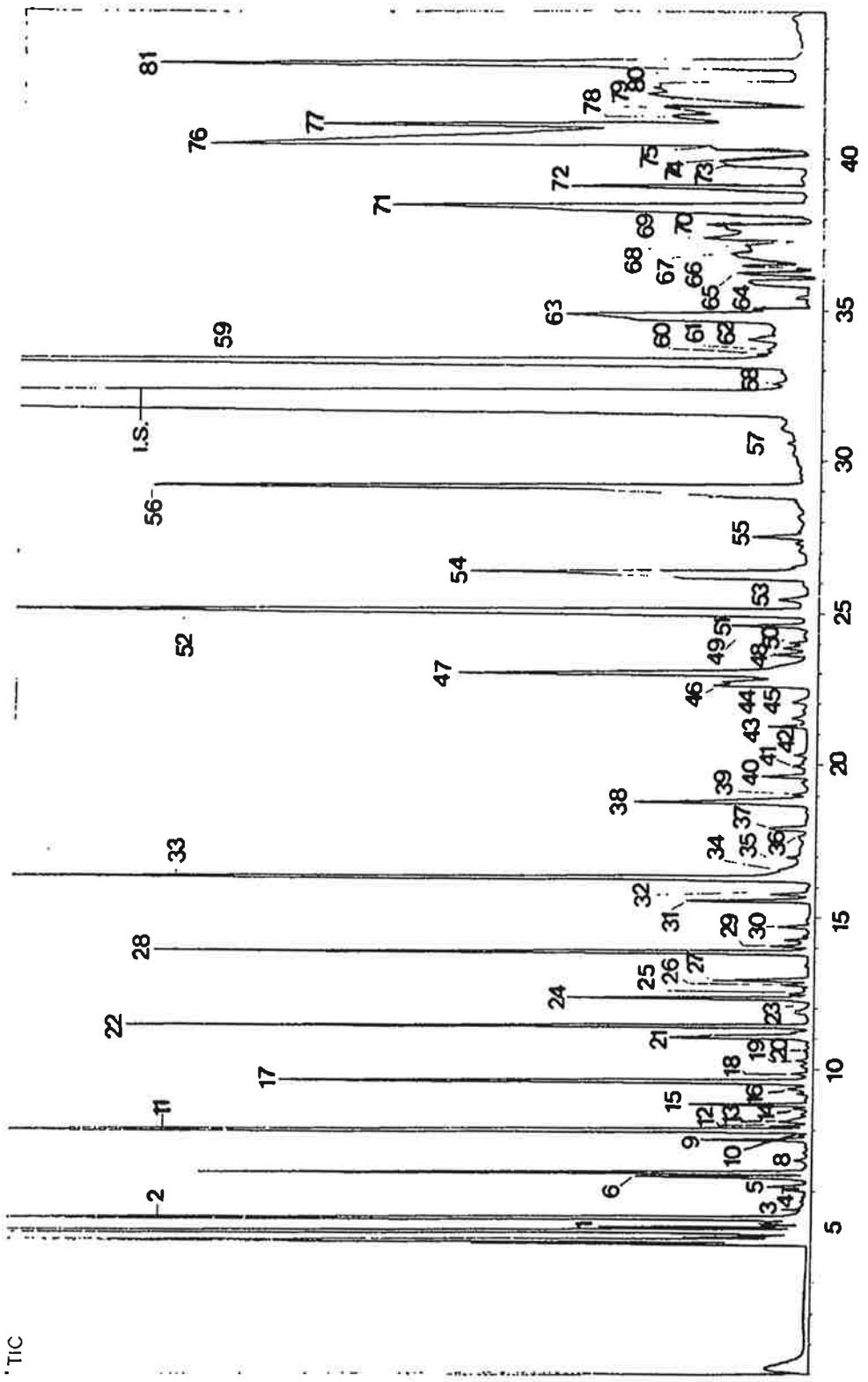

Fig. 39. GC chromatogram of volatile flavor components in Bokyu strawberry I

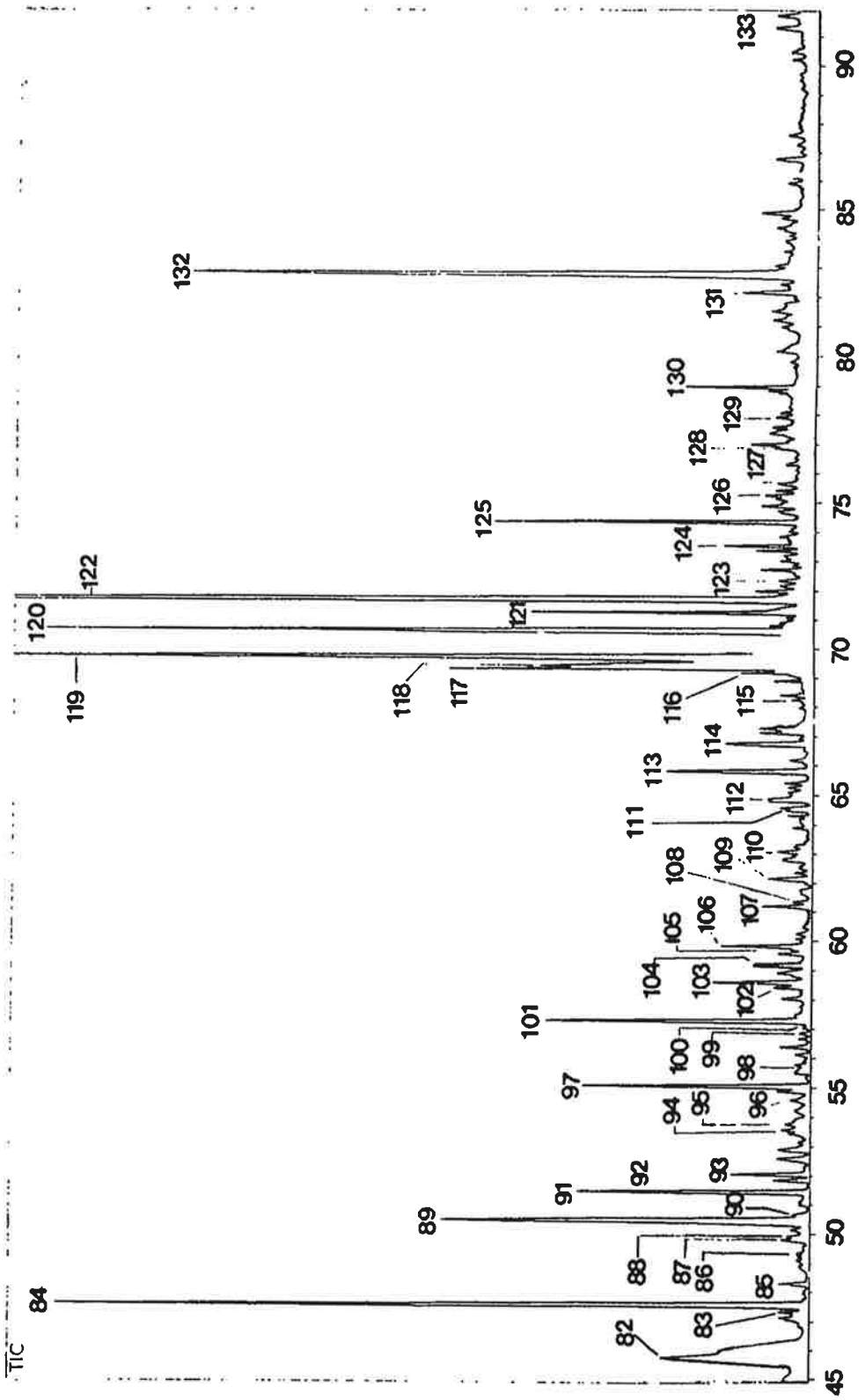

Fig. 39. GC chromatogram of volatile flavor components in Bokyu strawberry II

Table 52. GC chromatogram of volatile flavor components in Bokyu strawberry

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.833	592	$C_5H_{12}O$	88	0.20
2	Acetaldehyde	5.108	696	C_2H_4O	44	2.21
3	Ethyl isobutyl ether	5.408	708	$C_6H_{14}O$	102	0.01
4	Propanal	6.067	730	C_3H_6O	58	0.05
5	Octane	6.167	731	C_8H_{18}	114	0.08
6	2-Propanone	6.483	791	C_3H_6O	58	0.30
7	Ethyl formate	6.617	822	$C_3H_6O_2$	74	1.13
8	2-Propenal	7.033	842	C_3H_4O	56	0.03
9	Butanal	7.700	874	C_4H_8O	72	0.19
10	2-Butenal	7.833	882	C_4H_6O	70	0.01
11	Ethyl acetate	8.008	893	$C_4H_8O_2$	88	2.46
12	Acetal	8.133	900	$C_6H_{14}O_2$	118	0.05
13	Isopropyl acetate	8.292	908	C_2H_6O	102	0.09
14	2-Methylbutanal	8.717	929	$C_5H_{10}O$	86	0.03
15	3-Methylbutanal	8.858	936	$C_5H_{10}O$	86	0.20
16	2-Propanol	9.375	942	C_3H_8O	60	0.05
17	Ethanol	9.633	945	C_2H_6O	46	1.31
18	3-Buten-2-one	9.858	949	C_4H_6O	70	0.04
19	Ethyl propanoate	10.292	956	$C_5H_{10}O_2$	102	0.01
20	Ethyl 2-methylpropanoate	10.625	967	$C_6H_{12}O_2$	116	0.01

(continued)

21	2-Pentanone	11.050	979	$C_5H_{10}O$	86	0.45
22	Methyl butanoate	11.433	990	$C_5H_{10}O_2$	102	1.26
23	Decane	11.967	1000	$C_{10}H_{12}$	142	0.01
24	4-Methyl-2-pentanone	12.350	1008	$C_6H_{10}O$	100	0.49
25	Methyl 2-methylbutanoate	12.492	1011	$C_6H_{12}O_2$	116	0.03
26	3-Methyl-2-pentanone	12.792	1016	$C_6H_{10}O$	100	0.05
27	Methyl 3-methylbutanoate	12.942	1019	$C_6H_{12}O_2$	116	0.19
28	Ethyl butanoate	13.875	1039	$C_6H_{12}O_2$	116	1.44
29	Isopropyl butanoate	14.067	1042	$C_7H_{14}O_2$	130	0.08
30	Ethyl 2-methylbutanoate	14.700	1052	$C_7H_{14}O_2$	130	0.05
31	Ethyl 3-methylbutanoate	15.558	1068	$C_7H_{14}O_2$	130	0.29
32	Butyl acetate	15.775	1072	$C_6H_{12}O_2$	116	0.09
33	Hexanal	16.342	1081	$C_6H_{12}O$	100	2.56
34	Methyl pentanoate	16.583	1088	$C_6H_{12}O_2$	116	0.08
35	2-Methylpropanol	17.000	1101	$C_4H_{10}O$	74	0.03
36	Methyl *(E)*-2-butenoate	17.692	1107	$C_5H_8O_2$	100	0.01
37	2-Hydroxy-2-methylpropanal	17.958	1112	$C_4H_8O_2$	88	0.13
38	3-Methylbutyl acetate	18.792	1126	$C_7H_{14}O_2$	130	0.68
39	*(E)*-2-Pentenal	19.058	1131	C_5H_8O	84	0.04
40	*(E)*-Allyl propenyl ether	19.633	1141	$C_6H_{10}O$	98	0.10
41	2-Methyl-4-pentenal	19.958	1147	$C_6H_{10}O$	98	0.03
42	Butanol	20.325	1153	$C_4H_{10}O$	74	0.03

(continued)

43	1-Penten-3-ol	21.258	1163	$C_5H_{10}O$	86	0.09
44	2-Ethylbutanal	21.533	1166	$C_6H_{12}O$	100	0.05
45	Pentyl acetate	22.067	1171	$C_7H_{14}O_2$	130	0.05
46	2-Heptanone	22.608	1177	$C_7H_{14}O$	114	0.65
47	Methyl hexanoate	23.000	1188	$C_7H_{14}O_2$	130	1.78
48	Methanethiol	23.642	1194	CH_4S	48	0.08
49	*(Z)*-3-Hexenal	23.850	1196	$C_6H_{10}O$	98	0.08
50	Docosane	24.033	1198	$C_{12}H_{26}$	170	0.04
51	3-Methyl-1-butanol	24.608	1203	$C_5H_{12}O$	88	0.20
52	*(E)*-2-Hexenal	25.133	1217	$C_6H_{10}O$	98	3.84
53	2-Methyl-3-buten-2-ol	25.475	1224	$C_5H_{10}O$	86	0.14
54	Ethyl hexanoate	26.375	1240	$C_8H_{16}O_2$	144	1.60
55	Pentanol	27.525	1261	$C_5H_{12}O$	88	0.15
56	Hexyl acetate	29.158	1269	$C_8H_{16}O_2$	144	3.14
57	1-Hydroxy-2-propanone	30.592	1287	$C_3H_6O_2$	74	0.03
58	Butylbenzene	32.325	1305	$C_{10}H_{14}$	134	23.05
59	*(E)*-2-Heptenal	32.575	1307	$C_7H_{12}O$	112	0.04
I.S.	*(E)*-2-Hexenyl acetate	33.358	1338	$C_8H_{14}O_2$	142	5.54
60	6-Methyl-5-hepten-2-one	33.542	1341	$C_8H_{14}O$	126	0.05
61	Hexyl propanoate	33.725	1343	$C_9H_{18}O_2$	158	0.04
62	Ethyl 2-hexenoate	34.042	1348	$C_8H_{14}O_2$	142	0.11
63	Hexanol	34.867	1361	$C_6H_{14}O$	102	1.41

(continued)

64	Ethylidene diacetate	35.983	1380	$C_6H_{10}O_4$	146	0.09
65	Methyl 2-hydroxybutanoate	36.250	1384	$C_5H_{10}O_3$	118	0.09
66	5-Methylindan	36.475	1386	$C_{10}H_{12}$	132	0.08
67	*(Z)*-3-Hexen-1-ol	36.892	1390	$C_6H_{12}O$	100	0.18
68	Methyl octanoate	37.175	1392	$C_9H_{18}O_2$	158	0.05
69	Nonanal	37.392	1396	$C_9H_{18}O$	142	0.24
70	Methyl 2-hydroxy-3-methylbutanoate	37.675	1402	$C_6H_{12}O_3$	132	0.10
71	*(E)*-2-Hexen-1-ol	38.458	1418	$C_6H_{12}O$	100	1.95
72	Hexyl butanoate	39.100	1425	$C_{10}H_{20}O_2$	172	0.45
73	*(E)*-2-Octenal	39.817	1432	$C_8H_{14}O$	126	0.03
74	Hexyl 2-methylbutanoate	39.933	1433	$C_{11}H_{22}O_2$	186	0.04
75	Ethyl octanoate	40.383	1440	$C_{10}H_{20}O_2$	172	0.05
76	Acetic acid	40.492	1445	$C_2H_4O_2$	60	4.89
77	*(Z)*-Linalool oxide	41.142	1445	$C_{10}H_{18}O_2$	170	1.41
78	7-Octen-4-ol	41.400	1450	$C_8H_{16}O$	128	0.13
79	Furfural	41.717	1455	$C_5H_4O_2$	96	0.09
80	Pentyl hexanoate	42.167	1463	$C_{11}H_{22}O_2$	186	0.10
81	*(E)*-Linalool oxide	43.175	1481	$C_{10}H_{18}O_2$	170	1.76
82	Benzaldehyde	45.767	1467	C_7H_6O	106	0.11
83	*(E)*-2-Nonenal	47.317	1553	$C_9H_{16}O$	140	0.03
84	Linalool	47.608	1558	$C_{10}H_{18}O$	154	2.10
85	Octanol	48.292	1568	$C_8H_{18}O$	130	0.06

(continued)

86	Nonanyl acetate	49.350	1579	$C_{11}H_{22}O_2$	186	0.01
87	Dimethyl sulfoxide	49.817	1593	C_2H_6OS	78	0.08
88	*(E,Z)*-2,6-Nonadienal	49.942	1597	$C_9H_{14}O$	138	0.05
89	1,2-Propanediol	50.500	1613	$C_3H_8O_2$	76	1.48
90	2-Undecanone	50.683	1614	$C_{11}H_{22}O$	170	0.04
91	Hexyl hexanoate	51.467	1620	$C_{12}H_{24}O_2$	200	0.56
92	Octyl butanoate	51.867	1625	$C_{12}H_{24}O_2$	200	0.09
93	Butan-3-one-2-yl-butanoate	52.058	1627	$C_8H_{14}O_3$	158	0.18
94	*(E)*-2-Decenal	53.442	1643	$C_{10}H_{18}O$	154	0.04
95	Methyl 3-hydroxyhexanoate	53.783	1648	$C_7H_{14}O_3$	146	0.08
96	Nonanol	54.000	1650	$C_9H_{20}O$	144	0.04
97	*(E)*-2-Hexenyl hexanoate	55.083	1663	$C_{12}H_{22}O_2$	198	0.58
98	Ethyl 3-hydroxyhexanoate	55.792	1672	$C_8H_{16}O_3$	160	0.03
99	α-Terpineol	56.850	1700	$C_{10}H_{18}O$	154	0.03
100	γ-Hexalactone	57.042	1703	$C_6H_{10}O_2$	114	0.01
101	Unknown	57.292	1708			0.66
102	α-Muurolene	58.417	1730	$C_{15}H_{24}$	204	0.08
103	Benzyl acetate	58.592	1733	$C_9H_{10}O_2$	150	0.24
104	Epoxylinalol	59.267	1756	$C_{10}H_{18}O_2$	170	0.15
105	4,8-Dimethyl-nonanol	59.708	1770	$C_{11}H_{24}O$	172	0.04
106	Butyl butyrolactate	59.842	1775	$C_{11}H_{20}O_4$	216	0.20
107	4-Methyl-5-nonanone	61.208	1789	$C_{10}H_{20}O$	156	0.13

(continued)

108	2,6-Pyridiendiol	61.350	1792	$C_5H_5NO_2$	111	0.04
109	1-Phenyl-1-butanone	62.167	1808	$C_{10}H_{12}O$	148	0.11
110	β-Phenethyl acetate	63.092	1826	$C_{12}H_{12}O_2$	192	0.09
111	Undecanol	64.492	1859	$C_{11}H_{24}O$	172	0.06
112	Hexanoic acid	64.850	1868	$C_6H_{12}O_2$	116	0.21
113	Benzyl alcohol	65.808	1891	C_7H_8O	108	0.48
114	Dimethyl sulfone	66.767	1916	$C_2H_6O_2S$	94	0.28
115	Nerolidol oxide	68.250	1954	$C_{15}H_{26}O_3$	254	0.03
116	Heptanoic acid	69.175	1977	$C_7H_{14}O_2$	130	0.18
117	2-Hexenoic acid	69.300	1981	$C_6H_{10}O_2$	114	0.81
118	1-Phenyl-1-butanol	69.417	1984	$C_{10}H_{14}O$	150	0.60
119	Unknown	69.758	1991			3.11
120	Unknown	70.675	2052			2.41
121	Unknown	71.258	2113			0.64
122	*(E)*-Nerolidol	71.742	2167	$C_{15}H_{26}O$	222	4.46
123	3-Methylbutyl dodecanoate	72.525	2177	$C_{17}H_{34}O_2$	270	0.03
124	7-Tridecanol	73.850	2194	$C_{13}H_{28}O$	200	0.03
125	Hexahydrofarnesy acetone	74.350	2201	$C_{18}H_{36}O$	268	0.60
126	γ-Decalactone	75.267	2220	$C_{10}H_{18}O_2$	170	0.09
127	Tetradecanol	75.675	2229	$C_{14}H_{30}O$	214	0.06
128	δ-Undecalacton	76.875	2254	$C_{11}H_{20}O_2$	184	0.06
129	*(E,E)*-Farnesol	77.917	2277	$C_{15}H_{26}O$	222	0.05

(continued)

130	Isophytol	78.967	2299	$C_{20}H_{40}O$	296	0.23
131	Hexadecanol	82.167	2387	$C_{16}H_{34}O$	242	0.16
132	γ-Dodecalacton	82.825	2406	$C_{12}H_{22}O_2$	198	2.31
133	Octadecanol	91.300	2624	$C_{18}H_{38}O$	270	0.09
	Total					94.61

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 53. Relative content of functional groups in Strawberries

Peak area%

Functional group	Suhong	Bokyu
Aldehydes	3.86	10.13
Alcohols	22.39	15.91
Esters	29.96	23.22
Terpenes	0.21	0.08
Acids	2.95	6.09
Ethers	0.82	0.31
Ketones	8.57	5.69
Miscellaneous	3.41	3.49
T o t a l	72.17	64.92

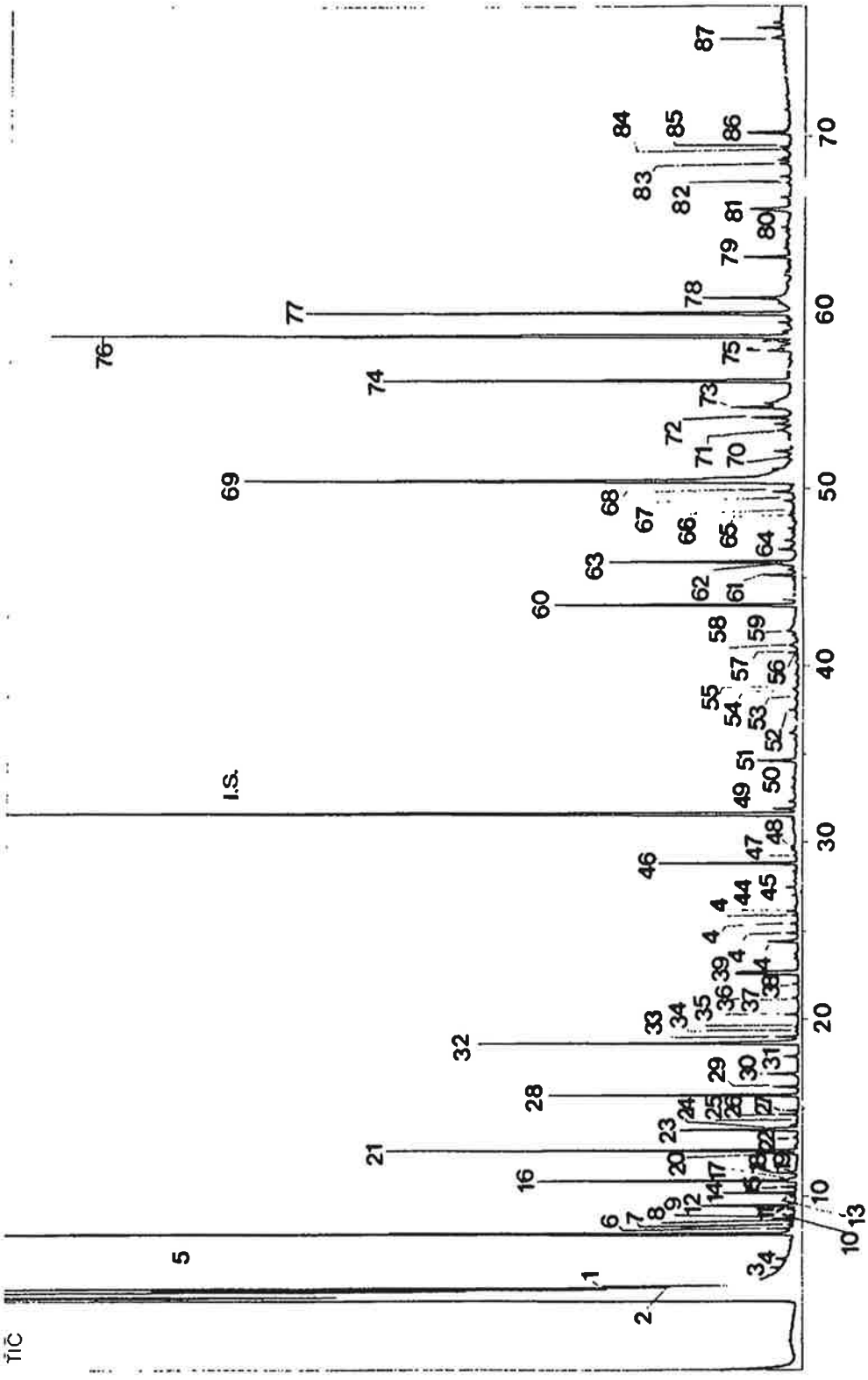

Fig. 40. GC chromatogram of volatile flavor components in Byultongbyul melon

Table 54. Volatile flavor components in Byultongbyul melon

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Isopropyl ethyl ether	4.708	530	$C_5H_{12}O$	88	1.43
2	2,3-Dimethyl-2-butene	4.908	697	C_6H_{12}	84	0.09
3	Butyl ethyl ether	6.008	791	$C_6H_{14}O$	102	0.07
4	Ethyl formate	6.492	821	$C_3H_6O_2$	74	0.06
5	Ethyl acetate	7.883	888	$C_4H_8O_2$	88	24.48
6	Isopropyl acetate	8.200	896	$C_5H_{10}O_2$	102	0.16
7	Methyl propanoate	8.408	901	$C_4H_8O_2$	88	0.03
8	2-Methylbutanal	8.608	906	$C_5H_{10}O$	86	0.07
9	3-Methylbutanal	8.683	908	$C_5H_{10}O$	86	0.13
10	Methyl 2-methylpropanoate	8.950	917	$C_5H_{10}O_2$	102	0.04
11	2-Propanol	9.250	932	C_3H_8O	60	0.06
12	Ethanol	9.467	942	C_2H_6O	46	0.68
13	2-Ethylfuran	9.992	951	C_6H_8O	96	0.04
14	Ethyl propanoate	10.192	955	$C_5H_{10}O_2$	102	0.46
15	Ethyl 2-methylpropanoate	10.533	965	$C_6H_{12}O_2$	116	0.10
16	Propyl acetate	10.867	974	$C_5H_{10}O_2$	102	1.96
17	Pentanal	11.000	977	$C_5H_{10}O$	86	0.01
18	Methyl butanoate	11.317	984	$C_5H_{10}O_2$	102	0.13
19	2-Butyl acetate	11.400	986	$C_6H_{12}O_2$	116	0.03
20	Methyl 2-methylbutanoate	12.408	1009	$C_6H_{12}O_2$	116	0.30

(continued)

21	2-Methylpropyl acetate	12.575	1013	$C_6H_{12}O_2$	116	2.96
22	2-Butanol	13.333	1027	$C_4H_{10}O$	74	0.03
23	Ethyl butanoate	13.750	1035	$C_6H_{12}O_2$	116	0.90
24	Propanol	14.008	1040	C_3H_8O	60	0.01
25	Methyl thioacetate	14.317	1046	C_3H_6OS	90	0.01
26	Ethyl 2-methylbutanoate	14.633	1051	$C_7H_{14}O_2$	130	0.15
27	2,3-Pentanedione	14.858	1056	$C_5H_8O_2$	100	0.13
28	Butyl acetate	15.733	1072	$C_6H_{12}O_2$	116	2.00
29	Hexanal	16.200	1081	$C_6H_{12}O$	100	0.19
30	2-Methylpropanol	16.933	1090	$C_4H_{10}O$	74	0.26
31	3-Pentanol	17.917	1101	$C_5H_{12}O$	88	0.11
32	2-Methylbutyl acetate	18.658	1121	$C_7H_{14}O_2$	130	3.40
33	2,3-Hexanedione	19.033	1128	$C_6H_{10}O_2$	114	0.19
34	*p*-Xylene	19.333	1133	C_8H_{10}	106	0.01
35	3,4-Hexanedione	19.592	1137	$C_6H_{10}O_2$	114	0.01
36	Butanol	20.283	1149	$C_4H_{10}O$	74	0.12
37	1-Penten-3-ol	21.217	1164	$C_5H_{10}O$	86	0.01
38	Pentyl acetate	22.017	1177	$C_7H_{14}O_2$	130	0.04
39	o -Xylene	22.383	1187	C_8H_{10}	106	0.01
40	2-Methyl-1-butanol	24.425	1214	$C_5H_{12}O$	88	0.34
41	(*E*)-2-Hexenal	24.900	1220	$C_6H_{10}O$	98	0.10
42	2-Hexanol	25.408	1227	$C_6H_{14}O$	102	0.01

(continued)

43	2-Pentylfuran	25.883	1233	$C_9H_{14}O$	138	0.04
44	Ethyl hexanoate	26.117	1236	$C_8H_{16}O_2$	144	0.07
45	Pentanol	27.467	1254	$C_5H_{12}O$	88	0.09
46	Hexyl acetate	28.808	1272	$C_8H_{16}O_2$	144	1.25
47	3-Hydroxy-2-butanone	29.608	1082	$C_4H_8O_2$	88	0.01
48	Methyl 2-hydroxy-2-methylbutanoate	29.767	1284	$C_6H_{12}O_3$	132	0.01
I.S.	Butylbenzene	31.600	1308	$C_{10}H_{14}$	134	11.76
49	*(Z)*-3-Hexenyl acetate	31.867	1316	$C_8H_{14}O_2$	142	0.20
50	(*E*)-2-Hexenyl acetate	33.608	1345	$C_8H_{14}O_2$	142	0.01
51	Hexanol	34.625	1362	$C_6H_{14}O$	102	0.44
52	Dimethyl trisulfide	36.192	1384	$C_2H_6S_3$	126	0.01
53	*(Z)*-3-Hexenol	36.733	1392	$C_6H_{12}O$	100	0.09
54	(*E*,*E*)-2,4-Hexadienal	37.650	1406	C_9H_8O	96	0.01
55	*(Z)*-3-Heptenyl acetate	38.608	1421	$C_9H_{16}O_2$	156	0.01
56	(*E*)-2-Octenal	39.533	1436	$C_8H_{14}O_2$	156	0.01
57	Ethyl (methylthio)acetate	40.758	1455	$C_5H_{10}O_2S$	134	0.10
58	3-(Methylthio)propanal	41.158	1461	C_4H_8OS	104	0.01
59	Acetic aicd	41.992	1473	$C_2H_4O_2$	60	0.07
60	D,L-2,3-Butandiol diacetate	43.442	1494	$C_8H_{14}O_4$	174	2.49
61	meso-2,3-Butandiol diacetate	45.150	1520	$C_8H_{14}O_4$	174	0.32
62	Benzaldehyde	45.733	1536	C_7H_6O	106	0.16
63	Unknown	45.875	1544			1.92

(continued)

64	*(E)*-2-Nonenal	46.608	1550	$C_9H_{16}O$	140	0.20
65	Octanol	48.225	1567	$C_8H_{18}O$	130	0.01
66	Ethyl 3-(methylthio)propanoate	48.658	1572	$C_6H_{12}O_2S$	148	0.01
67	Nonyl acetate	49.325	1579	$C_{11}H_{22}O_2$	186	0.07
68	*(E,Z)*-2,6-Nonadienal	49.833	1584	$C_9H_{14}O$	138	0.20
69	1,2-Propanediol	50.426	1604	$C_3H_8O_2$	76	8.75
70	4-Methylbenzaldehyde	51.808	1638	C_8H_8O	120	0.01
71	α-Tolualdehyde	53.308	1644	C_8H_8O	120	0.10
72	2,2-Dimethyl-1,3-propandiol di- acetate	54.042	1650	$C_9H_{16}O_4$	188	0.53
73	Nonanol	54.608	1663	$C_9H_{20}O$	144	0.59
74	(*Z*)-3-Nonen-1-ol	56.083	1696	$C_9H_{18}O$	142	4.58
75	(*E*)-2-Nonen-1-ol	57.833	1722	$C_9H_{18}O$	142	0.48
76	Benzyl acetate	58.633	1735	$C_9H_{10}O_2$	150	9.14
77	*(Z,Z)*-3,6-Nonadien-1-ol	59.933	1764	$C_9H_{16}O$	140	5.28
78	(*E,Z*)-2,6-Nonadien-1-ol	60.800	1780	$C_9H_{16}O$	140	0.87
79	β-Phenethyl acetate	63.133	1823	$C_{10}H_{12}O_2$	164	0.47
80	Nerylacetone	64.825	1864	$C_{13}H_{22}O$	194	0.07
81	Benzyl alcohol	65.867	1890	C_7H_8O	108	0.71
82	Phenethyl alcohol	67.317	1913	$C_8H_{10}O$	122	0.01
83	β-Ionone	68.425	1929	$C_{13}H_{20}O$	192	0.08
84	Dodecanol	69.208	1966	$C_{12}H_{26}O$	186	0.03
85	1-Phenyl-1-butanol	69.392	1983	$C_{10}H_{14}O$	150	0.09

(continued)

86	o-Methylbenzyl alcohol	70.200	2006	$C_8H_{10}O$	122	0.46
87	Tetradecanol	75.717	2181	$C_{14}H_{30}O$	214	0.17
	Total					93.31

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Fig. 41. GC chromatogram of volatile flavor components in Papaiya melon

Table 55. Volatile flavor components in Papaiya melon

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Isopropyl ethyl ether	4.708	530	$C_5H_{12}O$	88	0.98
2	Butyl ethyl ether	6.017	786	$C_6H_{14}O$	102	0.02
3	Ethyl formate	6.492	820	$C_3H_6O_2$	74	0.03
4	Methyl acetate	6.550	823	$C_3H_6O_2$	74	0.01
5	Butanal	7.583	872	C_4H_8O	72	0.01
6	Ethyl acetate	7.958	889	$C_4H_8O_2$	88	16.52
7	Isopropyl acetate	8.200	896	$C_5H_{10}O_2$	102	0.21
8	Methyl propanoate	8.425	902	$C_4H_8O_2$	88	0.09
9	2-Methylbutanal	8.617	907	$C_5H_{10}O$	86	0.04
10	3-Methylbutanal	8.750	916	$C_5H_{10}O$	86	0.05
11	Methyl 2-methylpropanoate	8.967	918	$C_5H_{10}O_2$	102	0.12
12	2-Propanol	9.275	921	C_3H_8O	60	0.04
13	Ethanol	9.492	942	C_2H_6O	46	0.76
14	2-Ethylfuran	10.025	951	C_6H_8O	96	0.03
15	Ethyl propanoate	10.233	955	$C_5H_{10}O_2$	102	1.96
16	Isopropyl propanoate	10.392	959	$C_6H_{12}O_2$	116	0.02
17	Ethyl 2-methylpropanoate	10.558	963	$C_6H_{12}O_2$	116	0.97
18	Propyl acetate	10.892	973	$C_5H_{10}O_2$	102	1.28
19	Pentanal	10.992	985	$C_5H_{10}O$	86	0.04
20	Methyl butanoate	11.333	994	$C_6H_{12}O_2$	116	0.10

(continued)

21	2-Butyl acetate	11.417	995	$C_6H_{12}O_2$	116	0.01
22	Methyl 2-methylbutanoate	12.433	1009	$C_6H_{12}O_2$	116	0.78
23	2-Methylpropyl acetate	12.617	1014	$C_6H_{12}O_2$	116	3.29
24	3-Methyl-2-pentanone	12.742	1017	$C_6H_{12}O$	100	0.01
25	2-Butanol	13.350	1029	C_4H_{10}	74	0.02
26	Ethyl butanoate	13.817	1036	$C_6H_{12}O_2$	116	3.24
27	Isopropyl butanoate	14.017	1040	$C_7H_{14}O_2$	130	0.06
28	Propyl propanoate	14.208	1043	$C_6H_{12}O_2$	116	0.10
29	S-Methylthio acetate	14.350	1045	C_3H_6OS	90	0.01
30	3-Hexanone	14.542	1049	$C_6H_{12}O$	100	0.01
31	Ethyl 2-methylbutanoate	14.683	1051	$C_7H_{14}O_2$	130	1.63
32	2,3-Pentanedione	14.883	1055	$C_5H_8O_2$	100	0.04
33	Ethyl 3-methylbutanoate	15.550	1068	$C_7H_{14}O_2$	130	0.01
34	Butyl acetate	15.767	1072	$C_6H_{12}O_2$	116	1.37
35	2-Hexanone	16.142	1079	$C_6H_{12}O$	100	0.01
36	2-Methylpropyl propanoate	16.242	1081	$C_7H_{14}O_2$	130	0.43
37	2-Methylpropanol	16.950	1093	$C_4H_{10}O$	74	0.48
38	3-Pentanol	17.933	1115	$C_5H_{12}O$	88	0.04
39	2-Methylbutyl acetate	18.700	1123	$C_7H_{14}O_2$	130	3.61
40	2,3-Hexanedione	19.058	1128	$C_6H_{10}O_2$	114	0.12
41	Methyl thiobutanoate	19.425	1134	$C_5H_{10}OS$	118	0.04
42	Ethyl pentanoate	19.558	1140	$C_7H_{14}O_2$	130	0.01

(continued)

43	Propyl 3-methylbutanoate	19.842	1149	$C_8H_{16}O_2$	144	0.01
44	Butyl propanoate	19.925	1152	$C_7H_{14}O_2$	130	0.03
45	Butanol	20.300	1159	$C_4H_{10}O$	74	0.09
46	3-Heptanone	20.658	1164	$C_7H_{14}O$	114	0.03
47	2-Methylpropyl butanoate	21.125	1164	$C_8H_{16}O_2$	144	0.14
48	1-Penten-3-ol	21.250	1166	$C_5H_{10}O$	86	0.03
49	Pentyl acetate	22.033	1176	$C_7H_{14}O_2$	130	0.01
50	2-Methylpropyl 2-methylbutanoate	22.267	1179	$C_9H_{18}O_2$	144	0.05
51	o-Xylene	22.608	1183	C_8H_{10}	106	0.20
52	Methyl hexanoate	22.925	1193	$C_7H_{14}O_2$	130	0.01
53	Pentyl propanoate	23.058	1194	$C_8H_{16}O_2$	144	0.05
54	2-Methylbutyl 2-methylpropanoate	23.592	1202	$C_9H_{18}O_2$	158	0.05
55	3-Hexanol	23.783	1204	$C_6H_{14}O$	102	0.01
56	2-Methyl-1-butanol	24.450	1213	$C_5H_{12}O$	88	0.31
57	Butyl butanoate	25.092	1219	$C_8H_{16}O_2$	144	0.01
58	2-Hexanol	25.450	1222	$C_6H_{14}O$	102	0.01
59	2-Pentylfuran	25.917	1226	$C_9H_{14}O$	138	0.09
60	Ethyl hexanoate	26.158	1233	$C_8H_{16}O_2$	144	0.29
61	Pentanol	27.508	1258	$C_5H_{12}O$	88	0.08
62	3-Methylbutyl butanoate	28.392	1267	$C_9H_{18}O_2$	158	0.05
63	Hexyl acetate	28.842	1272	$C_8H_{16}O_2$	144	0.46
64	2-Methylbutyl 2-methylbutanoate	29.517	1287	$C_{10}H_{20}O_2$	172	0.01

(continued)

65	3-Hydroxy-2-butanone	29.633	1289	$C_4H_8O_2$	88	0.05
66	2-Hydroxy-2-methyl methylbutanoate	29.792	1291	$C_6H_{12}O_3$	132	0.07
67	3-Heptanol	30.733	1303	$C_7H_{16}O$	116	0.01
I.S.	Butylbenzene	31.892	1318	$C_{10}H_{14}$	134	25.57
68	(*E*)-2-Heptenal	32.367	1326	$C_7H_{12}O$	112	0.05
69	6-Methyl-5-hepten-2-one	32.858	1337	$C_8H_{14}O$	126	0.01
70	2-Phenyl-1-propanol	33.133	1340	$C_9H_{10}O$	134	0.01
71	*(E)*-2-Hexenyl acetate	33.683	1347	$C_8H_{14}O_2$	142	0.01
72	2-Methylpropyl hexanoate	34.442	1359	$C_{10}H_{20}O_2$	142	0.01
73	Hexanol	34.650	1362	$C_6H_{14}O$	102	0.12
74	1,1-Ethanediol diacetate	36.292	1375	$C_6H_{10}O_4$	146	0.09
75	5-Methylindane	36.450	1378	$C_{10}H_{12}$	132	0.01
76	*(Z)*-3-Hexen-1-ol	36.750	1385	$C_6H_{12}O$	100	0.03
77	Nonanal	37.142	1393	$C_9H_{18}O$	142	0.01
78	2-Methylindane	37.375	1398	$C_{10}H_{12}$	132	0.01
79	(*E,E*)-2,4-Hexadienal	37.683	1404	C_9H_8O	96	0.01
80	2,6-Dimethyl-4-heptanol	38.875	1423	$C_9H_{10}O$	144	0.01
81	(*E*)-2-Octenal	39.525	1434	$C_8H_{14}O_2$	156	0.01
82	2,6-Dimethyl-2-octanol	39.742	1437	$C_{10}H_{22}O$	158	0.07
83	Ethyl (methylthio)acetate	40.808	1448	$C_5H_{10}O_2S$	134	0.68
84	3-(Methylthio)propanal	41.217	1454	C_4H_8OS	104	0.13
85	Heptanol	41.617	1459	$C_7H_{16}O_2$	116	0.01

(continued)

86	Acetic acid	41.750	1461	$C_2H_4O_2$	60	0.08
87	(*E,E*)-2,4-Heptadienal	41.917	1463	$C_7H_{10}O$	110	0.09
88	D.L-2,3-Butanediol diacetate	43.525	1496	$C_8H_{14}O_4$	174	4.76
89	Unknown	43.931	1504			2.66
90	meso-2,3-Butanediol diacetate	45.175	1520	$C_8H_{14}O_4$	174	0.24
91	Benzaldehyde	45.758	1531	C_7H_6O	106	0.16
92	Unknown	45.933	1534			2.22
93	*(E)*-2-Nonenal	46.642	1544	$C_9H_{16}O$	140	0.22
94	Octanol	48.267	1562	$C_8H_{18}O$	130	0.01
95	Ethyl 3-(methylthio) propanoate	48.700	1566	$C_6H_{12}OS$	148	0.32
96	*(E,E)*-3,5-Octandien-2-one	48.900	1569	$C_8H_{12}O$	124	0.01
97	*(E,E)*-2,6-Nonadienal	49.875	1588	$C_9H_{14}O$	138	0.25
98	1,2-Propanediol	50.433	1608	$C_3H_8O_2$	76	1.38
99	4-Methylbenzaldehyde	51.825	1632	$C_8H_{18}O$	120	0.07
100	2-Methylpropanoic acid	52.642	1651	$C_4H_8O_2$	88	0.93
101	α-Tolualdehyde	53.367	1659	$C_8H_{18}O$	120	0.36
102	Acetophenone	53.875	1665	$C_8H_{18}O$	120	0.06
103	2,2-Dimethyl-1,3-propanediol diacetate	54.075	1667	$C_9H_{16}O_4$	188	0.25
104	Nonanol	54.642	1672	$C_9H_{20}O$	144	0.30
105	*p*-Allylanisole	55.067	1679	$C_{10}H_{12}O$	148	0.01
106	(*Z*)-3-Nonen-1-ol	56.142	1697	$C_9H_{18}O$	142	2.35
107	(*E*)-2-Nenen-1-ol	57.867	1725	$C_9H_{18}O$	142	0.31

(continued)

108	Benzyl acetate	58.667	1736	$C_9H_{10}O_2$	150	3.14
109	*(Z,Z)*-3,6-Nonadienol	59.957	1765	$C_9H_{16}O$	140	1.95
110	(*E,Z*)-2,6-Nonadienol	60.825	1780	$C_9H_{16}O$	140	0.29
111	(*E,E*)-2,4-Decadienal	62.858	1820	$C_{10}H_{16}O$	152	0.07
112	β-Phenethyl acetate	63.150	1823	$C_{10}H_{13}O_2$	164	0.35
113	Ethyl dodecanoate	64.300	1852	$C_{14}H_{28}O$	228	0.01
114	Nerylacetone	64.883	1867	$C_{13}H_{22}O$	194	0.04
115	Benzyl alcohol	65.825	1890	C_7H_8O	108	0.42
116	Phenethyl alcohol	67.342	1928	$C_8H_{10}O$	122	0.07
117	Phenylpropyl acetate	68.467	1964	$C_{11}H_{14}O_2$	178	0.04
118	Dihydro-β-Ionone	68.792	1982	$C_{13}H_{22}O$	194	0.30
119	1-Phenyl-1-butanol	69.408	1997	$C_{10}H_{14}O$	150	0.09
120	o-Methylbenzyl alcohol	70.233	2016	$C_8H_{10}O$	122	0.46
121	Tetradecanol	75.742	2161	$C_{14}H_{30}O$	214	0.21
	Total					92.08

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

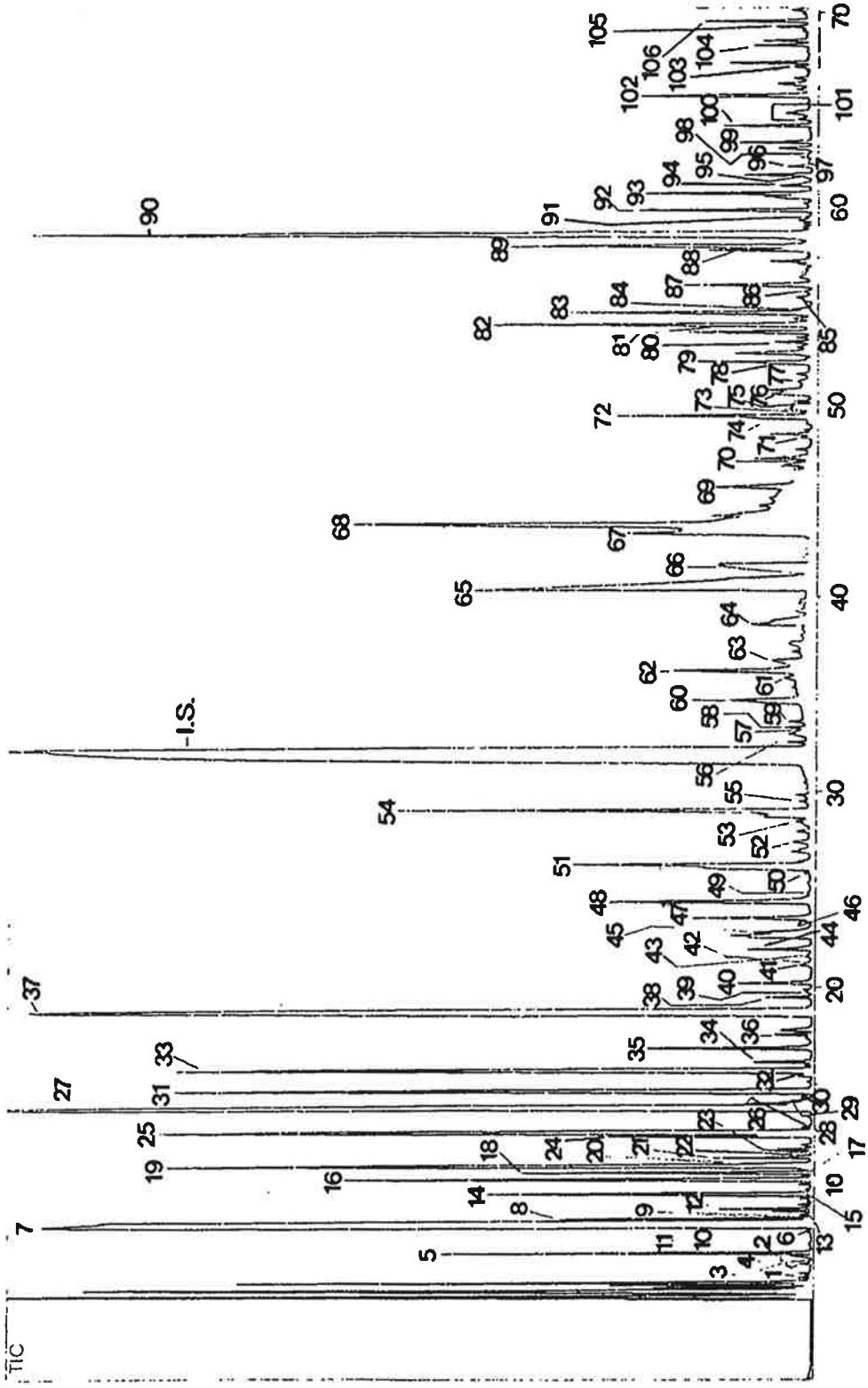

Fig. 42. GC chromatogram of volatile flavor components in Muskmelon

Table 56. Volatile flavor components in Muskmelon

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	sec-Butyl ethyl ether	5.270	705	$C_6H_{14}O$	102	0.01
2	Propanal	5.892	790	C_3H_6O	58	0.02
3	2-Methylpropanal	6.250	807	C_4H_8O	74	0.01
4	2-Propanone	6.308	810	C_3H_6O	58	0.06
5	Ethyl formate	6.467	820	$C_3H_6O_2$	74	0.83
6	Butanal	7.583	874	C_4H_8O	72	0.01
7	Ethyl acetate	7.875	888	$C_4H_8O_2$	88	9.56
8	Isopropyl acetate	8.233	897	$C_5H_{10}O_2$	102	0.40
9	Methyl propanoate	8.425	902	$C_4H_8O_2$	88	0.03
10	2-Methylbutanal	8.600	906	$C_5H_{10}O$	86	0.08
11	3-Methylbutanal	8.733	911	$C_5H_{10}O$	86	0.17
12	Methyl 2-methylpropanoate	8.933	919	$C_5H_{10}O_2$	102	0.03
13	2-Propanol	9.250	931	C_3H_8O	60	0.01
14	Ethanol	9.500	941	C_2H_6O	46	1.11
15	3-Buten-2-one	9.708	946	C_4H_6O	70	0.01
16	Ethyl propanoate	10.233	949	$C_5H_{10}O_2$	102	1.63
17	Isopropyl propanoate	10.350	952	$C_6H_{12}O_2$	116	0.01
18	Ethyl 2-methylpropanoate	10.542	957	$C_6H_{12}O_2$	116	0.74
19	Propyl acetate	10.925	967	$C_5H_{10}O_2$	102	2.96
20	2-Pentanone	10.983	968	$C_5H_{10}O$	86	0.01

(continued)

21	Methyl butanoate	11.292	977	$C_6H_{12}O_2$	116	0.21
22	2-Butyl acetate	11.375	979	$C_6H_{12}O_2$	116	0.02
23	Ethyl 2-propenoate	11.600	985	$C_5H_8O_2$	100	0.04
24	Methyl 2-methylbutanoate	12.400	1006	$C_6H_{12}O_2$	116	0.70
25	2-Methylpropyl acetate	12.658	1013	$C_6H_{12}O_2$	116	3.33
26	Methyl 3-methylbutanoate	12.850	1016	$C_6H_{12}O_2$	116	0.02
27	Ethyl butanoate	13.950	1034	$C_6H_{12}O_2$	116	6.95
28	Propanol	14.058	1036	C_3H_8O	60	0.21
29	Propyl propanoate	14.192	1039	$C_6H_{12}O_2$	116	0.04
30	Methyl thioacetate	14.325	1042	C_3H_6OS	90	0.02
31	Ethyl 2-methylbutanoate	14.750	1050	$C_7H_{14}O_2$	130	3.05
32	Ethyl 3-methylbutanoate	15.467	1064	$C_7H_{14}O_2$	130	0.07
33	Butyl acetate	15.808	1071	$C_6H_{12}O_2$	116	3.59
34	Hexanal	16.183	1074	$C_6H_{12}O$	100	0.15
35	2-Methylpropanol	16.908	1081	$C_4H_{10}O$	74	0.50
36	Diethyl carbonate	17.592	1072	$C_5H_{10}O_3$	118	0.10
37	2-Methylbutyl acetate	18.892	1098	$C_7H_{14}O_2$	130	7.80
38	Ethyl pentanoate	19.517	1103	$C_7H_{14}O_2$	130	0.12
39	Propyl 3-methylbutanoate	19.783	1105	$C_8H_{16}O_2$	144	0.01
40	Butanol	20.242	1040	$C_4H_{10}O$	74	0.26
41	1-Penten-3-ol	21.142	1117	$C_5H_{10}O$	86	0.01
42	Ethyl 2-butenoate	21.233	1119	$C_6H_{10}O_2$	114	0.01

(continued)

43	2-Butyltetrahydrofuran	21.575	1121	$C_8H_{16}O$	128	0.01
44	Pentyl acetate	21.967	1134	$C_7H_{14}O_2$	130	0.23
45	Methyl hexanoate	22.842	1165	$C_7H_{14}O_2$	130	0.28
46	4-Penten-1-ol acetate	23.400	1382	$C_7H_{12}O_2$	128	0.02
47	α-Limonene	23.575	1190	$C_{10}H_{16}$	136	0.47
48	2-Methyl-1-butanol	24.408	1204	$C_5H_{12}O$	88	0.90
49	*(E)*-2-Hexenal	24.850	1212	$C_6H_{10}O$	98	0.01
50	2-Pentylfuran	25.817	1228	$C_9H_{14}O$	138	0.02
51	Ethyl hexanoate	26.100	1233	$C_8H_{16}O_2$	144	1.79
52	Pentanol	27.442	1253	$C_5H_{12}O$	88	0.08
53	*p*-Cymene	28.475	1268	$C_{10}H_{14}$	134	0.03
54	Hexyl acetate	28.750	1272	$C_8H_{16}O_2$	144	2.53
55	3-Hydroxy-2-butanone	29.508	1280	$C_4H_8O_2$	88	0.02
I.S.	Butylbenzene	32.217	1307	$C_{10}H_{14}$	134	19.21
56	*(Z)*-3-Hexenyl acetate	32.900	1316	$C_8H_{14}O_2$	142	0.01
57	Ethyl heptanoate	33.100	1321	$C_9H_8O_2$	158	0.01
58	2-Phenylpentane	33.333	1327	$C_{11}H_{16}$	148	0.06
59	*(E)*-2-Hexenyl acetate	33.625	1334	$C_8H_{14}O_2$	142	0.06
60	Hexanol	34.750	1362	$C_6H_{14}O$	102	0.53
61	Heptyl acetate	35.867	1381	$C_7H_{18}O_2$	158	0.01
62	1,1-Ethanediol diacetate	36.258	1387	$C_6H_{10}O_4$	146	0.64
63	*(Z)*-3-Hexen-1-ol	36.758	1395	$C_6H_{12}O$	100	0.01

(continued)

64	3-Heptenyl acetate	38.650	1426	$C_9H_{16}O_2$	156	0.07
65	Acetic acid	40.408	1455	$C_2H_4O_2$	60	2.96
66	Furfural	41.633	1469	$C_5H_4O_2$	96	0.06
67	D,L-2,3-Butanediol diacetate	43.325	1489	$C_8H_{14}O_4$	174	0.32
68	meso-2,3-Butanediol diacetate	43.800	1494	$C_8H_{14}O_4$	174	2.75
69	Benzaldehyde	45.658	1515	C_7H_6O	106	0.40
70	Furfuryl acetate	46.850	1534	$C_7H_8O_3$	140	0.04
71	Octanol	48.183	1554	$C_8H_{18}O$	130	0.03
72	Unknown	49.275	1571			0.64
73	1-Hydroxy-2-butanone acetate	49.433	1574	$C_6H_{10}O_3$	130	0.03
74	Dimethyl sulfoxide	49.600	1576	C_2H_6OS	78	0.01
75	(*E*,*Z*)-2,6-Nonadienal	49.817	1580	$C_9H_{14}O$	138	0.24
76	1,2-Propanediol	50.425	1589	$C_3H_8O_2$	76	0.22
77	2-Nonenyl acetate	51.042	1599	$C_{11}H_{20}O_2$	184	0.01
78	Butan-3-one-2-yl butanoate	51.958	1628	$C_8H_{14}O_3$	158	0.01
79	Allylidene diacetate	52.050	1631	$C_7H_{10}O_4$	158	0.42
80	Ethyl decanoate	53.083	1642	$C_{12}H_{24}O_2$	200	0.11
81	Acetophenone	53.767	1654	C_8H_8O	120	0.01
82	2,2-Dimethyl-1,3-propanediol diacetate	53.992	1662	$C_9H_{16}O_4$	188	1.40
83	Nonanol	54.608	1670	$C_9H_{20}O$	144	0.94
84	Ethyl benzoate	54.775	1673	$C_9H_{10}O_2$	150	0.07
85	3-Methylbutanoic acid	55.192	1679	$C_5H_{10}O_2$	102	0.03

(continued)

86	Ethyl 3-hydroxyhexanoate	55.675	1687	$C_8H_{16}O_3$	162	0.01
87	*(Z)*-3-Nonen-1-ol	56.033	1693	$C_9H_{18}O$	142	0.47
88	*(E)*-2-Nonen-1-ol	57.800	1724	$C_9H_{18}O$	142	0.35
89	*(Z)*-6-Nonen-1-ol	58.017	1729	$C_9H_{18}O$	142	1.22
90	Benzyl acetate	58.707	1732	$C_9H_{10}O_2$	150	5.68
91	α-Farnesene	59.483	1752	$C_{15}H_{24}$	204	0.01
92	*(Z,Z)*-3,6-Nonadien-1-ol	59.850	1762	$C_9H_{16}O$	140	0.59
93	*(E,Z)*-2,6-Nonadien-1ol	60.725	1779	$C_9H_{16}O$	140	0.54
94	1,4-Butanediol diacetate	61.108	1789	$C_8H_{14}O_4$	174	0.11
95	4-Ethylphenyl acetate	61.542	1800	$C_{10}H_{12}O_2$	164	0.01
96	1-Phenyl-1-butanone	62.092	1815	$C_{10}H_{12}O$	148	0.08
97	Methyl dodecanoate	62.283	1820	$C_{13}H_{26}O_2$	214	0.01
98	*(E,E)*-2,4-Decadienal	62.742	1832	$C_{10}H_{16}O$	152	0.01
99	β-Phenethyl acetate	63.017	1839	$C_{10}H_{12}O_2$	164	0.11
100	Ethyl dodecanoate	64.208	1890	$C_{13}H_{22}O$	228	0.24
101	Hexanoic acid	64.508	1891	$C_6H_{12}O_2$	116	0.04
102	Benzyl alcohol	65.758	1896	C_7H_8O	108	0.65
103	Phenethyl alcohol	67.225	1914	$C_8H_{10}O$	122	0.04
104	Phenylpropyl acetate	68.342	1945	$C_{11}H_{14}O_2$	178	0.15
105	1-Phenyl-1-butanol	69.300	1971	$C_{10}H_{14}O$	150	0.08
106	Neophytodiene	69.600	1982	$C_{20}H_{38}$	278	0.28
	Total					93.28

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 57. Relative content of functional groups in Melons

Peak area%

Functional group	Byultongbyul	Papaiya	Musk
Aldehydes	1.2	1.57	1.16
Alcohols	24.28	9.98	8.75
Esters	51.89	47.04	59.4
Terpenes	-	-	0.48
Acids	0.07	1.01	3.03
Ethers	1.5	1.0	0.01
Ketones	0.49	0.69	0.19
Miscellaneous	1.92	0.34	0.41
T o t a l	81.35	61.63	73.43

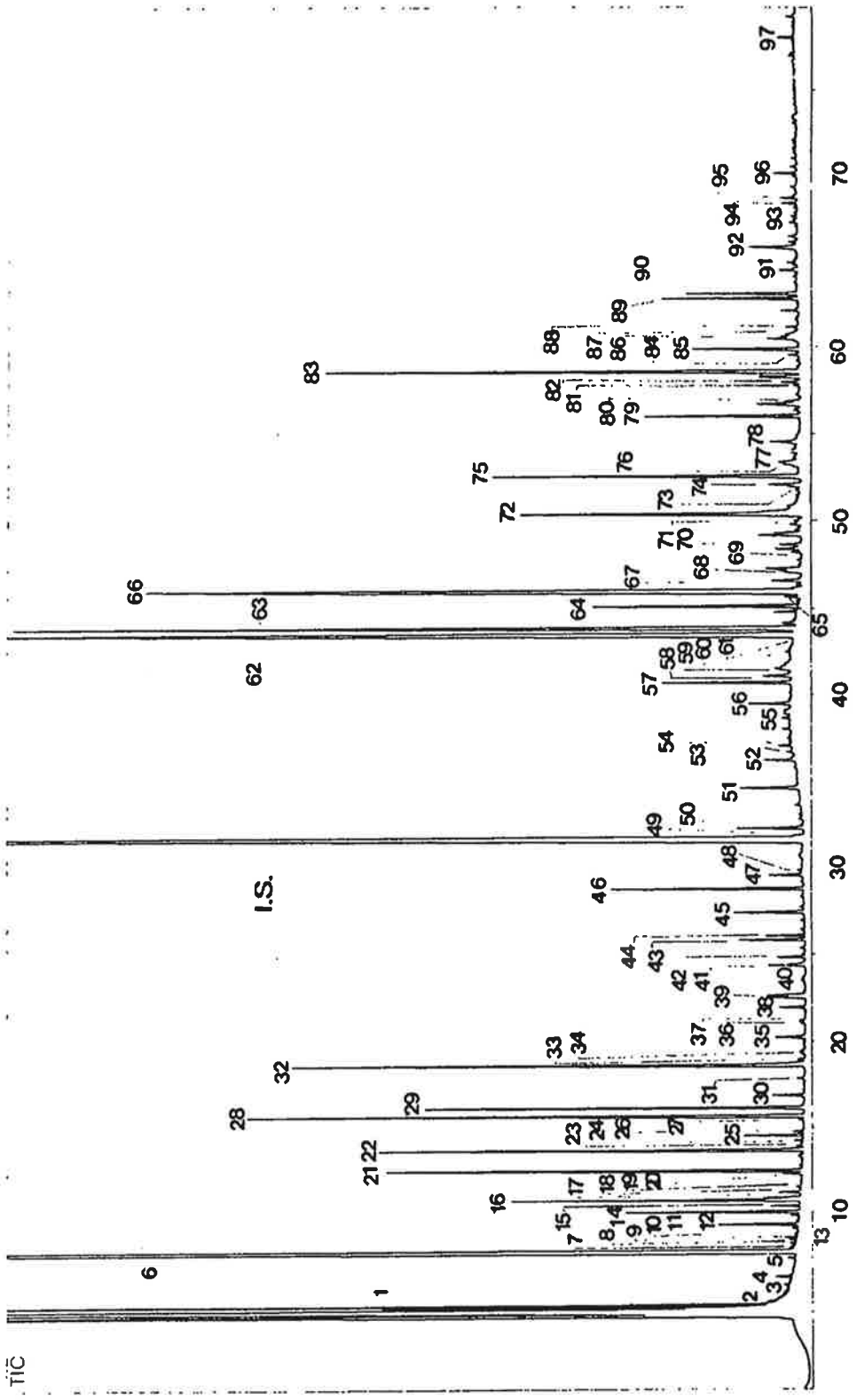

Fig. 43. GC chromatogram of volatile flavor components in Oriental melon

Table 58. Volatile flavor components in Oriental melon

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.683	522	$C_5H_{12}O$	88	1.29
2	sec-Butyl ethyl ether	5.275	706	$C_5H_{10}O_2$	102	0.01
3	Octane	6.017	800	C_8H_{18}	114	0.03
4	Ethyl formate	6.467	821	$C_3H_6O_2$	74	0.04
5	Butanal	7.550	879	C_4H_8O	72	0.03
6	Ethyl acetate	7.917	888	$C_4H_8O_2$	88	16.15
7	Methyl propanoate	8.392	905	$C_4H_8O_2$	88	0.01
8	2-Methylbutanal	8.575	912	$C_5H_{10}O$	86	0.03
9	3-Methylbutanal	8.708	916	$C_5H_{10}O$	86	0.04
10	Methyl 2-methylpropanoate	8.917	924	$C_5H_{10}O_2$	102	0.01
11	2-Propanol	9.233	935	C_3H_8O	60	0.01
12	Ethanol	9.450	943	C_2H_6O	46	0.33
13	2-Ethylfuran	9.967	952	C_6H_8O	96	0.03
14	Ethyl propanoate	10.167	956	$C_5H_{10}O_2$	102	0.64
15	Ethyl 2-methylpropanoate	10.500	964	$C_6H_{12}O_2$	116	0.11
16	Propyl acetate	10.842	975	$C_5H_{10}O_2$	102	1.29
17	Pentanal	10.972	978	$C_5H_{10}O$	86	0.15
18	Methyl butanoate	11.283	986	$C_5H_{10}O_2$	102	0.08
19	Ethyl propenoate	11.600	994	$C_5H_8O_2$	100	0.01
20	Methyl 2-methylbutanoate	12.375	1010	$C_6H_{12}O_2$	116	0.08

(continued)

21	2-Methylpropyl acetate	12.550	1014	$C_6H_{12}O_2$	116	1.88
22	Ethyl butanoate	13.742	1036	$C_6H_{12}O_2$	116	2.07
23	Propanol	13.975	1040	C_3H_8O	60	0.01
24	S-Methyl thioacetate	14.283	1045	C_3H_6OS	90	0.03
25	Ethyl 2-methylbutanoate	14.592	1051	$C_7H_{14}O_2$	130	0.27
26	2,3-Pentanedione	14.817	1055	$C_5H_8O_2$	100	0.04
27	Ethyl 3-methylbutanoate	15.483	1068	$C_7H_{14}O_2$	130	0.01
28	Butyl acetate	15.725	1073	$C_6H_{12}O_2$	116	2.95
29	Hexanal	16.192	1082	$C_6H_{12}O$	100	1.90
30	2-Methylpropanol	16.908	1100	$C_4H_{10}O$	74	0.12
31	3-Pentanol	17.883	1111 1115	$C_5H_{12}O$	88	0.01
32	2-Methylbutyl acetate	18.650	1123	$C_7H_{14}O_2$	130	3.19
33	*(E)*-2-Pentenal	18.958	1129	C_5H_8O	84	0.03
34	Ethyl pentanoate	19.475	1138	$C_7H_{14}O_2$	130	0.01
35	Butanol	20.242	1152	$C_4H_{10}O$	74	0.19
36	2-Methylpropyl butanoate	21.042	1163	$C_8H_{16}O_2$	144	0.01
37	1-Penten-3-ol	21.175	1165	$C_5H_{10}O$	86	0.01
38	Pentyl acetate	21.958	1177	$C_7H_{14}O_2$	130	0.13
39	1,2-Dimethyl benzene	22.533	1189	C_8H_{10}	106	0.21
40	α-Limonene	23.525	1203	$C_{10}H_{16}$	136	0.01
41	2-Methyl-1-butanol	24.375	1214	$C_4H_{10}O$	88	0.23
42	Butyl butanoate	25.017	1219	$C_8H_{16}O_2$	144	0.01

(continued)

43	2-Pentylfuran	25.842	1226	$C_9H_{14}O$	138	0.35
44	Ethyl hexanoate	26.075	1231	$C_8H_{16}O_2$	144	0.21
45	Pentanol	27.425	1258	$C_5H_{12}O$	88	0.48
46	Hexyl acetate	28.767	1273	$C_8H_{16}O_2$	144	1.09
47	3-Hydroxy-2-butanone	29.550	1289	$C_4H_8O_2$	88	0.20
48	Octanal	29.817	1292	$C_8H_{16}O$	128	0.01
I.S.	Butylbenzene	31.733	1312	$C_{10}H_{14}$	134	15.63
49	*(Z)*-3-Hexenyl acetate	31.833	1314	$C_8H_{14}O_2$	142	0.05
50	*(E)*-2-Heptenal	32.267	1325	$C_7H_{12}O$	112	0.40
51	Hexanol	34.575	1362	$C_6H_{14}O$	102	0.39
52	Ethylidene diacetate	36.217	1392	$C_6H_{10}O_4$	146	0.16
53	*(Z)*-3-Hexen-1-ol	36.667	1395	$C_6H_{12}O$	100	0.01
54	Nonanal	37.058	1397	$C_9H_{18}O$	142	0.07
55	3-Methyl-2-methyl-1,3-hexadi-ene	38.667	1417	C_9H_{16}	124	0.03
56	*(E)*-2-Octenal	39.500	1429	$C_8H_{14}O$	126	0.24
57	Ethyl (methylthio)acetate	40.717	1448	$C_5H_{10}O_2S$	134	0.80
58	7-Octen-4-ol	41.100	1454	$C_8H_{16}O$	128	0.20
59	Furfural	41.700	1466	$C_5H_4O_2$	96	0.04
60	*(E,E)*-2,4-Heptadienal	41.842	1468	$C_7H_{10}O$	110	0.01
61	Ethyl *(Z)*-4-octenoate	42.508	1480	$C_{10}H_{18}O_2$	170	0.01
62	Meso-2,3-butandiol diacetate	43.550	1498	$C_8H_{14}O_4$	174	10.23
63	Unknown	43.906	1498			6.61

(continued)

64	Ethylidene diacetate	45.133	1523	$C_6H_{10}O_4$	146	1.27
65	Benzaldehyde	45.675	1532	C_7H_6O	106	0.08
66	Nonanyl acetate	46.024	1538	$C_{11}H_{22}O_2$	186	8.30
67	*(E)*-2-Nonenal	46.583	1546	$C_9H_{16}O$	140	0.19
68	Ethylene diacetate	47.042	1552	$C_6H_{10}O_4$	146	0.09
69	Octanol	48.183	1568	$C_8H_{18}O$	130	0.05
70	Ethyl 3-(methylthio)propanoate	48.625	1574	$C_6H_{12}O_2S$	148	0.13
71	*(E,Z)*-2,6-Nonadienal	49.792	1590	$C_9H_{14}O$	138	0.04
72	1,2-Propanediol	50.400	1598	$C_3H_8O_2$	76	2.59
73	Ethylidene dibutanoate	51.992	1625	$C_{10}H_{18}O_4$	202	0.04
74	2-Propen-1,1-diol diacetate	52.108	1627	$C_7H_{10}O_4$	158	0.17
75	Unknown	52.583	1635			2.30
76	Benzenacetaldehyde	53.250	1642	C_8H_8O	120	0.08
77	*(E)*-2-Decenal	53.375	1643	$C_{10}H_{20}O$	154	0.11
78	Nonanol	54.692	1663	$C_9H_{20}O$	144	0.01
79	*(Z)*-3-Nonen-1-ol	56.033	1694	$C_9H_{18}O$	142	1.00
80	*(E,E)*-2,4-Nonadienal	56.900	1708	$C_9H_{14}O$	138	0.09
81	*(E)*-2-Nonen-1-ol	57.783	1722	$C_9H_{18}O$	142	0.01
82	*(E)*-6-Nonen-1-ol	57.967	1725	$C_9H_{18}O$	142	0.12
83	Benzyl acetate	58.592	1735	$C_9H_{10}O_2$	150	3.48
84	α-Farnescene	59.517	1755	$C_{15}H_{24}$	204	0.04
85	*(Z,Z)*-3,6-Nonadien-1-ol	59.875	1763	$C_9H_{16}O$	140	0.79

(continued)

86	*(E,Z)*-2,4-Decadienal	60.475	1770	$C_{10}H_{16}O$	152	0.17
87	*(E,Z)*-2,6-Nonadien-1-ol	60.758	1774	$C_{9}H_{16}O$	140	0.05
88	Butanediene diacetate	61.150	1780	$C_{8}H_{14}O_{4}$	174	0.05
89	*(E,E)*-2,4-Decadienal	62.800	1817	$C_{10}H_{16}O$	152	0.83
90	Phenethyl acetate	63.083	1824	$C_{10}H_{12}O_{2}$	164	0.65
91	α-Methyl-α-vinyl-2-furanacet aldehyde	64.450	1841	$C_{9}H_{10}O_{2}$	150	0.09
92	Benzyl alcohol	65.808	1890	$C_{7}H_{8}O$	108	0.36
93	Phenethyl alcohol	67.275	1919	$C_{8}H_{10}O$	122	0.04
94	3-Phenylpropyl acetate	68.400	1953	$C_{11}H_{14}O_{2}$	178	0.08
95	1-Phenyl-1-butanol	68.717	1982	$C_{10}H_{14}O$	150	0.09
96	*(E)-m*-Propenyl guaiacol	75.733	2201	$C_{10}H_{12}O_{2}$	164	0.17
97	Ethyl hexadecanoate	78.050	2260	$C_{18}H_{36}O_{2}$	284	0.08
	Total					94.55

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

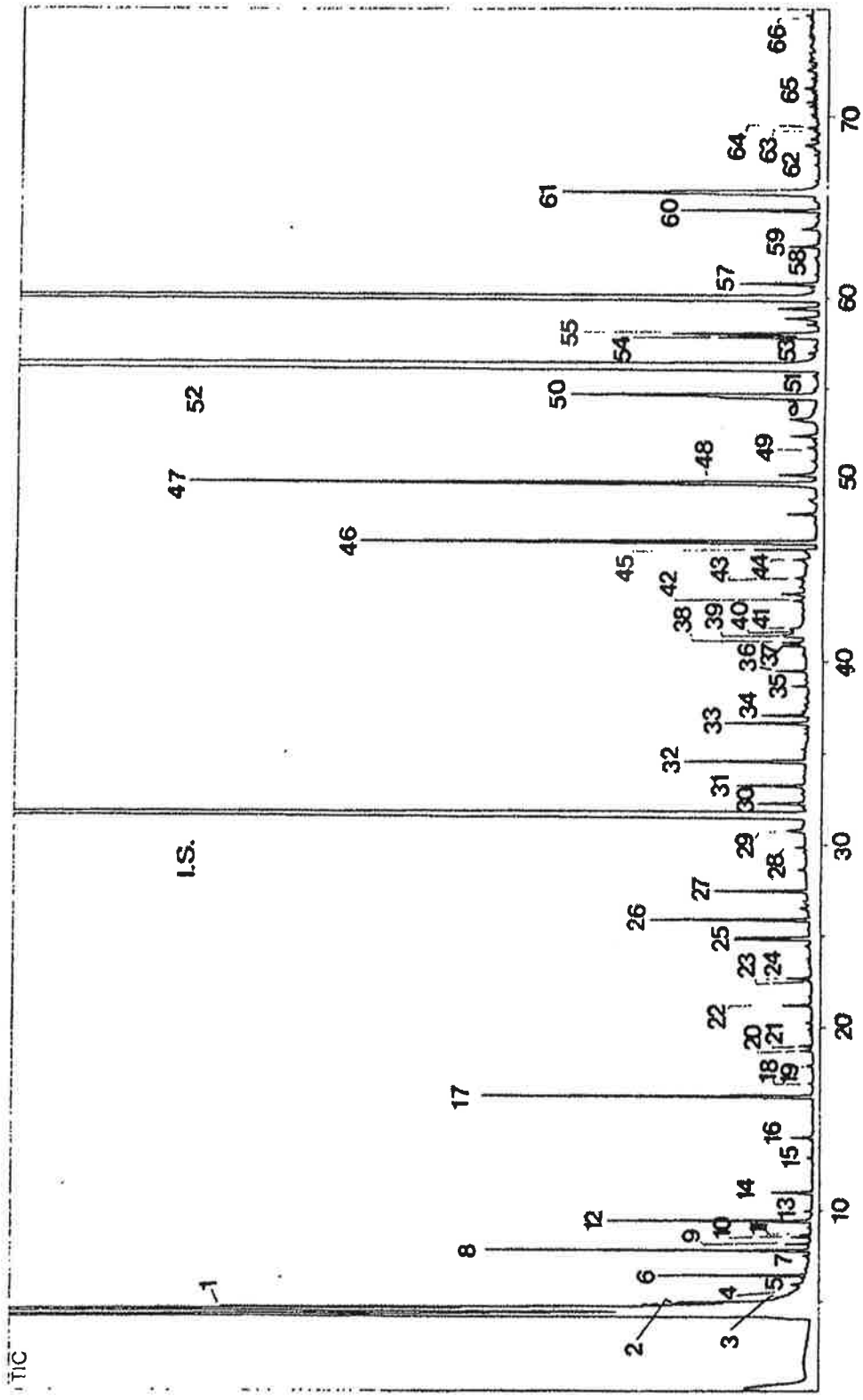

Fig. 44. GC chromatogram of volatile flavor components in Watermelon

Table 59. Volatile flavor components in Watermelon

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.683	521	$C_5H_{12}O$	88	1.73
2	3-Methyl-2-pentene	4.892	697	C_6H_{12}	84	0.23
3	sec-Butyl ethyl ether	5.267	702	$C_6H_{14}O$	102	0.05
4	Propanal	5.917	779	C_3H_6O	58	0.01
5	Ethyl butyl ether	5.983	785	$C_6H_{14}O$	102	0.03
6	Ethyl formate	6.467	821	$C_3H_6O_2$	74	0.33
7	Butanal	7.542	875	C_4H_8O	72	0.01
8	Ethyl acetate	7.850	887	$C_4H_8O_2$	88	0.80
9	Methanol	8.192	901	CH_4O	32	0.07
10	2-Methylbutanal	8.533	914	$C_5H_{10}O$	86	0.05
11	3-Methylbutanal	8.717	917	$C_5H_{10}O$	86	0.03
12	Ethanol	9.450	942	C_2H_6O	46	0.61
13	2-Ethylfuran	9.975	952	C_6H_8O	96	0.03
14	Pentanal	10.983	981	$C_5H_{10}O$	86	0.15
15	1-Peten-3-one	12.867	1018	C_5H_8O	84	0.01
16	Propanol	13.992	1025	C_3H_8O	60	0.08
17	Hexanal	16.200	1080	$C_6H_{12}O$	100	1.13
18	2-Methylpropanol	16.917	1100	$C_4H_{10}O$	74	0.01
19	3-Pentanol	17.892	1115	$C_5H_{12}O$	88	0.03
20	2-Pentanol	18.717	1128	$C_5H_{12}O$	88	0.04

(continued)

21	*(E)*-2-Pentanal	18.975	1130	C_5H_8O	84	0.05
22	1-Penten-3-ol	21.200	1156	$C_5H_{10}O$	86	0.09
23	2-Heptanone	22.533	1179	$C_7H_{14}O$	114	0.01
24	Heptanal	22.700	1182	$C_7H_{14}O$	114	0.09
25	*(E)*-2-Hexenal	24.892	1224	$C_6H_{10}O$	98	0.25
26	2-Pentylfuran	25.883	1232	$C_9H_{14}O$	138	0.61
27	Pentanol	27.442	1259	$C_5H_{12}O$	88	0.37
28	Octanal	29.875	1284	$C_8H_{16}O$	128	0.04
29	α-Limonene	30.792	1294	$C_{10}H_{16}$	136	0.09
I.S.	Butylbenzene	31.792	1304	$C_{10}H_{14}$	134	17.53
30	*(E)*-2-Heptenal	32.283	1314	$C_7H_{12}O$	112	0.24
31	6-Methyl-5-hepten-2-one	33.258	1334	$C_8H_{14}O$	126	0.27
32	Hexanol	34.583	1365	$C_6H_{14}O$	102	0.51
33	*(Z)*-3-Hexen-1-ol	36.692	1395	$C_6H_{12}O$	100	0.35
34	Nonanal	37.108	1404	$C_9H_{18}O$	142	0.19
35	3-Ethyl-2-methyl-1,3-hexadiene	38.708	1419	C_9H_{16}	124	0.07
36	*(E)*-2-Octenal	39.525	1430	$C_8H_{14}O$	126	0.13
37	*(Z)*-6-Nonenal	40.933	1448	$C_9H_{16}O$	140	0.11
38	7-Octen-4-ol	41.100	1454	$C_8H_{16}O$	128	0.11
39	Acetic acid	41.417	1456	$C_2H_4O_2$	60	0.15
40	Unknown	41.655	1462			0.01
41	*(E,E)*-2,4-Heptadienal	41.867	1470	$C_7H_{10}O$	110	0.03

(continued)

42	*(Z)*-3-Octen-1-ol	43.425	1485	$C_8H_{16}O$	128	0.05
43	*(E)*-2-Nonenal	44.683	1506	$C_9H_{16}O$	140	0.04
44	*(E,E)*-3,5-Octadien-2-one	45.542	1511	$C_8H_{12}O$	124	0.01
45	Benzaldehyde	45.700	1519	C_7H_6O	106	0.07
46	*(E)*-2-Nonenal	46.675	1535	$C_9H_{16}O$	140	2.42
47	*(E,Z)*-2,6-Nonadienal	49.900	1587	$C_9H_{14}O$	138	3.52
48	1,2-Propanediol	50.342	1595	$C_3H_8O_2$	76	0.24
49	*(E)*-2-Octen-1-ol	51.883	1622	$C_8H_{16}O$	128	0.04
50	Nonanol	54.692	1670	$C_9H_{20}O$	144	1.64
51	Estragole	55.017	1675	$C_{10}H_{12}O$	148	0.03
52	*(Z)*-3-Nonen-1-ol	56.383	1694	$C_9H_{18}O$	142	33.98
53	*(E,E)*-2,4-Nonadienal	56.950	1706	$C_9H_{14}O$	138	0.03
54	*(E)*-2-Nonen-1-ol	57.842	1724	$C_9H_{18}O$	142	0.47
55	*(Z)*-6-Nonen-1-ol	58.025	1728	$C_9H_{18}O$	142	0.69
56	*(Z,Z)*-3,6-Nonadien-1-ol	60.117	1763	$C_9H_{16}O$	140	21.63
57	*(E,Z)*-2,6-Nonadien-1-ol	60.792	1775	$C_9H_{16}O$	140	0.31
58	1-Phenyl-1-butanone	62.200	1800	$C_{10}H_{12}O$	148	0.01
59	*(E,E)*-2,4-Decadienal	62.833	1811	$C_{10}H_{16}O$	152	0.13
60	Geranylacetone	64.808	1863	$C_{13}H_{22}O$	194	0.52
61	Unknown	65.783	1886			2.18
62	2-Hexylthiophene	68.717	1955	$C_{10}H_{16}S$	168	0.03
63	Dodecanol	69.200	1961	$C_{12}H_{26}O$	186	0.03

(continued)

64	1-Phenyl-1-butanol	69.375	1962	$C_{10}H_{14}O$	150	0.05
65	γ-Nonalactone	71.600	2039	$C_9H_{16}O_2$	256	0.04
66	Tetradecanol	75.658	2182	$C_{14}H_{30}O$	214	0.03
	Total					94.92

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 60. Relative content of functional groups in Oriental melon and Watermelon

Peak area%

Functional group	Waterlmelon	Orientalmelon
Aldehydes	8.72	4.63
Alcohols	61.46	7.27
Esters	1.13	55.87
Terpenes	0.09	0.05
Acids	0.15	-
Ethers	1.81	1.3
Ketones	0.87	0.24
Miscellaneous	0.97	0.65
T o t a l	75.20	70.01

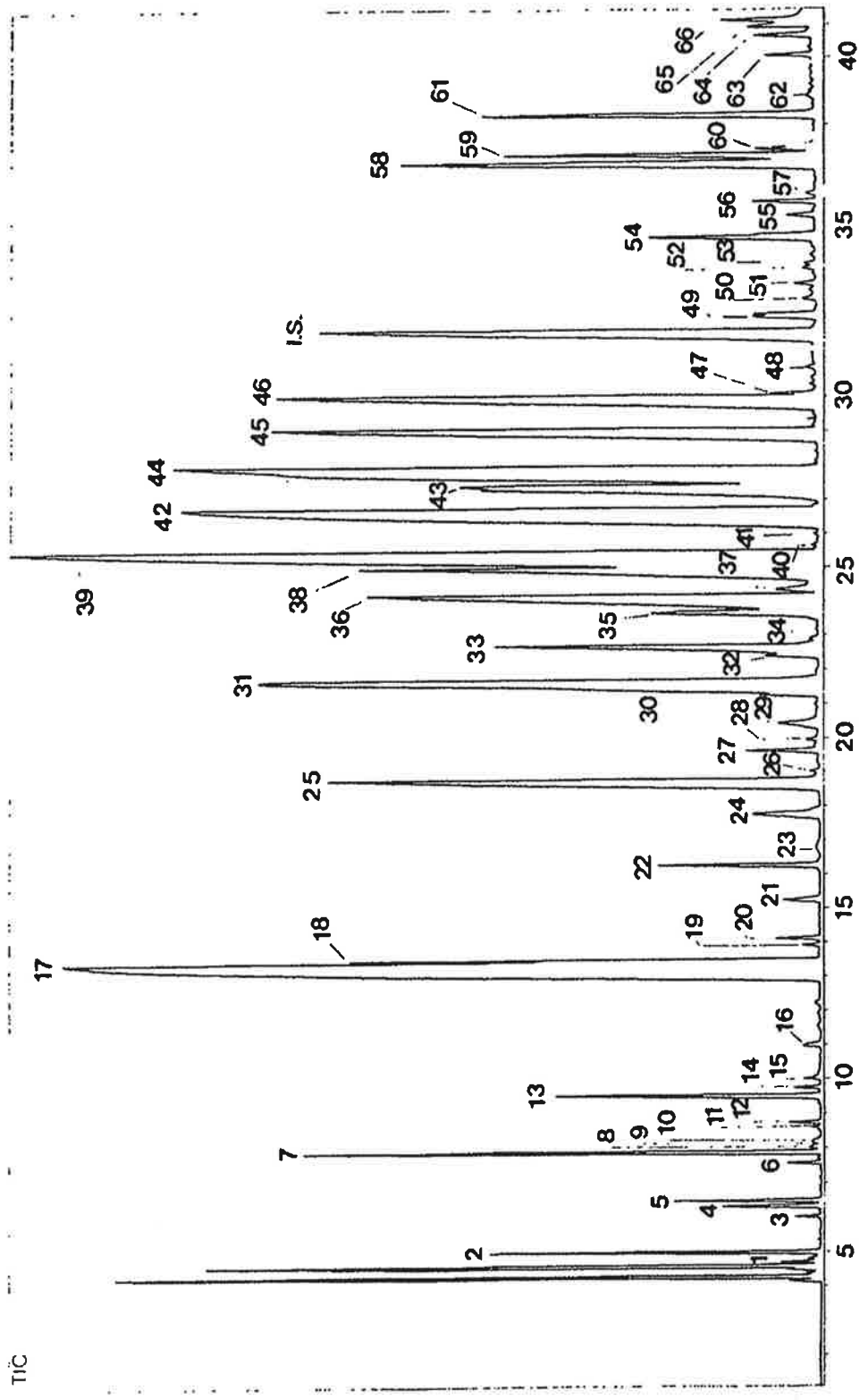

Fig. 45. GC chromatogram of volatile flavor components in leaf of Sanchoo I

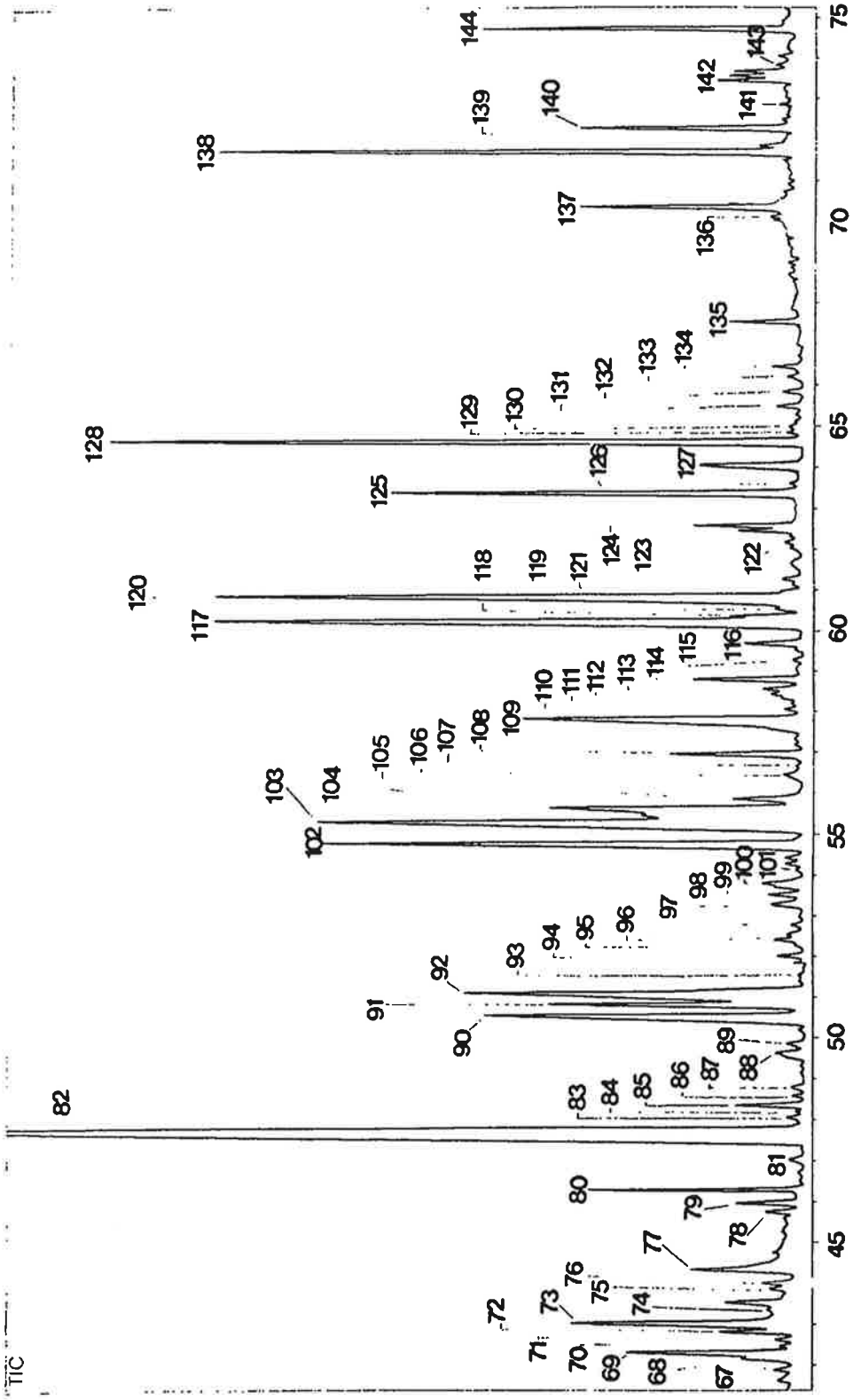

Fig. 45. GC chromatogram of volatile flavor components in leaf of Sanchoo II

Table 61. Volatile flavor components in leaf of Sanchoo

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.708	530	$C_5H_{12}O$	88	0.01
2	Acetaldehyde	4.983	715	C_2H_4O	44	0.44
3	Octane	6.033	796	C_8H_8	114	0.03
4	2-Propanone	6.333	813	C_3H_6O	58	0.18
5	Ethyl formate	6.492	822	$C_3H_6O_2$	74	0.19
6	Butanal	7.575	877	C_4H_8O	72	0.05
7	Ethyl acetate	7.892	891	$C_4H_8O_2$	88	0.91
8	Diethylacetal	8.025	893	$C_4H_8O_2$	88	0.03
9	2-Methylfuran	8.067	894	C_5H_6O	82	0.01
10	Nonane	8.167	896	C_9H_{20}	126	0.03
11	2-Methylbutanal	8.608	905	$C_5H_{10}O$	86	0.01
12	3-Methylbutanal	8.750	918	$C_5H_{10}O$	86	0.05
13	Ethanol	9.533	945	C_2H_6O	46	0.55
14	3-Buten-2-one	9.750	950	C_4H_8O	70	0.04
15	2-Ethylfuran	10.008	957	C_6H_8O	96	0.03
16	2-Pentanone	10.967	980	$C_5H_{10}O$	86	0.05
17	α-Pinene	13.425	1028	$C_{10}H_{16}$	136	7.73
18	α-Thujene	13.500	1029	$C_{10}H_{16}$	136	0.64
19	Methylbenzene	13.925	1043	C_7H_8	92	0.03
20	2-Methyl-3-butene-2-ol	14.125	1049	$C_5H_{10}O$	86	0.08

(continued)

21	Camphene	15.250	1062	$C_{10}H_{16}$	136	0.10
22	Hexanal	10.267	1084	$C_6H_{12}O$	100	0.33
23	α-Cyclocitral	16.775	1104	$C_{10}H_{16}O$	152	0.01
24	2-β-Pinene	17.767	1107	$C_{10}H_{16}$	136	0.28
25	Sabinene	18.787	1124	$C_{10}H_{16}$	136	2.56
26	*(E)*-2-Pentenal	19.033	1128	C_5H_8O	84	0.02
27	*(E)*-Allyl propenyl ether	19.633	1138	$C_6H_{10}O$	98	0.15
28	2-Methyl-4-pentenal	19.958	1142	$C_6H_{10}O$	98	0.02
29	δ-3-Carene	20.433	1148	$C_{10}H_{16}$	136	0.16
30	1-Penten-3-ol	21.267	1163	$C_5H_{10}O$	86	0.11
31	β-Myrcene	21.658	1170	$C_{10}H_{16}$	136	3.80
32	α-Terpinene	22.408	1181	$C_{10}H_{16}$	136	0.14
33	δ-4-Carene	22.708	1185	$C_{10}H_{16}$	136	1.24
34	Heptanal	22.917	1188	$C_7H_{14}O$	114	0.02
35	2-Methyl-2-butenal	23.667	1197	C_5H_8O	84	0.67
36	α-Limonene	24.192	1204	$C_{10}H_{16}$	136	2.94
37	α-Phellandrene	24.350	1207	$C_{10}H_{16}$	136	0.18
38	β-Phellandrene	24.983	1217	$C_{10}H_{16}$	136	2.39
39	*(E)*-2-Hexenal	25.475	1230	$C_6H_{10}O$	98	7.04
40	Ethyl α-methylcrotonate	25.658	1232	$C_7H_{12}O_2$	128	0.01
41	2-Pentylfuran	25.975	1236	$C_9H_{14}O$	138	0.01
42	*(Z)*-β-Ocimen	26.717	1246	$C_{10}H_{16}$	136	6.26

(continued)

43	γ -Terpinene	27.308	1254	$C_{10}H_{16}$	136	2.46
44	*(E)*-β -Ocimene	27.963	1262	$C_{10}H_{16}$	136	5.90
45	*p*-Cymene	29.050	1276	$C_{10}H_{14}$	134	3.13
46	α -Terpinolene	30.017	1287	$C_{10}H_{16}$	136	3.29
47	Octanal	30.100	1289	$C_8H_{16}O$	128	0.08
48	*(E)*-3-Hepten-2-one	30.858	1300	$C_7H_{12}O$	112	0.02
I.S.	Butylbenzene	31.950	1315	$C_{10}H_{14}$	134	2.69
49	Cyclopentanol	32.350	1330	$C_5H_{10}O$	86	0.14
50	2-Butyltetrahydrofuran	32.900	1346	$C_8H_{16}O$	128	0.04
51	6-Methyl-5-hepten-2-one	33.358	1360	$C_8H_{14}O$	126	0.05
52	3-Methyl-3-heptanol	33.808	1364	$C_8H_{18}O$	130	0.03
53	Ethyl 2-hexenoate	33.933	1365	$C_8H_{14}O_2$	142	0.02
54	Hexanol	34.708	1371	$C_6H_{14}O$	102	0.51
55	*(E)*-3-Hexen-1-ol	35.350	1379	$C_6H_{12}O$	100	0.06
56	Alloocimene	35.758	1383	$C_{10}H_{16}$	136	0.13
57	α -Pinene dioxide	35.992	1386	$C_{10}H_{12}O$	152	0.02
58	*(Z)*-3-Hexen-1-ol	36.908	1397	$C_6H_{12}O$	100	1.67
59	2-Nonanone	37.142	1405	$C_9H_{18}O$	142	0.84
60	Nonanal	37.300	1407	$C_9H_{18}O$	142	0.13
61	*(E)*-2-Hexen-1-ol	38.335	1418	$C_6H_{12}O$	100	0.94
62	*(Z)*-2-Hexen-1-ol	38.867	1423	$C_6H_{12}O$	100	0.01
63	α -*p*-Dimethylstyrene	40.100	1434	$C_{10}H_{12}$	134	0.11

(continued)

64	*(E)*-3-Caren-2-ol	40.700	1443	$C_{10}H_{16}O$	152	0.15
65	Acetic acid	40.967	1452	$C_2H_4O_2$	60	0.20
66	7-Octen-4-ol	41.192	1459	$C_8H_{16}O$	128	0.29
67	Furfural	41.633	1465	$C_5H_4O_2$	96	0.09
68	7-Methyl-4-octyl acetate	41.907	1467	$C_{11}H_{22}O_2$	186	0.05
69	3-Cyclohexene-1-carboxaldehyde	42.325	1471	$C_7H_{10}O$	110	0.45
70	δ-Elemene	42.475	1472	$C_{15}H_{24}$	204	0.03
71	*(E)*-Linalool oxide	42.633	1473	$C_{10}H_{18}O_2$	170	0.03
72	Octyl acetate	42.842	1475	$C_{10}H_{20}O_2$	172	0.15
73	β-Citronellal	43.050	1483	$C_{10}H_{18}O$	154	0.73
74	Longicyclene	43.350	1486	$C_{15}H_{24}$	204	0.06
75	*(E,E)*-2,4-Heptadienal	43.875	1491	$C_7H_{10}O$	110	0.04
76	α-Copaene	44.008	1494	$C_{15}H_{24}$	204	0.06
77	Decanal	44.358	1503	$C_{10}H_{20}O$	156	0.41
78	β-Bourbonene	45.758	1516	$C_{15}H_{24}$	204	0.05
79	2-Nonanol	45.983	1527	$C_9H_{20}O$	144	0.14
80	Unknown	46.308	1539			0.28
81	β-Cubebene	47.042	1546	$C_{15}H_{24}$	204	0.04
82	Linalool	47.792	1563	$C_{10}H_{18}O$	154	6.06
83	Limonene dioxide	48.058	1566	$C_{10}H_{16}O$	152	0.05
84	Linalyl acetate	48.200	1568	$C_{12}H_{20}O_2$	196	0.01
85	Octanol	48.367	1570	C_8H_8O	130	0.15

(continued)

86	Methyl citronellate	48.583	1573	$C_{11}H_{20}O_2$	184	0.02
87	*(E)*-1-Methyl-4(1-methylethyl)-2-cyclohexen-1-ol	48.800	1577	$C_{10}H_{18}O$	154	0.04
88	Elemene	49.642	1584	$C_{15}H_{24}$	204	0.12
89	α-Bornyl acetate	49.867	1587	$C_{12}H_{20}O_2$	196	0.05
90	β-Elemene	50.575	1593	$C_{15}H_{24}$	204	1.19
91	2-Undecanone	50.850	1596	$C_{11}H_{22}O$	170	0.68
92	*(E)*-β-Caryophyllen	51.125	1599	$C_{15}H_{24}$	204	1.56
93	Hexyl hexanoate	51.542	1602	$C_{12}H_{24}O_2$	200	0.03
94	Octyl butanoate	52.025	1606	$C_{12}H_{20}O_2$	200	0.05
95	β-Cyclocitral	52.283	1614	$C_{10}H_{16}O$	152	0.02
96	Valencene	52.425	1619	$C_{15}H_{24}$	204	0.07
97	*(Z)*-1-Methyl-4(1-methylethyl)-2-cyclohexen-1-ol	52.792	1625	$C_{10}H_{18}O$	154	0.03
98	γ-Elemene	53.292	1633	$C_{15}H_{24}$	204	0.10
99	*(E)*-2-Decenal	53.533	1637	$C_{10}H_{18}O$	154	0.08
100	Ascaridiol	53.805	1640	$C_{10}H_{16}O_2$	168	0.18
101	*(E)*-Pinocarveyl acetate	54.133	1643	$C_{12}H_{18}O_2$	194	0.02
102	Citronellyl acetate	54.808	1650	$C_{12}H_{22}O_2$	198	1.53
103	Estragole	55.325	1672	$C_{10}H_{12}O$	148	2.24
104	α-Humulene	55.658	1676	$C_{15}H_{24}$	204	1.40
105	*(Z)*-Citral	55.867	1679	$C_{10}H_{16}O$	152	0.20
106	Aromadendrene	56.450	1686	$C_{15}H_{24}$	204	0.06
107	Methyl geranate	56.675	1689	$C_{11}H_{18}O_2$	182	0.01

(continued)

108	α -Terpineol	56.967	1693	$C_{15}H_{24}$	204	0.34
109	Germacrene D	57.850	1709	$C_{15}H_{24}$	204	1.27
110	γ -Muurolene	58.075	1716	$C_{15}H_{24}$	204	0.05
111	2-Undecanol	58.192	1719	$C_{11}H_{24}O$	172	0.03
112	δ -Guaiene	58.342	1720	$C_{15}H_{24}$	204	0.05
113	*p*-Mentha-1,5-dien-8-ol	58.583	1731	$C_{10}H_{16}O$	152	0.11
114	*(E)*-Citral	58.825	1738	$C_{10}H_{16}O$	152	0.29
115	Azulene	59.292	1750	$C_{10}H_{8}$	128	0.03
116	*(E,E)*-α -Farnesene	59.708	1757	$C_{15}H_{24}$	204	0.15
117	Neryl acetate	60.258	1768	$C_{12}H_{20}O_2$	196	2.24
118	δ - Cadinene	60.367	1772	$C_{15}H_{24}$	204	0.13
119	γ - Cadinene	60.550	1779	$C_{15}H_{24}$	204	0.06
120	β - Citronellol	60.867	1791	$C_{10}H_{20}O$	156	2.21
121	*p*-Methyl acetophenone	61.125	1796	$C_{9}H_{10}O$	134	0.02
122	α -Muurolene	62.183	1816	$C_{15}H_{24}$	204	0.04
123	Nerol	62.467	1822	$C_{10}H_{18}O$	154	0.13
124	1,4-Dimethyl-δ -3-tetrahydro-acetophenone	62.600	1825	$C_{10}H_{16}O$	152	0.22
125	Unknown	63.392	1840			1.01
126	*p*-Propenylanisole	63.617	1842	$C_{10}H_{12}O$	148	0.03
127	Germacrene B	64.067	1847	$C_{15}H_{24}$	204	0.34
128	Geraniol	64.533	1856	$C_{10}H_{18}O$	154	1.82
129	Geranyl acetate	64.858	1862	$C_{13}H_{22}O$	194	0.03

(continued)

130	Hexanoic acid	64.992	1865	$C_6H_{12}O_2$	116	0.05
131	Ascaridiol	65.483	1875	$C_{10}H_{16}O_2$	168	0.07
132	Benzyl alcohol	65.850	1883	C_7H_8O	108	0.05
133	3-Ethyl-4-methyl-3-hepten-2-one	66.208	1890	$C_{10}H_{18}O$	154	0.04
134	Geranyl 2-methylpropanoate	66.442	1895	$C_{14}H_{24}O_2$	224	0.07
135	Neophytadiene	67.567	1931	$C_{20}H_{38}$	278	0.13
136	Epiglobulol	70.117	1993	$C_{15}H_{26}O$	222	0.07
137	Caryophyllene oxide	70.358	2000	$C_{15}H_{24}O$	220	0.56
138	δ-Nerolidol	71.733	2026	$C_{15}H_{26}O$	222	1.40
139	Ledol	71.858	2032	$C_{15}H_{26}O$	222	0.11
140	1,5,5,8-Tetramethyl-12-oxabicyclo 9.1.0 dodeca-3,7-diene	72.300	2051	$C_{15}H_{24}O$	220	0.51
141	Methyl 3-hydroxydecanoate	72.867	2077	$C_{11}H_{22}O_3$	202	0.03
142	2,5-Dimethyl-3-hexyne-2,5-diol	73.458	2104	$C_8H_{14}O_2$	142	0.17
143	*p*-Cymen-7-ol	73.833	2121	$C_{10}H_{14}O$	150	0.07
144	Spathulenol	74.733	2138	$C_{15}H_{24}O$	220	0.68
	Total					95.61

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

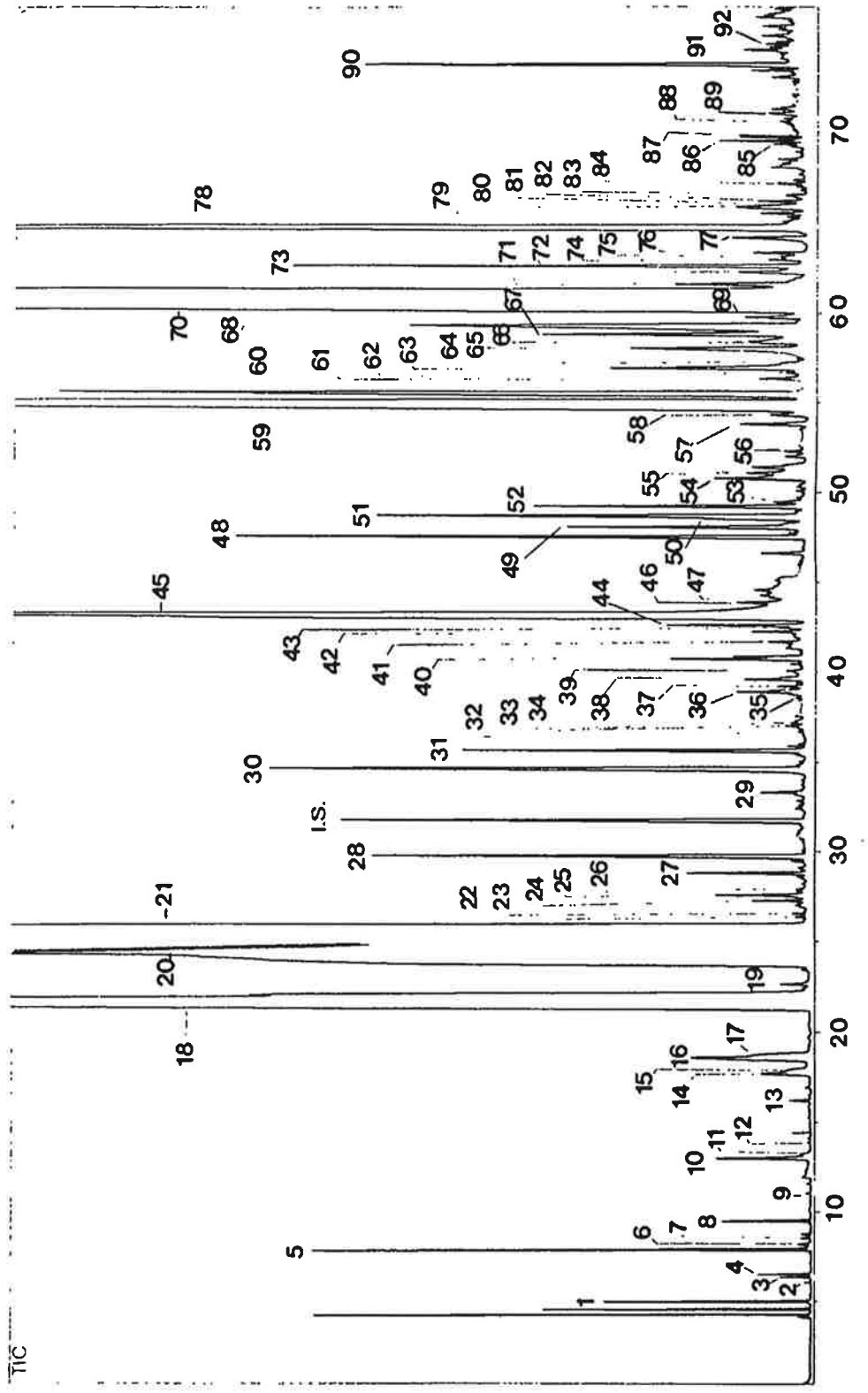

Fig. 46. GC chromatogram of volatile flavor components in seed of Sanchoo

Table 62. Volatile flavor components in seed of Sanchoo

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Acetaldehyde	5.008	697	C_2H_4O	44	0.12
2	Octane	6.058	785	C_8H_8	114	0.01
3	2-Propanone	6.358	810	C_3H_6O	58	0.02
4	Ethyl formate	6.508	823	$C_3H_6O_2$	74	0.03
5	Ethyl acetate	7.892	891	$C_4H_8O_2$	88	0.41
6	Nonane	8.183	900	C_9H_{20}	126	0.01
7	3-Methyl-butanal	8.758	917	$C_5H_{10}O$	86	0.01
8	Ethanol	9.429	943	C_2H_6O	46	0.07
9	Pantanal	10.983	979	$C_5H_{10}O$	86	0.01
10	α-Pinene	12.975	1022	$C_{10}H_{16}$	136	0.15
11	α-Thjune	13.223	1026	$C_{10}H_{16}$	136	0.01
12	2-Methyl-3-butene-2-ol	14.083	1042	$C_5H_{10}O$	86	0.01
13	Hexanal	16.267	1081	$C_6H_{12}O$	100	0.02
14	2-β-Pinene	17.767	1115	$C_{10}H_{16}$	136	0.10
15	1-β-Pinene	17.942	1120	$C_{10}H_{16}$	136	0.04
16	Sabinene	18.580	1138	$C_{10}H_{16}$	136	0.33
17	1-penten-4-ol	18.758	1139	$C_5H_{10}O$	86	0.10
18	β-Myrcene	21.950	1163	$C_{10}H_{16}$	136	11.32
19	Cyclopentanone	22.700	1169	C_5H_8O	84	0.03
20	α-Phellandrene	25.213	1177	$C_{10}H_{16}$	136	21.86

(continued)

21	β-Phelladrene	25.553	1205	$C_{10}H_{16}$	136	9.21
22	Pulegone	26.350	1225	$C_{10}H_{16}O$	152	0.01
23	*(Z)*-β-Ocimene	26.525	1228	$C_{10}H_{16}$	136	0.01
24	γ-Terpinene	27.267	1255	$C_{10}H_{16}$	136	0.06
25	*(E)*-β-Ocimene	27.575	1258	$C_{10}H_{16}$	136	0.11
26	Styrene	27.783	1260	C_8H_8	104	0.01
27	ρ-Cymene	28.808	1271	$C_{10}H_{14}$	134	0.13
28	α-Terpinolene	29.817	1284	$C_{10}H_{16}$	136	0.77
I.S.	Butyl benzene	31.817	1313	$C_{10}H_{14}$	134	0.81
29	6-Methyl-5-hepten-2-one	33.358	1331	$C_8H_{14}O$	126	0.04
30	*(Z)*-Rose oxide	34.708	1341	$C_9H_{18}O$	154	1.09
31	*(E)*-Rose oxide	35.705	1372	$C_9H_{18}O$	154	0.52
32	4-Methyl-3-penten-1-ol	37.047	1390	$C_6H_{12}O$	100	0.02
33	Nonanal	37.225	1394	$C_9H_{18}O$	142	0.02
34	*(E)*-2,4-Hexadienal	37.375	1397	C_6H_8O	96	0.01
35	Hexyl butanoate	38.800	1413	$C_{10}H_{20}O_2$	172	0.01
36	Perillene	38.933	1414	$C_{10}H_{14}O$	150	0.09
37	Dihydro-α-terpineol	39.242	1421	$C_{10}H_{20}O$	156	0.03
38	2-Methyl-2,4-pentanediol	39.625	1429	$C_6H_{14}O_2$	118	0.09
39	α-ρ-Dimethyl styrene	40.092	1438	$C_{10}H_{12}$	132	0.01
40	*(Z)*-Linalool oxide	40.730	1451	$C_{10}H_{18}O_2$	170	0.17
41	*(Z)*-2,7-Octadien-1-ol acetate	41.700	1453	$C_{10}H_{16}O_2$	168	0.03

(continued)

42	3-Cyclohexene-1-carboxaldehyde	42.258	1454	$C_7H_{10}O$	110	0.06
43	Nerol oxide	42.467	1455	$C_{10}H_{16}O$	152	0.03
44	*(E)*-Linalool oxide	42.617	1456	$C_{10}H_{18}O_2$	170	0.18
45	β-Citronellal	43.300	1469	$C_{10}H_{18}O$	154	4.29
46	2-Ethyl-1-hexanol	43.867	1481	$C_8H_{18}O$	130	0.04
47	α-Copaene	44.125	1486	$C_{15}H_{24}$	204	0.01
48	Linalool	47.558	1557	$C_{10}H_{18}O$	154	0.87
49	Linalyl acetate	48.100	1568	$C_{12}H_{20}O_2$	196	0.41
50	Methyl citronellate	48.533	1577	$C_{12}H_{22}O_2$	198	0.12
51	*(Z)*-1-Methyl-4(1-methylethyl)-2-cyclohexen-1-ol	48.725	1581	$C_{10}H_{18}O$	154	0.80
52	Isopulegol	49.250	1585	$C_{10}H_{18}O$	154	0.45
53	Isopulegyl acetate	49.483	1586	$C_{12}H_{22}O_2$	198	0.06
54	*(E)*-Caryophyllene	50.800	1595	$C_{15}H_{24}$	204	0.23
55	Terpinene-4-ol	51.092	1601	$C_{10}H_{18}O$	154	0.13
56	2-Methyl-6-methylene-3,7-oct-adiene-2-ol	52.292	1626	$C_{10}H_{16}O$	152	0.02
57	4-Isopropylcyclohexanol	53.792	1652	$C_9H_{18}O$	142	0.12
58	β-Citronellol	54.325	1663	$C_{10}H_{20}O$	156	0.08
59	Citronellyl acetate	55.092	1679	$C_{12}H_{22}O_2$	198	8.34
60	Cryptone	55.575	1682	$C_9H_{14}O$	138	2.07
61	*(Z)*-Citral	56.333	1687	$C_{10}H_{16}O$	152	0.97
62	Methyl geranate	56.667	1689	$C_{11}H_{18}O_2$	182	0.04
63	α-Terpineol	56.925	1691	$C_{10}H_{18}O$	154	0.47

(continued)

64	Nery acetate	57.200	1693	$C_{12}H_{20}O_2$	196	0.03
65	Unknown	58.042	1700			0.44
66	Phellandral	58.400	1710	$C_{10}H_{16}O$	152	0.19
67	*(E)*-Citral	58.883	1724	$C_{10}H_{16}O$	152	0.54
68	Unknown	59.325	1736			1.31
69	*(E)*-Piperitol	59.783	1753	$C_{10}H_{18}O$	154	0.12
70	Geranyl acetate	60.867	1793	$C_{12}H_{20}O_2$	196	17.16
71	Cuminal	61.617	1802	$C_{10}H_{12}O$	148	0.26
72	2-Caren-10-al	62.275	1810	$C_{10}H_{14}O$	150	0.15
73	Nerol	62.642	1814	$C_{10}H_{18}O$	154	0.67
74	2-Tridecanone	62.958	1818	$C_{13}H_{26}O$	198	0.04
75	*(E,E)*-Decadienal	63.125	1820	$C_{10}H_{16}O$	152	0.06
76	Geranyl propionate	63.333	1822	$C_{13}H_{22}O_2$	210	0.07
77	*(E)*-Carveol	64.167	1851	$C_{10}H_{16}O$	152	0.13
78	Geraniol	64.825	1873	$C_{10}H_{18}O$	154	4.25
79	*(Z)*-Carveol	65.533	1887	$C_{10}H_{16}O$	152	0.06
80	Benzyl alcohol	65.875	1893	C_7H_8O	108	0.08
81	*(Z)-p*-Menth-2-en-7-ol	65.983	1896	$C_{10}H_{18}O$	154	0.03
82	*(Z)*-Isogeraniol	66.208	1900	$C_{10}H_{18}O$	154	0.06
83	A-Phellandrene epoxide	67.017	1916	$C_{10}H_{16}O$	152	0.01
84	Dodecanol	67.167	1919	$C_{12}H_{26}O$	186	0.03
85	Benzothiazole	69.217	1948	C_7H_5NS	135	0.01

(continued)

86	*p*-Mentha-1,5-diene-7-ol	69.892	1957	$C_{10}H_{16}O$	152	0.09
87	Allethrolone	70.628	1981	$C_9H_{12}O_2$	152	0.03
88	Perillyl alcohol	71.408	2011	$C_{15}H_{24}$	152	0.02
89	2-Pentadecanone	71.742	2026	$C_{15}H_{30}O$	226	0.21
90	*p*-Cymen-7-ol	73.850	2121	$C_{10}H_{14}O$	150	0.62
91	Widdrol	74.658	2142	$C_{15}H_{26}O$	222	0.06
92	δ-Cadinol	75.989	2157	$C_{15}H_{26}O$	222	0.21
	Total					94.64

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 63. Relative content of functional groups in Sanchoo

	Peak area%	
Functional group	Leaf	Seed
Aldehydes	11.21	6.71
Alcohols	20.67	9.74
Esters	0.16	26.71
Terpenes	47.03	44.21
Acids	0.25	-
Ethers	0.16	-
Ketones	2.14	2.45
Miscellaneous	4.24	2.26
T o t a l	85.86	92.08

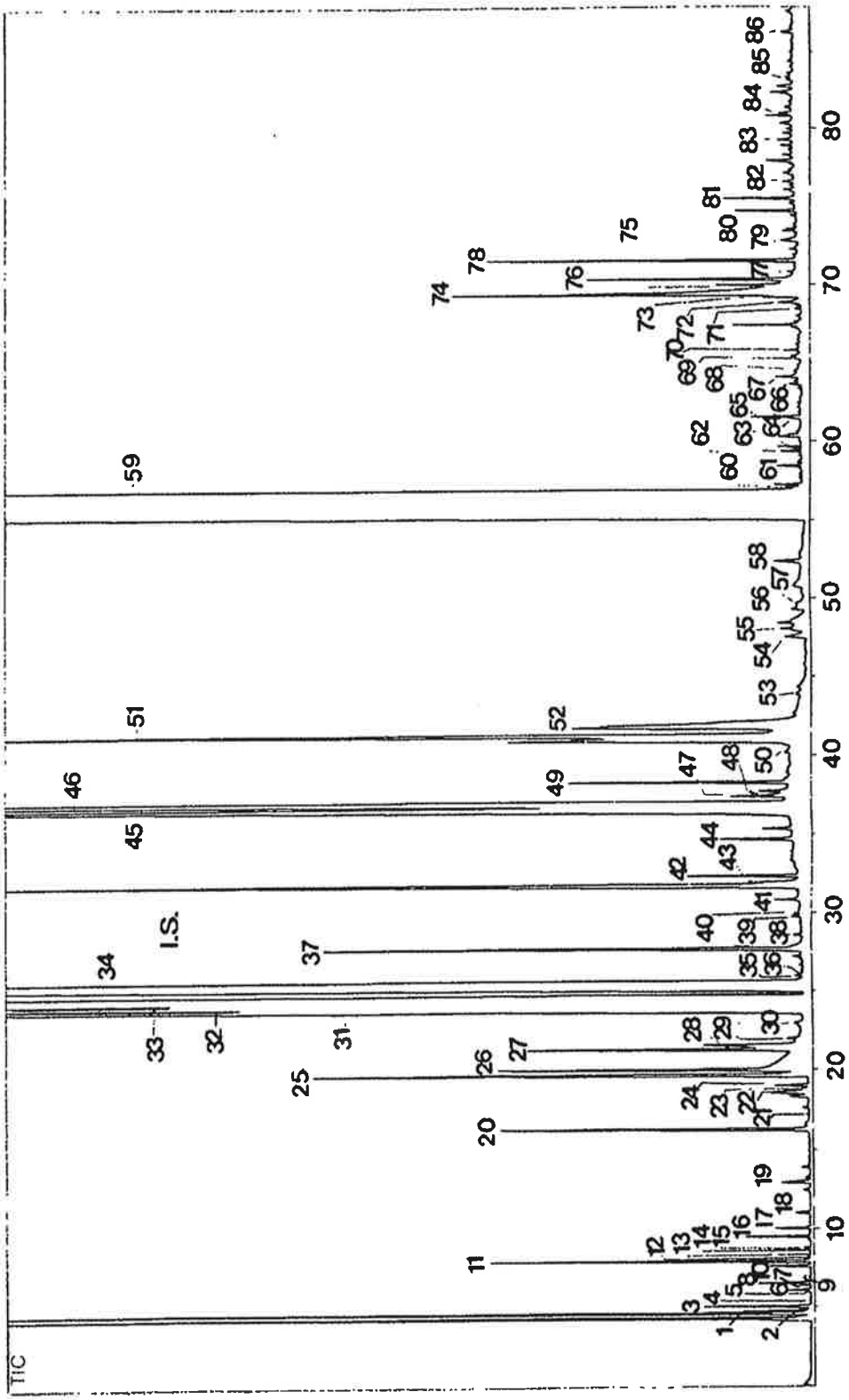

Fig. 47. GC chromatogram of volatile flavor components in Bangah herb

Table 64. Volatile flavor components in Bangah herb

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Ethyl isopropyl ether	4.733	692	$C_5H_{12}O$	88	0.03
2	3-Methyl-2-pentene	4.850	694	C_7H_{14}	98	0.01
3	Acetaldehyde	5.017	697	C_2H_4O	44	0.08
4	Ethyl isopropyl ether	5.317	716	$C_5H_{12}O$	88	0.01
5	Propanal	5.988	759	C_3H_6O	58	0.01
6	Octane	6.067	798	C_8H_{18}	114	0.01
7	2-Propanone	6.392	816	C_3H_6O	58	0.01
8	Ethyl formate	6.525	823	$C_3H_6O_2$	74	0.04
9	2-Propenal	6.933	843	C_3H_4O	56	0.01
10	Butanal	7.600	876	C_4H_8O	72	0.03
11	Ethyl acetate	7.900	890	$C_4H_8O_2$	88	0.25
12	Diethylacetal	8.083	895	$C_6H_{14}O_2$	118	0.01
13	2-Butanone	8.258	909	C_4H_8O	72	0.01
14	2-Methylbutanal	8.633	915	$C_5H_{10}O$	86	0.01
15	3-Methylbutanal	8.767	917	$C_5H_{10}O$	86	0.01
16	Ethanol	9.508	943	C_2H_6O	46	0.05
17	2-Ethylfuran	10.033	955	C_6H_8O	96	0.03
18	Pentanal	11.067	979	$C_5H_{10}O$	86	0.02
19	1-Penten-3-one	12.933	1021	C_5H_8O	84	0.04
20	Hexanal	14.375	1081	$C_6H_{12}O$	100	0.01

(continued)

21	4-Methyl-penten-3-one	17.233	1104	$C_6H_{10}O$	98	0.01
22	Sabinene	18.600	1115	$C_{10}H_{16}$	136	0.08
23	3-Methylbutyl acetate	18.850	1117	$C_7H_{14}O_2$	130	0.01
24	*(E)*-2-Pentenal	19.033	1129	C_5H_8O	84	0.04
25	*(E)*-Allyl propenyl ether	19.683	1137	$C_6H_{10}O$	98	0.68
26	2-Methyl-4-pentenal	20.017	1142	$C_6H_{12}O$	100	0.44
27	1-Penten-3-ol	20.280	1159	$C_5H_{10}O$	86	0.03
28	β-Myrcene	21.425	1165	$C_{10}H_{16}$	136	0.19
29	2-Ethylthiophene	21.915	1173	C_6H_8S	112	0.01
30	Heptanal	22.983	1189	$C_7H_{14}O$	114	0.01
31	Bornylene	23.833	1202	$C_{10}H_{16}$	136	2.38
32	*(Z)*-3-Hexenal	24.033	1204	$C_6H_{10}O$	98	1.94
33	α-Limonene	24.717	1212	$C_{10}H_{16}$	136	10.96
34	*(E)*-2-Hexenal	25.634	1231	$C_6H_{10}O$	98	13.66
35	2-Hexanol	25.967	1236	$C_6H_{14}O$	102	0.01
36	2-Pentylfuran	26.058	1237	$C_9H_{14}O$	138	0.01
37	3-Octanone	27.875	1260	$C_8H_{16}O$	126	0.61
38	3-Hexen-1-ol formate	28.567	1242	$C_7H_{12}O_2$	130	0.01
39	1-Octen-3-ol acetate	29.775	1286	$C_{10}H_{18}O_2$	170	0.01
40	Octanal	29.958	1288	$C_8H_{16}O$	126	0.01
41	4-Octen-3-one	30.842	1299	$C_8H_{14}O$	126	0.03
I.S.	Butylbenzene	31.767	1311	$C_{10}H_{14}$	134	1.65

(continued)

42	*(Z)*-3-Hexenyl acetate	31.950	1317	$C_8H_{14}O_2$	142	0.06
43	*(Z)*-2-Penten-1-ol	32.342	1329	$C_5H_{10}O$	86	0.13
44	Hexanol	34.677	1363	$C_6H_{14}O$	102	0.10
45	Octen-1-ol acetate	36.617	1386	$C_{10}H_{20}O$	168	3.76
46	*(Z)*-3-Hexen-1-ol	37.033	1397	$C_6H_{12}O$	100	4.59
47	Nonanal	37.375	1407	$C_9H_{18}O$	142	0.10
48	*(E,E)*-2,4-Hexadienal	37.742	1410	C_6H_8O	96	0.04
49	*(E)*-2-Hexen-1-ol	38.329	1415	$C_6H_{12}O$	100	0.25
50	*p*-Methylanisole	40.200	1441	$C_8H_{10}O$	122	0.01
51	7-Octen-4-ol	41.300	1460	$C_8H_{16}O$	128	1.93
52	2,7-Octadien-1-ol acetate	41.750	1466	$C_{10}H_{16}O_2$	168	0.90
53	*(E,E)*-2,4-Heptadienal	43.908	1487	$C_7H_{10}O$	110	0.01
54	Linalool	47.529	1522	$C_{10}H_{12}O$	154	0.05
55	*p*-Mentha-1,8-dien-9-ol	48.036	1537	$C_{10}H_{16}O$	152	0.05
56	Isopulegone	49.283	1558	$C_{10}H_{16}O$	152	0.01
57	Dimethyl sulfoxide	49.658	1600	C_2H_6OS	78	0.01
58	*(E)*-Caryophyllene	52.420	1638	$C_{15}H_{24}$	204	0.05
59	Estragole	55.725	1711	$C_{10}H_{12}O$	148	48.26
60	Crypton	57.117	1722	$C_9H_{14}O$	138	0.01
61	*p*-Acetonylanisole	58.483	1749	$C_{10}H_{12}O_2$	164	0.03
62	Carvone	59.408	1762	$C_{10}H_{14}O$	150	0.02
63	Azulene	59.625	1765	$C_{10}H_8$	128	0.01

(continued)

64	*(E)*-3-Hepten-2-one	61.487	1790	$C_7H_{12}O$	112	0.01
65	*(Z)*-3-Hexenyl-*(E)*-2-hexenoate	61.567	1791	$C_{12}H_{20}O_2$	196	0.05
66	Anethole	63.658	1819	$C_{10}H_{12}O$	148	0.02
67	*(E)*-Carveol	64.133	1825	$C_{10}H_{16}O$	152	0.04
68	*p*-Mentha-1,8-dien-3-one	64.475	1830	$C_{10}H_{14}O$	150	0.01
69	Hexanoic aicd	65.258	1840	$C_6H_{12}O_2$	116	0.01
70	*(Z)*-Carveol	65.450	1843	$C_{10}H_{16}O$	152	0.01
71	β-Ionone	68.467	1944	$C_{13}H_{20}O$	192	0.01
72	(*Z*)-Jasmone	68.692	1949	$C_{11}H_{16}O$	164	0.01
73	5-Hexenoic acid	69.208	1973	$C_6H_{10}O_2$	114	0.04
74	3-Hexenoic acid	69.342	1981	$C_6H_{10}O_2$	114	0.88
75	Caryophyllene oxide	69.983	1998	$C_{15}H_{24}O$	220	0.13
76	Unknown	70.350	2008			0.24
77	Methyleugenol	70.842	2021	$C_{11}H_{14}O_2$	178	0.01
78	*p*-Anisaldehyde	71.542	2040	$C_8H_8O_2$	136	0.35
79	2-Methyl-6-propylphenol	72.850	2069	$C_{10}H_{14}O$	150	0.03
80	Spathulenol	74.700	2118	$C_{15}H_{24}O$	220	0.06
81	*p*-Acetonylanisole	75.480	2140	$C_{10}H_{12}O_2$	164	0.08
82	Eugenol acetate	76.575	2204	$C_{12}H_{14}O_3$	206	0.02
83	*p*-Anisyl alcohol	79.292	2251	$C_8H_{10}O_2$	138	0.02
84	3-(*o*-Hydroxyphenyl)-Propanol	81.033	2337	$C_9H_{12}O_2$	152	0.02
85	3-Methylcinnamaldehyde	83.433	2418	$C_{10}H_{10}O_2$	162	0.01

(continued)

86	4-Methoxybenzenepropanol	86.367	2473	$C_{10}H_{14}O_2$	166	0.02
	Total					95.92

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 65. Relative content of functional groups in Bangah herb

	Peak area%
Functional group	Leaf
Aldehydes	16.8
Alcohols	55.8
Esters	5.11
Terpenes	13.66
Acids	0.93
Ethers	0.72
Ketones	0.79
Miscellaneous	0.22
T o t a l	94.03

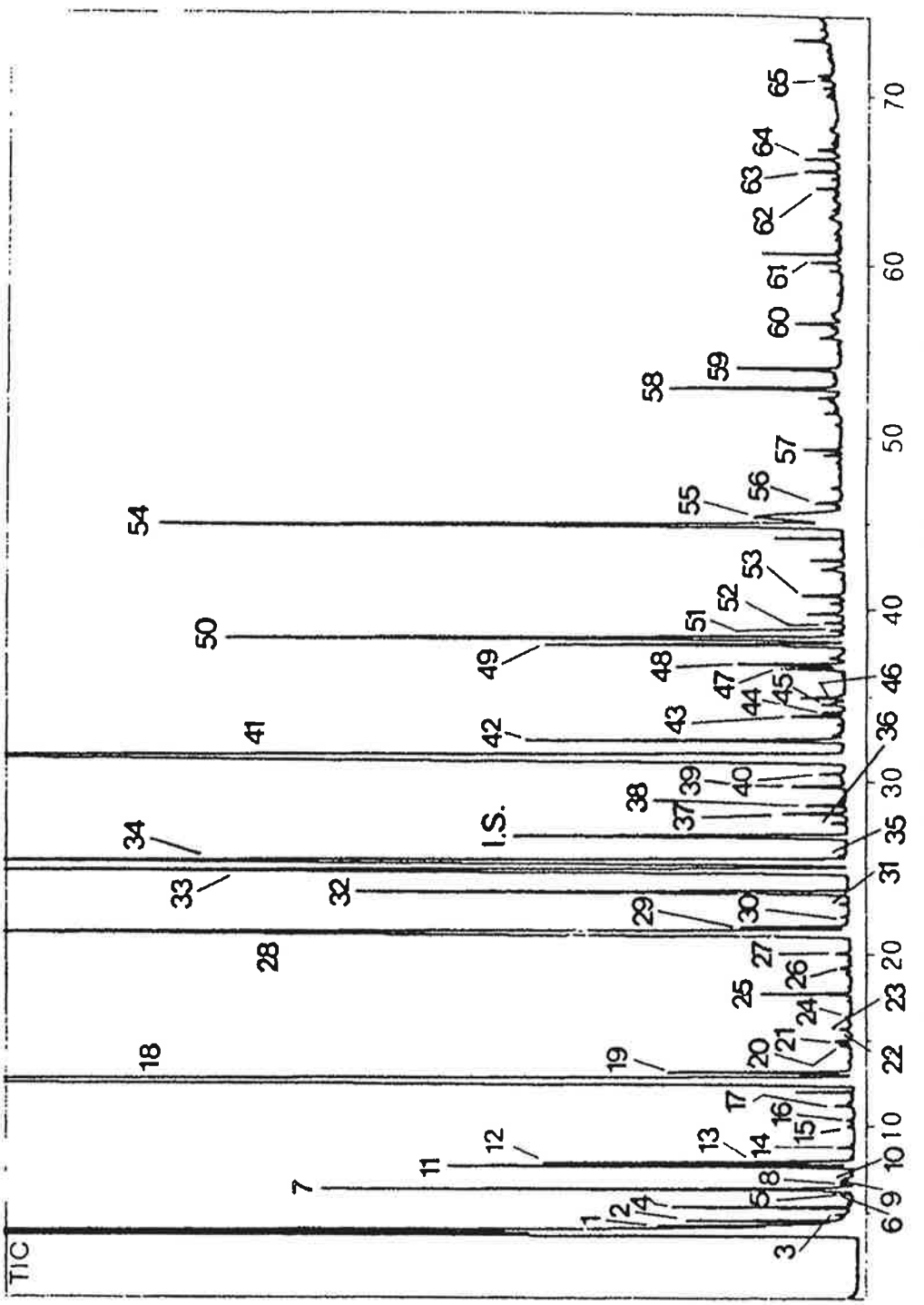

Fig. 48. GC chromatogram of volatile flavor components in Leek

Table 66. Volatile flavor components in Leek

Peak No.	Components	RTa)	RIb)	MFc)	FWd)	Peak Area (%)
1	Acetaldehyde	4.242	692	C_2H_4O	44	0.30
2	Dimethyl sulfide	4.542	722	C_2H_6S	62	0.27
3	Propanal	4.933	788	C_3H_6O	58	0.02
4	Ethyl formate	5.333	822	$C_3H_6O_2$	74	0.40
5	Butanal	6.142	876	C_4H_8O	72	0.03
6	2-Propenethiol	6.267	884	C_3H_6S	74	0.01
7	Ethyl acetate	6.375	890	$C_4H_8O_2$	88	1.74
8	3,4-Epoxy-1-butene	6.800	907	C_4H_6O	70	0.08
9	2-Methylbutanal	6.908	917	$C_5H_{10}O$	86	0.02
10	3-Methylbutanal	7.017	929	$C_5H_{10}O$	86	0.03
11	Ethanol	7.692	949	C_2H_6O	46	1.30
12	2-Methyl-1,5-Hexadiene	7.892	955	C_6H_8O	96	0.97
13	Methyl allyl sulfide	7.967	957	C_4H_8S	88	0.22
14	Isopropyl vinyl ether	8.808	980	$C_5H_{10}O$	86	0.06
15	Methyl-(*Z*)-propenyl sulfide	10.000	1015	C_4H_8S	88	0.02
16	1-Penten-3-one	10.367	1023	C_5H_8O	84	0.01
17	2-Butenal	11.225	1041	C_4H_6O	70	0.06
18	Dimethyl disulfide	12.767	1083	$C_4H_6S_2$	94	19.47
19	Hexanal	13.158	1089	$C_6H_{12}O$	100	0.67
20	3-Methylbutyl methyl sulfide	14.883	1113	$C_6H_{14}S$	118	0.03

(continued)

21	2-Propen-1-ol	14.975	1120	C_3H_6O	58	0.06
22	2-Pentanol	15.492	1127	$C_5H_{12}O$	88	0.02
23	4-Pentenal	15.667	1130	C_5H_8O	84	0.05
24	Diallyl sulfide	16.367	1143	$C_6H_{10}S$	114	0.02
25	1-Penten-3-ol	17.708	1167	$C_5H_{10}O$	86	0.36
26	Pyridine	19.225	1193	C_5H_5N	79	0.05
27	2-Methyl-4-pentenal	20.058	1207	$C_6H_{10}O$	98	0.07
28	*(E)*-2-Hexenal	21.325	1228	$C_6H_{10}O$	98	9.95
29	Methylpropyl disulfide	21.592	1231	$C_4H_{10}S_2$	122	0.46
30	3-Pentanethiol	22.192	1238	$C_5H_{12}S$	104	0.03
31	2,4-Dimethylthiophene	22.925	1250	C_6H_8S	112	0.04
32	*(Z)*-Propenylmethyl disulfide	23.625	1262	$C_4H_8S_2$	120	3.01
33	Methylpropenyl disulfide	24.908	1285	$C_4H_8S_2$	120	8.04
34	*(E)*-Propenylmethyl disulfide	25.483	1294	$C_4H_8S_2$	120	10.11
35	3-Hydroxy-2-butanone	25.758	1300	$C_4H_8O_2$	88	0.05
I.S.	Butylbenzene	26.883	1310	$C_{10}H_{14}$	134	2.22
36	*(Z)*-3-Hexenyl acetate	27.633	1322	$C_8H_{14}O_2$	142	0.07
37	2-Hepten-1-ol	28.175	1331	$C_7H_{14}O$	114	0.28
38	Pantolactone	28.658	1336	$C_6H_{10}O_3$	130	0.17
39	2,4-Dimethyl-3-heptanol	29.758	1359	$C_9H_{20}O$	144	0.26
40	Hexanol	30.452	1370	$C_6H_{14}O$	102	0.10
41	Dimethyl trisulfide	31.575	1389	$C_2H_6S_3$	126	17.38

(continued)

42	*(Z)*-3-Hexen-1-ol	32.425	1396	$C_6H_{12}O$	100	1.74
43	*(E)*-2-Hexen-1-ol	33.858	1417	$C_6H_{12}O$	100	0.24
44	4-Ethyl-2-hexynal	34.092	1421	$C_8H_{12}O$	124	0.10
45	Dipropyl disulfide	34.542	1428	$C_6H_{14}S_2$	150	0.10
46	Methylpentyl disulfide	34.658	1430	$C_6H_{14}S_2$	150	0.05
47	Acetic acid	36.583	1456	$C_2H_4O_2$	60	0.37
48	3-Ethyl-1,2-dithi-4-ene	36.858	1460	$C_6H_{10}S_2$	146	0.48
49	Diallyl disulfide	37.983	1479	$C_6H_{10}S_2$	146	1.52
50	3-Ethyl-1,2-dithi-5-ene	38.392	1487	$C_6H_{10}S_2$	146	4.09
51	*(Z)*-3-Hexenyl-3-methyl butanoate	38.833	1492	$C_{11}H_{20}O_2$	184	0.06
52	*(E,E)*-2,4-Heptadienal	39.283	1502	$C_7H_{10}O$	110	0.09
53	Methylpropyl trisulfide	40.825	1514	$C_4H_{10}S_3$	154	0.20
54	Methyl-*(Z)*-1-propenyltrisulfide	44.958	1597	$C_4H_8S_3$	152	5.15
55	Methyl-*(E)*-1-propenyltrisulfide	45.358	1601	$C_4H_8S_3$	152	1.80
56	Dimethyl sulfoxide	46.208	1610	C_2H_6OS	78	0.17
57	Methylmethylthiomethyldisulfide	49.300	1666	$C_3H_8S_3$	140	0.18
58	1-Nonyne	52.867	1721	C_9H_{16}	124	0.85
59	Dimethyl tetrasulfide	54.025	1741	$C_2H_6S_4$	158	0.54
60	Diallyl trisulfide	56.658	1795	$C_6H_{10}S_3$	178	0.20
61	Hexanoic acid	60.208	1866	$C_6H_{12}O_2$	116	0.14
62	β-Ionone	64.542	1952	$C_{13}H_{20}O$	192	0.09
63	2-Hexenoic acid	65.542	1968	$C_6H_{10}O_2$	114	0.15

(continued)

64	S-Methylmethyl thiosulfonate	66.258	2007	$C_2H_6O_2S_2$	126	0.13
65	4,4'-Dithiodibutanoic acid	70.950	2102	$C_8H_{14}O_4S_2$	238	0.06
	Total					97.01

RTa): retention time RIb): retention index MFc): molecule formula FWd): formula weight

Table 67. Relative content of functional groups in Leek

	Peak area%
Functional group	Leaf
Aldehydes	73.78
Alcohols	11.39
Esters	4.36
S-containing compounds	2.27
Acids	0.66
Ethers	-
Ketones	0.32
Miscellaneous	1.95
T o t a l	94.73

Appendix 1. Basic program for analysis of retention index(covats index)

```
10   DIM K$[40],N$[20],S$[40],A(34),M(350)
20   G=1
30   FILE=1:G=G+1
40   A.SAVE
50   METHOD$(1)="1"
60   FORMAT$(1)="1111"
62   WIDTH(1)=12
65   MIN.AREA(1)=100
67   STOP.TM(1)=98
70   ATTEN(1)=5
80   SPEED(1)=5
85   SLOPE(1)=200
90   PRINT  "COPYRIGHT SOFT CHOSUN UNI FOOD & NUTR PROF DR KIM"
100  A$="USER":C$="SAMPLE NAME"
110  F$="      ":G$="                "
120  H$="NAME":I$="QUANTITY"
130  PRINT  A$:INPUT K$
140  PRINT  C$:INPUT S$
150  PRINT  "MY NAME IS HP 5890II PLUS CHOSUN UNI. FOOD AND NUTRITION"
160  PRINT  "GC-COLUMN: CARBOWAX 20M(60M*0.25MM I.D/FILM0.25UM)"
170  PRINT  "TIME.PRG: 40GRD/3MIN 2GRA/MIN 150GRD/MIN 4GRA/MIN
     220GRD/10MIN"
175  PRINT  "ALKANE VOM 10.08.1996 BY KIM"
```

```
180  PRINT  "ATTEN(1)";"=";ATTEN(1)
190  PRINT  "SPEED(1)";"=";SPEED(1);"MM/MIN"
200  PRINT  "OK"
210  WAIT  ANAL  1
220  P=MAXPK
225  REM
230  PRINT  "QUANTITY WANT?1=YES 0=NO"
240  INPUT  Q
250  IF Q=1 GOTO 350
255  REM
260  PRINT  "PKNO   RT   AREA    AREA%     RI"
270  AR=0:CO=0
280  FOR I = 1 TO P
290  GOSUB 610
300  PRINT  USING 310;I,RWRT(I),AREA(I),CONCPK(I),X
310  IMAGE;>###  ####.###>############  ###.##      ####
320  AR=AR*AREA(I):CO=CO+CONCPK(I)
330  NEXT I
340  GOTO 520
350  PRINT  "NAME OF STANDARDS?":INPUT NO$
360  PRINT  "RETENTION TIME OF STANDARDS" :INPUT  NO$
370  PRINT  "QUANTITY OF STANDARD":INPUT MO
380  FOR I=1 TO P
390  IF (RWRT (I)-((RWRT(I)*1000-INT(RWRT(I)*1000))/1000))>RO THEN 410
400  NEXT I
```

```
410  AO=AREA(I-1)
430  PRINT "PKNO   RT   AREA    AREA%    QUANTITY     RI"
440  AR=0:CO=0
450  FOR I=1 TO P
460  GOSUB 610
470  M(I)=MO*AREA(I)/AO
480  PRINT  USING 490;I,RWRT(I),AREA(I),CONCPK(I),M(I),X
490  IMAGE;>### ####.###>########  ###.## #######.###  ####
500  AR=AR+AREA(I):CO=CO+CONCPK(I)
510  NEXT I
520  PRINT  "          -------- -----"
530  PRINT  USING 540;AR,CO
540  IMAGE;           >########  ###.##
550  PRINT "REINTEGRATION? YES=1 NO=0":INPUT R
560  IF R=0 GOTO 590
570  PRINT  "IF REINTEGRATION, PARAMETER CHANGE, RUN PRESS WITH ANAL"
580  GOTO 210
590  PRINT  "NEXT RUN NR",G:GOTO 30
600  END
610  REM  -----KOVATS-ROUTINE-----
620  RESTORE
630  L=7:H=30:K=RWRT(I)
640  FOR J=L TO H
650  READ A(J)
660  IF A(J)>K THEN GOTO 680
```

```
670  NEXT J
680  X=100*((K-A(J-1))/(A(J)-A(J-1)))+100*(J-1)
690  DATA 4.887,5.518,7.16,10.177,14.76,20.527,26.82,33.093
700  DATA 39.2,45.053,50.648,55.938,60.77,64.66,67.917,70.748
710  DATA 73.28,75.615,78.038,80.877,84.3,88.598,93.378,97.586
715  RETURN
```