18TH INTERNATIONAL SYMPOSIUM ON ESSENTIAL OILS

SEPTEMBER 24-26, 1987

LEIDEN UNIVERSITY

THE NETHERLANDS

Organizers
A. Baerheim Svendsen and J.J.C. Scheffer
Division of Pharmacognosy
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ABSTRACTS

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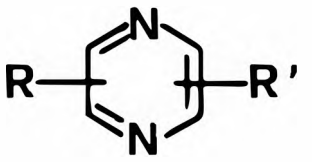
LECTURES

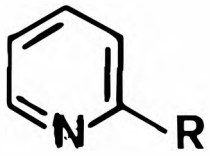
HETEROCYCLIC TRACE COMPONENTS IN THE ESSENTIAL OIL OF *Coriandrum sativum* L.

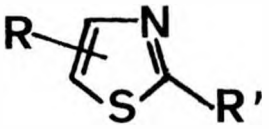
D. Lamparsky and I. Klimes

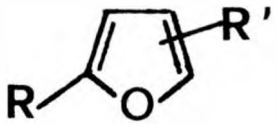
The special sensory effects of coriander oil have always stirred the attention of flavourists and perfumers all over the world. Trace components with a relatively high sensory impact must be responsible for the olfactory modification which the main constituent linalool (*ca.* 70% of the oil) shows in comparison to a purely synthetic specimen.

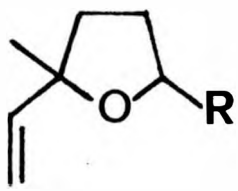
We found it of interest to search for such modifying substances. GC-MS studies revealed the presence of a number of heterocyclic compounds (pyrazines, pyridines, thiazoles, furans) which will be discussed in more detail. Tetrahydrofuran derivatives of terpenoic origin round off the picture of trace constituents present in coriander oil. They contribute at least partly to the typical odoriferous properties of the total oil.











Givaudan Research Company Ltd., 8600 Dübendorf-Zürich (Switzerland)

TRANSFORMATIONS OF THE PUNGENT PRINCIPLES IN EXTRACTS OF GINGER

D. McHale, W.A. Laurie and J.B. Sheridan

Gingerols, the pungent principles of ginger, are thermally labile. Two degradation pathways have been established: retro-aldol condensation to zingerone and the appropriate aldehyde, and dehydration to shogoals. Evidence is now presented which suggests that shogaols are also sensitive to certain processing conditions. A series of gingerols ethylated at the aliphatic hydroxyl group has been detected in commercial oleoresin gingers. Ethanol is commonly used to extract the pungent principles from the rhizomes. The chemical addition of ethanol to α,β-unsaturated ketones is well known, and such a reaction with the shogaols is the likely origin of the gingerol ethers.

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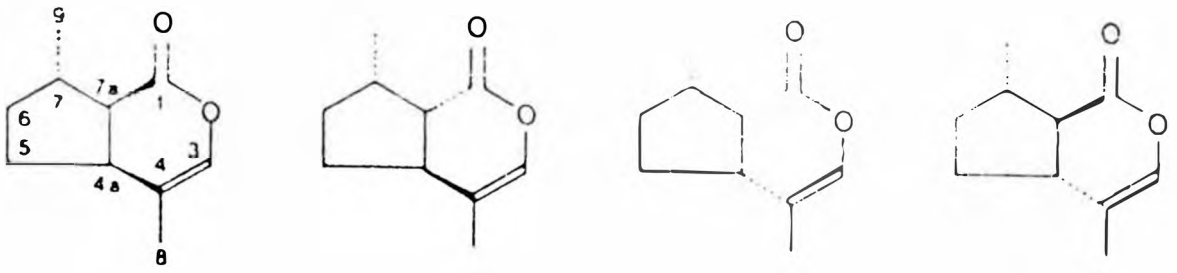
THE ESSENTIAL OIL OF FIVE *Nepeta* SPECIES. TRY-OUT FOR CHEMOTAXONOMIC USE

H.L. de Pooter*, J. de Laet*, P. Goetghebeur[O] and N.M. Schamp*

The large genus *Nepeta* (*ca.*280 species) has been studied only sparsely, although it has generated interest because of the feline attractant properties by some of its members. Mainly nepetalactones are thought to be responsible for this characteristic.
The oils of *N. cataria*, *N.* x *faassenii*, *N. nepetella*, *N. nuda* and *N. sibirica* contain varying amounts of a varying nepetalactone mixture (I-IV). The structure of the fourth isomer (IV), unknown till very recently, was determined by MS, ^{13}C- and ^{1}H-NMR analyses.
The composition of the oils was subjected to a cluster-analysis, in order to find out whether they might be used as a help for simplifying the complex, often ambiguous classification of the diversified, species-rich genus *Nepeta*; the last complete revision dates back as far as 1848.



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THE CHEMICAL COMPOSITION OF BITTER ORANGE PEEL OILS FROM LIVING FULLY DEVELOPED UNRIPE AND RIPE FRUITS AND FROM DEAD FRUITS

M.H. Boelens and R.J. Sindreu

The oil isolated from setting fruits of *Citrus aurantium* L. ssp. *amara* Engl. contains up to 75% linalool and linalyl acetate, whereas peel oil from ripe fruits contains more than 90% limonene. This prompted us to study the relation between linalool and its esters and limonene in bitter orange peels during ripening. The chemical composition of bitter orange peel oils from living fully developed unripe and ripe fruits, and from dead fruits was studied. 90 constituents were detected of which 50 were quantified, comprising about 99% of the oil.

A relation was found between the concentrations of linalool and linalyl acetate (0.3-3.2%) and limonene (92-95%) in the oils from living bitter oranges. Ripe bitter orange peels contained higher concentrations of aliphatic aldehydes and oxygen-containing mono- and sesquiterpenes than fully developed unripe fruits. Lower aliphatic constituents are formed during ripening. In fully developed unripe bitter orange oils the sesquiterpenes nootkatone and alpha-selinenone could not be detected at all, whereas oils from ripe living and dead fruits contained up to 0.3% of them. Thus, some oxygen-containing sesquiterpenes seem to be formed during ripening.

During isolation linalyl acetate partly decomposed into monoterpene hydrocarbons, and into alpha-terpineol, neryl and geranyl acetate.

Destilaciones Bordas Chinchurreta S.A., Apartado 11, Sevilla (Spain)

GC-MS ANALYSIS OF VOLATILES FROM SOME ASTERACEAE SPECIES GROWING IN EGYPT

E.A. Aboutabl

The family Asteraceae is one of the largest plant families comprising *ca.* 1000 genera and 23000 species forming approximately 10% of the World's flora. In Egypt, it is represented by 93 genera and *ca.* 250 species. In previous papers, the composition of volatiles from *Achillea fragrantissima* (Forssk.) Sch.Bip (1), *A. wilhelmsii* C.Koch (=*A. santolina* Auct. mult.) (2) and *Santolina chamaecyparissus* L. (3) was described. In the present study, volatiles from *Senecio glaucus* ssp. *coronopifolius* Maire Alexander (=*S. desfontainei* Druce) and *Asteriscus graveolens* Less. (=*Odontospermum graveolens* Sch.Bip) were analysed using capillary gas chromatography coupled to mass spectrometry. Components were identified by their retention times or Kovats indices and comparison of their mass spectra with those of known compounds. Percentage composition was based on peak area measurements. Dehydrofukinone(21%) was isolated from *S. glaucus* ssp. *coronopifolius* and characterized by different spectroscopic techniques. It is the character impact compound of the oil.

1. E.A. Aboutabl, F.M. Soliman, S.M. El-Zalabani, E.J. Brunke and T.A. El-Kersh, Sci.Pharm., 54 (1986) 37
2. E.J. Brunke, F.J. Hammerschmidt and E.A. Aboutabl, in: Progress in Essential Oil Research, 1986, Walter de Gruyter & Co., Berlin/New York pp. 85-92
3. E.A. Aboutabl, F.J. Hammerschmidt and A.A. El-Azzouny, Sci.Pharm., in press

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FORMATION OF 7-syn-HYDROXYCAMPHENE

G. Buchbauer, H. Spreitzer, A. Worm, W. Bauer and S. Zabern

In continuation of our syntheses in the isocamphane series, and because of our interest in developing short synthetic pathways to simple terpenoid compounds, we were interested in preparing 6-exo-hydroxycamphene, also known as nojigiku alcohol. We chose the easily obtainable 5,6-epoxy-iso-camphenilanic acid as starting material, and transformed it in three steps into 5,6-epoxy-camphene. This compound should have yielded the desired target molecule by reductive opening of the oxirane ring. However, instead of this alcohol we obtained 7-syn-hydroxycamphene in good yield. The structure of this compound was elucidated mainly by ^{13}C-NMR and ^{1}H-NMR spectroscopy. The possible mechanism of its formation will be discussed.

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SUPERCRITICAL EXTRACTION OF THE VOLATILE OIL IN CHAMOMILE FLOWERHEADS

H. Vuorela*, Y. Holm*, T. Harvala[O], A. Laitinen[▽] and R. Hiltunen*

Chamomile (*Matricaria recutita* L.) flowerheads are usually extracted by ethanol, or hydrodistilled, in order to isolate the volatile oil for phytotherapeutical products. In the present study the volatile oil was extracted supercritically by carbon dioxide. Comparison of the untreated flowerheads and the extract was carried out using HSGC-MS and HSGC-FID techniques.

HSGC-MS showed that the untreated flowerheads of two different chemotypes and the supercritical extracts contained the same terpenoids. The HSGC-MS technique was also useful for detecting compounds other than terpenoids, such as small oxygen-containing compounds, tentatively identified as pentanal, 2-methylbutanal and 2-methylpropanal. The peaks of these compounds and the solvent usually overlapped in GC analyses, but they were now separated thanks to the application of HSGC.

The composition varied slightly in flowerheads and extracts. The α-bisabolol content was diminished in the extracts, whereas the content of the bisabololoxides was increased. The content of chamazulene, which is formed from matricine, was, however, very low in the extracts.

The volatile oil yield obtained by supercritical extraction was on average 80%.

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INFLUENCE OF THE DISTILLATION PERIOD ON THE YIELD AND COMPOSITION OF THE ESSENTIAL OIL OF *Achillea millefolium*

P. Chatzopoulou and S.T. Katsiotis

The high price of some essential oils requires a standard quality, which depends also on the technological procedures used. In the present paper, the influence of factors such as the distillation period on the quality of the essential oil of *Achillea millefolium* will be discussed. Not only the yield of oil (variation of 27%), but also its percentage composition was influenced by the duration of the distillation process. GC analysis showed differences ranging from 15% to 450% for one and the same component.
The results showed that the distillation period is a very important factor influencing the quality of the oil of *A. millefolium*.

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ANTIBACTERIAL AND ANTIFUNGAL PROPERTIES OF ESSENTIAL OIL COMPONENTS

K. Knobloch, A. Pauli, B. Iberl, H. Weigand and N. Weis

Antimicrobial properties of terpenoids were studied on cultures of bacteria and fungi. In particular, Gram-negative organisms like the Enterobacteriaceae *Proteus vulgaris* and *Escherichia coli*, and the Rhodospirillaceae *Rhodopseudomonas sphaeroides* were grown under similar conditions like the Gram-positive *Micrococcus luteus*. Likewise, mycelia of *Aspergillus flavus*, *Penicillium viridicatum* and *Fusarium graminearum* were cultivated. Cultures of bacteria and fungi were raised in the presence and absence of terpenoids. The results obtained for many of the compounds tested seem to indicate that their antimicrobial potency is more powerful the better the compound is soluble in water. This holds true for aromatic and non-aromatic esters, aliphatic ketones, hydrocarbons and aliphatic alcohols.
On the other hand, there are phenols, like thymol, carvacrol and eugenol, aromatic aldehydes, especially cinnamaldehyde, which appear less water soluble but more antimicrobially powerful.
Concerning monoterpene alcohols, we found that their activity against fungi is less powerful than against bacteria. The sesquiterpene alcohol farnesol, on the other hand, revealed almost similar activities against bacteria and fungi.
Besides the activities on intact cells, we observed an inhibitory effect on enzymatic reactions, catalysed by cell-free bacterial membranes. Especially phenols, aldehydes and ketones decreased the membrane-dependant energy metabolism.

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ESSENTIAL OILS AS SPROUT INHIBITORS FOR POTATOES

K.J. Hartmans and A. van Es

Chlorpropham and propham are used on a large scale as sprout inhibitors on potatoes. For some time the availability of other sprout inhibitors has been wanted, which should easily be accepted as additives in food and food products. Therefore, the aim was to find sprout inhibitors originating from edible plants, parts of plants or plant products. Meigh (1) and Beveridge *et al.* (2) tested a number of volatile compounds for their sprout inhibiting activity. Some of them were effective. The inhabitants of the Andes mountains put the leaves of Muña plants (*Minthostachys glabrescens*) between the potato tubers during storage. Sprout suppression of the tubers was positively influenced. One of the main components of Muña is pulegone. It has now become evident that pulegone itself has sprout inhibiting properties. Pulegone and other carbonyl compounds are also occurring in essential oils of a number of plants growing in Europe, some of which are cultivated for essential oil production.

The results of small-scale experiments showed that a number of these oils have an efficient sprout inhibiting effect, *e.g.* the pulegone-containing essential oils of *Minthostachys glabrescens* and *Mentha pulegium*, or the carvone-containing essential oils of *Anethum graveolens* and *Carum carvi*. The results of sprout inhibition of potato tubers will be presented.

1. D.F. Meigh, J. Sci. Food Agric., 20 (1969) 159-164
2. J.L. Beveridge, J. Dalziel and H.J. Duncan, Potato Res., 24 (1981) 61-76

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ENVIRONMENTAL EFFECTS ON THE YIELD AND COMPOSITION OF THE ESSENTIAL OIL OF *Melissa officinalis* L.

L. Kutter and H. Friedrich

Dried leaves of *Melissa officinalis* L. are well known for their antispasmodic, carminative and sedative activities, which are mainly due to the essential oil. Some components of the essential oil have also been reported to show antibacterial effects.

Previous publications (1,2) indicated that the qualitative and quantitative composition of the essential oil of *M. officinalis* is strongly influenced by ecological factors such as the place of growth and the climate.

In order to study the influence of different climatic conditions on the yield and composition of the oil, cuttings of *M. officinalis* were cultivated in growth chambers under different conditions, and extracted with pentane. The extracts were analysed by GLC.

The results showed that cultivation under elevated temperatures led to increased yields of the volatiles, and differences in the intensity of light and the daylength to variations in the essential oil composition.

1. F.W. Hefendehl, Arch. Pharm., 303 (1970) 345
2. G. Tittel, H. Wagner and R. Bos, Planta Med., 46 (1982) 91

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THE ESSENTIAL OIL OF *Peucedanum lancifolium* AND ITS CHEMOTAXONOMIC VALUE

K.-H. Kubeczka, G. Schmaus, W. Schultze and I. Ullmann

In connection with systematic investigations of the essential oils from middle and west European *Peucedanum* species, the essential oil of *Peucedanum lancifolium* Lange was analysed.
The distribution of this rarely occurring plant, which grows at wet places, is restricted to the Atlantic coast regions of northwestern France, northwestern Spain and western Portugal.
Hydrodistillation of the chopped fresh roots, collected in the Britanny (Bretagne), yielded a pale yellow oil which was fractionated into hydrocarbons and oxygenated components by silica gel dry column chromatography. Both fractions were analysed by capillary GC and GC-MS. The hydrocarbon fraction contained several ubiquitous mono- and sesquiterpenes. The main constituent of the polar fraction was elucidated as the uncommon sesquiterpene alcohol *trans*-sesquilavandulol. Besides further terpenoids of known structures, some hitherto unknown natural substances were identified by chromatographic and spectroscopic methods.
The possible chemotaxonomic value of the essential oil composition with regard to the botanical relationship of *Peucedanum lancifolium* to other *Peucedanum* species will be discussed.

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CARVACROL RICH PLANTS IN GREECE

S. Kokkini* and D. Vokou[O]

Carvacrol may be considered as a characteristic "xerochemic" compound, abundant in aromatic plants with xeromorphic characters. Carvacrol is the major component of the essential oils of four species of the Lamiaceae growing wild in Greece, *viz. Coridothymus capitatus* (L.) Reichb.f., *Satureja thymbra* L., *Origanum onites* L. and *Origanum vulgare* L. ssp. *hirtum* (Link) Ietswaart. Their distribution all over Greece was studied.

The volatile oil yields from populations collected all over their area of distribution were determined. The first three species, having a strictly determined habitat, showed slight variations only, whereas the fourth one (*O. vulgare* ssp. *hirtum*) which is less limited in its distribution by environmental factors, showed a large variation in oil yield. However, carvacrol was always the major constituent of the essential oils.

The four species investigated are rich in volatile oils, particularly *O. vulgare* ssp. *hirtum* contained large amounts of oil (*ca.* 8%).

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DIRECT CAPTURE OF VOLATILES EMITTED BY LIVING PLANTS (PART II)

C. Bicchi*, A. D'Amato*, P. Sandra[O] and F. David[O]

The knowledge of the chemical composition of the atmosphere surrounding an odorous plant is of great importance in the study of both allelopathy and living cycles. In a previous paper (1) on the construction of a sampling device and on the possibility of open traps (very thick film FSOT columns), preliminary results were presented. The desorption using a single and a double oven gas chromatograph was compared.

In the present paper the latest results are described. A 530 µm i.d. x 3 m FSOT column coated with a thick film of PS 255 (15 µm) was used as a trapping column. A 220 µm i.d. x 25 m FSOT column, coated with OV-1 (0.5 µm) was used as analytical column. Both columns were coupled through a Multiple Intelligent Switching Controller (MUSIC) allowing an efficient reconcentration and injection.

The GC patterns of the headspace of some odorous Mediterranean plants of commercial interest directly captured in the field will also be shown.

1. C. Bicchi, A. D'Amato, P. Sandra and F. David, Direct capture of volatiles emitted by living plants (Part I). Flavour Fragr. J., in press

The authors are indebted to NATO for the financial support of this research project (NATO grant for scientific research 718/83)

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CHROMATOGRAPHIC AND SPECTROSCOPIC TECHNIQUES IN THE CHEMICAL CHARACTERIZATION OF LAVANDIN (*Lavandula hybrida* Rev.) ESSENTIAL OIL

G.C. Galletti* and G. Bonaga[O]

Lavandin essential oil was analysed by single and combined gaschromatographic and spectroscopic techniques, in order to evaluate the efficiency of various instrumental methods in essential oil analysis. Steam distilled oil from lavandin (*Lavandula hybrida* Rev., var. abrialis, Super A, Grosso) inflorescences collected in northern Italy, was analysed either directly or after preliminary separation in hydrocarbons and oxygenated compounds using silica gel microcolumns. Capillary GC was performed on polar and non-polar columns, for more reliable peak identification by comparison of their retention times with those of authentic compounds. Quadrupole and double focussing magnetic mass spectrometers were used for GC-MS. The results were compared with those obtained by the newest and less expensive tridimensional quadrupole mass filter Ion Trap Detector (GC-ITD). GC coupled with a Fourier Transform Infrared detector (FTIR) was also evaluated. GC-FTIR is a non destructive technique and provides more specific data for isomer identification, which are complementary to GC-MS results. The results obtained by ^{13}C-NMR, a technique that makes possible the analysis of essential oils without preliminary separation of their components, thanks to the high sensitivity and resolution of the instruments now available, will also be discussed.

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THE SELECTIVE GAS CHROMATOGRAPHIC DETERMINATION OF OXYGENATED COMPOUNDS IN ESSENTIAL OILS WITH THE O-FID

K.-H. Kubeczka

The determination of individual oxygenated compounds in complex natural mixtures is of primary importance in the analysis of essential oils, flavours and fragrances. Recently a new oxygen-specific gas chromatographic detector has become commercially available (1). The applicability of this detection system in the field of essential oil analysis was investigated.
The results showed that such a detection system offers the advantage of higher specifity than can be obtained by the commonly used column chromatographic pre-separation of essential oils into hydrocarbons and oxygenated compounds over silica gel. A further advantage is the high sensitivity of the O-FID, which is useful when very small samples of volatiles have to be analysed, *e.g.* from tissue cultures, individual oil glands or biological samples.

1. Carlo Erba Strumentazione, 8th International Symposium on Capillary Chromatography, Riva del Garda, Italy, May 19-21, 1987

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POSTERS

GC-MS ANALYSIS OF THE ESSENTIAL OIL OF *Lasiocephalus ovatus* (COMPOSITAE)

S. Abdo*, M. De Bernardi[O], G. Marinoni*, G. Mellerio[▽] and G. Vidari[O]

Lasiocephalus ovatus Schlechtendal (= *Culcitium reflexum* HBK) is a plant endemic of Ecuador where it is better known under the name of Arquitecta. The plant grows at very high altitudes and is used in folk medicine.

During our studies on plants of Ecuador, we isolated from Arquitecta nine furoeremophylanes as main constituents. Here we report on the composition of the essential oil obtained from the stems of the plant. The oil, very rich in sesquiterpene hydrocarbons, was analysed by GC-MS. The results will be discussed. Identification was achieved by comparison of the spectra obtained and literature data.

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THE ESSENTIAL OIL OF *Thymus glandulosus*

T. Adzet*, R. Vila*, C. Ibáñez[O] and S. Cañigueral*

The genus *Thymus* L. (Labiatae), largely represented in the Iberian flora, is constituted by aromatic plants used in folk medicine. Following our previous work on the essential oils of its species, we report here on that of *Thymus glandulosus* Lag. ex H. del Villar.
It is an endemic plant of southern Spain and northern Africa, the essential oil of which has not been previously investigated. The plant material was collected between Cartagena and Mazarrón (Murcia, Spain) in June 1984, and a voucher specimen was included in the BCF Herbarium (Lab. Botany, Fac. Pharmacy, Univ. Barcelona) with the nº 33585.
The air-dried aerial parts were subjected to hydrodistillation (European Pharmacopoeia) giving an essential oil yield of 0.9% (v/w).
The qualitative analysis was carried out by GC and GC-MS, using Silicone SE-30 and Carbowax 20M capillary columns. The components were identified by their MS and by their retention indices on both stationary phases, comparing with literature data and authentic samples. The quantification was performed on the basis of the GC peak areas.
The major components were: *p*-cymene (58%), borneol (8.7%), α-pinene (7.2%) and camphene (5.3%).

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ANALYSIS OF THE ESSENTIAL OIL OF VIETNAMESE GINGER

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A dried sample of Vietnamese ginger (*Zingiber officinale*) was investigated and the composition of its hydrodistilled essential oil analysed by GC, GC-MS and 13C-NMR (1). The oil yield was 2.7%. The oil consisted of 28% monoterpene hydrocarbons, 37% oxygenated monoterpenes, 25% sesquiterpene hydrocarbons, 8% oxygenated sesquiterpenes and 2% non-terpenoid compounds. The composition was most similar to a variety of fresh Sri Lankan ginger. The main component was geranial (16%) which, together with neral, gave the ginger a lemon-like character. Other compounds which are supposed to be of importance for the characteristic odour of ginger were all present. Furfural, 2,6-dimethyl-5-heptene-1-al, dihydro-perillene, *p*-cymene-8-ol, allo-aromadendrene, γ-muurolene, lauric acid, methyl-isoeugenol, γ-eudesmol, farnesal and xanthorrhizol have not been identified before in ginger oil.

It was further found that the duration of distillation influenced the yield, composition and odour of the oil. Decontamination of the dried ginger by means of gamma-irradiation did not influence the yield or the composition of the oil.

1. T.A. van Beek, M.A. Posthumus, G.P. Lelyveld, H.V. Phiet and B.T. Yen, Phytochemistry, 26 (1987) in press

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VOLATILE CONSTITUENTS OF THE UNDERGROUND PARTS OF *Melissa officinalis* L.

R. Bos*, L. Kutter[O] and H. Friedrich[O]

The essential oil of the leaves of *Melissa officinalis* L. has been thoroughly investigated (1), whereas the volatile constituents of the underground parts of the same plant seem to have been ignored.
The present study was aimed at the identification of the volatiles from the underground parts, using hydrodistillation followed by GC-MS analysis.
The results showed that cyclic monoterpene ketones were the main constituents, in contrast to acyclic oxygen-containing terpenes, which are reported to be present in the essential oil from the leaves (1,2).

1. G. Tittel, H. Wagner and R. Bos, Planta Med., 46 (1982) 91
2. L. Kutter, Dissertation, 1987, in preparation

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THE ESSENTIAL OIL OF *Salvia candelabrum* LEAVES

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Salvia candelabrum Boiss. (Labiatae) is a southern Iberian endemism. From its leaves we previously isolated some flavonoids (1) and the new abietane diterpene candelabrone (2). Its essential oil has been partially studied some years ago by IR, GC and TLC (3).

In the present study we analysed the composition of the hydrodistilled essential oil (1.9% v/w) by means of GC-MS and by comparison of retention indices, on Carbowax 20M and Silicone SE-30 capillary columns, as described in a previous paper (4).

More than 98% of the essential oil was identified. The major components were 1,8-cineole (32%), camphor (21%), camphene (12%), α-pinene (8%), borneol (6%) and β-pinene (6%). Sixteen of the identified substances had not been reported previously in *S. candelabrum*.

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THE ESSENTIAL OIL OF CYPRESS

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Cupressus lusitanicus Mill. is a species of the Cupressaceae, which grows in Portugal. It is very common in gardens and fields, as hedges all over the country. This so-called "Portuguese Cypress" yields an essential oil of good quality to use as an adjuvant in soaps, room-sprays, deodorants, and many aromatic formulations. The yield of the oil obtained by hydrodistillation was 0.05-0.3%.

Most of the monoterpene hydrocarbons were identified: α-pinene, camphene, sabinene, Δ_3-carene and myrcene, α- and β-phellandrene, limonene, α- and γ-terpinene, *p*-cymene, and terpinolene, amounting to 60% of the oil. Of the carbonyl compounds, umbellulone was the main one; it was identified by the absorption spectra. Among the aromatic alcohols we identified terpinen-4-ol, α-terpineol, linalool, borneol and citronellol in small quantities.

Chromatograms will be presented.

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PRELIMINARY STUDY ON THE CHEMICAL COMPOSITION OF THE ESSENTIAL OIL OF *Achillea millefolium* GROWN WILD IN GREECE

P. Chatzopoulou and S.T. Katsiotis

The essential oil of *Achillea millefolium* which grows wild in Greece, and may yield an interesting industrial product, was investigated. The plant material (leaves and flowers) was hydrodistillated and the yield of the essential oil was 0.70%. The samples of the oils obtained were studied by routine methods and GLC analysis. More than twenty constituents were identified, of which borneol, 1,8-cineole, camphor and *p*-cymene were the main ones.

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CONSTITUENTS OF *Ocimum canum* OIL

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Ocimum canum Sims is an annual herb, which is often used in African ethnomedicine for the treatment of various diseases. On the basis of the essential oil composition, four chemotypes, *viz.* methyl cinnamate (1,2), camphor (3), citral (1,2) and linalool (4), are known.
The essential oil obtained by hydrodistillation of the leaves of the Nigerian grown *O. canum* was analysed by means of GC and GC-MS. The composition of the oil was significantly different from those previously reported. Twenty-seven compounds were identified in the oil, and eugenol was the dominant constituent (66%). A number of mono- and sesquiterpenoids were detected for the first time in the oil.
The present paper reports the existence of a new eugenol chemo-type of *Ocimum canum*.

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THE QUALITY OF PEPPERMINT OIL IN MICROPROPAGATION EXPERIMENTS

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Peppermint, *Mentha* x *piperita* L., can be propagated vegetatively, but it is a slow and laborious method. For this reason micropropagation was used. The explants, apical and axillary buds, originated from greenhouse grown *M.* x *piperita*. The *in-vitro* initiation and multiplication of the plants were performed on MS media containing 2.0 mg/l kinetin and 0.01 mg/l α-naphthaleneacetic acid. The growing conditions were 2000 lux cool-white light, 16/8 L/D, + 25°C.

The micro-shoots were rooted in a peat-perlite mixture in the greenhouse for two weeks, and then transferred to the experimental field. Samples were collected in three different stages of development. The total oil content and the composition of the volatile oil were determined by headspace gas chromatography (HSGC) as described earlier (1). The total oil content ranged from 1.10% to 2.56% in the donor plants, and from 0.90% to 1.54% within the clone. The clone had a slightly higher concent of menthol and menthofuran, but a lower content of menthone than the donor plant. The composition of the volatile oil did not appear to be dependant on the harvesting time.

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VOLATILES IN THE ROOT OF *Angelica archangelica*

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Angelica archangelica L. ssp. *archangelica* has been used for medicinal and flavouring purposes for hundreds of years. The whole plant is aromatic. The root oil is used in highgrade perfumes and to flavour alcoholic beverages. The stalks and leaves are used as vegetables. The plant was brought from Norway to central Europe in the Middle Ages. The herb used in industry originates mainly from plantations in central Europe.

The aim of the present work was to study the variation in the composition of the essential root oil in 15 cultivated populations of *A. archangelica*. Parental seed samples were collected from Finland and northern Norway. Root samples were collected in two successive years of cultivation. The root oil was isolated by steam distillation. The content of the root oil was determined by a gravimetric method. The volatiles were identified by GC-MS using a capillary fused silica OV-351 column.

The oil content of the roots varied considerably between the two years, but the oil composition of a population remained rather constant. The main components were β-phellandrene and α-pinene. The populations of northern Finland usually had relatively high amounts of sabinene, whereas the Norwegian ones had low *p*-cymene and myrcene contents. A clear cline was found in 3-carene amounts, from a low value in the south to a high one in the north.

A. archangelica is a prospective crop in Finland. Careful selection on the basis of the essential oil composition of the strains to be cultivated is necessary.

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THE COMPOSITION OF THE ESSENTIAL ROOT OILS FROM *Pimpinella saxifraga* L. AGGREGATE AND CHEMOTAXONOMIC IMPLICATIONS

K.-H. Kubeczka, I.Bohn and W. Schultze

Pimpinella saxifraga(Apiaceae) is a perennial herb, which is very variable with respect to size, colour of petals, pubescence and leaf dissection, so that classification and delimitation of the species has been treated differently by several authors. Hence, it seemed desirable to investigate the most important taxa belonging to the *P. saxifraga* aggregate. Since in previous investigations (1), the essential root oils proved to be of taxonomic value, regarding the definition of the genus *Pimpinella*, we analysed the volatiles from fresh roots of *P. saxifraga* ssp. *eusaxifraga*, *P. saxifraga* ssp. *alpestris* and *P. saxifraga* ssp. *nigra* by means of GC-MS.
Characteristic constituents of all oils were pseudo-isoeugenol derivatives, sesquiterpene and nor-sesquiterpene hydrocarbons, but the qualitative and quantitative patterns were significantly different: the root oil of ssp. *nigra* contained a high amount of C12-terpene hydrocarbons (>50%) including 1,4-dimethylazulene, and less than 10% phenylpropanoids, whereas the oil of ssp. *eusaxifraga* was dominated by the latter group of compounds, especially by epoxy-pseudo-isoeugenyl 2-methylbutyrate (up to 70%). More detailed investigations of morphologically different plants of this subspecies revealed the presence of two different types of root oil composition, which could be correlated to the degree of leaf dissection.
Ssp. *alpestris* yielded an essential root oil which allowed a delimitation of this subspecies, that has been regarded by several authors to be only a dwarf-form of *P. saxifraga* ssp. *eusaxifraga*.

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THE ESSENTIAL OIL OF *Laserpitium siler* L.

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Laserpitium siler L. (syn. *Siler montanum* Crantz) is a perennial umbelliferous plant, growing in the mountains of southern and southern-central Europe. While several papers deal with the composition of the essential fruit oil of this species (*e.g.* 1,2), which contains up to 90% perilla aldehyde and small amounts of limonene, nothing seemed to be known about the volatile constituents of the other parts of it. Therefore, we analysed the essential oils of the herb and the root of *L. siler* from northern Italy (Riva del Garda) by means of GC-MS. Both oils were rich in monoterpene hydrocarbons (more than 80%). The most abundant constituents of the herb oil were sabinene (37%), limonene (22%), α-pinene (15%) with minor amounts of other common monoterpenes. The remainder comprised predominantly sesquiterpenes, *e.g.* germacrene-D (3.8%), β-caryophyllene (0.6%) and humulene (0.6%).

Although the essential root oil mainly consisted of monoterpene hydrocarbons (80%) and small amounts of sesquiterpene hydrocarbons (4.5%), its qualitative and quantitative composition differed significantly from that of the herb oil. The main constituent of the root oil was α-pinene (6%); β-phellandrene (13%), guaiol (4%) and several minor constituents like bicyclogermacrene, 1,4-dimethylazulene and chamazulene were also identified. Comparison of the compositions of the fruit, herb and root oils revealed remarkable qualitative and quantitative differences.

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ENHANCEMENT OF FUNGAL TERPENE PRODUCTION EMPLOYING DIFFERENT ADSORBENTS*

B. Kühne and E. Sprecher

The first attempts to enhance the production of lower terpenes by fungi, using lipophilic adsorbents, were made by Schindler and Bruns (1). By adsorbing the volatile metabolites, these agents are supposed to minimize factors, such as toxic effects of the lipophilic volatiles, feed-back mechanisms and losses by evaporation, which lead to reduced yields.
We investigated the effect of different adsorbents on the production of volatiles by the mycoparasitic ascomycete *Hypomyces odoratus* G. Arnold. The strain *H. odoratus* CBS 818.69 produces mainly novel tricyclic sesquiterpene ethers and related alcohols, when cultivated on defined synthetic liquid culture medium.
Six adsorbing agents of different properties were applied as follows: a) as free particles or b) enclosed in polyester bags added to the culture medium, or c) enclosed in polyester bags above the culture medium (headspace).
Volatiles bound to the adsorbents were extracted with diethyl ether, the remaining essential oil was obtained by steam distillation and further analysed by GLC, GLC-MS, ^{1}H-NMR and ^{13}C-NMR.
Distinctly increased terpene yields (factor 10 to 15 compared with standard conditions) were obtained by addition of Amberlite XAD-2 and a weak-acid cation exchanger.

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COMPOSITION OF THE ESSENTIAL OIL OF SOME *Thymus* AND *Thymbra* SPECIES

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The content and the composition of the essential oils of some continental and littoral species of the genera *Thymus* and *Thymbra (Coridothymus)* in Yugoslavia were investigated. The samples of the continental species *Thymus glabrescens* Willd. and *Thymus pulegioides* L. were collected on sandy soildunes "Djurdjevechki Sands". The samples of *Thymus longicaulis* C. Presl. and *Thymbra capitata* (L.) Cav.(= *Coridothymus capitatus* (L) Rchb. f.) were collected on rocky grounds of the littoral region in Istra and on the Island of Hvar.
The essential oil contents were determined by hydrodistillation. Their composition was investigated by GC, which revealed significant differences. The oil of *Thymus glabrescens* was characterized by a high 1,8-cineole content (29%) and small amounts of thymol and carvacrol (0.15% and 2.17% respectively). The oil of *Thymus pulegioides* contained little 1,8-cineole (0.67%) and relatively large amounts of *p*-cymene (10%) as well as of thymol and carvacrol (8% and 11%). In the oil samples of *Thymbra capitata* a very high content of carvacrol (83%) was found.
The purpose of the investigation was to determine the value and the possibilities of using regional resources of medicinal plants in our country.

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THE ESSENTIAL OIL OF *Blumea lacera* DC (Compositae) FROM NIGERIA

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Blumea lacera DC is a strong-scented, 0.5-1 m high herb with toothed leaves and purple flowerheads (1). According to an earlier study, "cineole", d-fenchone and citral were described as the characteristic components of the essential oil (2).

The leaf oil of *Blumea lacera* DC of Nigerian origin was submitted to more detailed analysis. Thymoquinol dimethyl ether was found to be the most abundant constituent (ca. 30%). The SIM GC-MS of an authentic sample was used to confirm its occurrence. Normalized abundancies of the major fragments were as follows: 179 (100%), 194 (M^+) (42), 164 (35), 91 (25), 77 (18) and 149 (15). Other constituents included β-caryophyllene, α-humulene, *E*-β-farnesene and caryophyllene epoxide. A trace amount of precocene I, a chromene, was also detected in the oxygenated fraction. This chromene has been found in high amounts particularly in other Compositae species, such as *Ageratum conyzoides* L. leaf oil (3). The occurrence of thymoquinol dimethyl ether as well as precocene I in *Blumea lacera* leaf oil is reported for the first time.

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GLYCOSIDIC BOUND VOLATILES IN SOME LAMIACEAE

IJ.M. Merkx and A. Baerheim Svendsen

A method for the detection of glycosidic bound volatile aglycones in small amounts of living plant material was developed and applied for the detection of such compounds in some Lamiaceae. Glycosidic bound monoterpenes containing a hydroxyl group, and a number of glycosidic bound aromatic and aliphatic alcohols were detected. Their occurrence varied strongly in the leaves, stems and roots of the species investigated, suggesting that the glycosides play a role in the formation, transport and accumulation of the aglycones in question. The species investigated were: *Mentha longifolia*, *Mentha spicata* and *Origanum vulgare*. Most of the volatile aglycones did not occur as free compounds in the essential oils of these Lamiaceae species and we found that some of them also occurred as glycosides in plants that do not produce essential oils (like for instance *Taxus baccata*). Hence, in addition to the before mentioned role as intermediates in the formation of free compounds in essential oils, these glycosides may also contribute to other plant physiological processes.

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ENHANCEMENT OF THE ANTIFUNGAL ACTIVITY OF CARVACROL AND EUGENOL IN COMBINATION WITH IRON CATIONS

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The antifungal activity of cresol was reported to be enhanced in the presence of Fe^{2+}/Fe^{3+} cations (1). We cultivated *Aspergillus niger* and *Penicillium viridicatum* in a medium containing Fe^{2+}/Fe^{3+} in equimolar amounts at concentrations of 0.06 to 5.8m*M* and in the presence of 32.5 n*mol* eugenol or 32.5 n*mol* carvacrol. The method used was a modified paper disk technique.
We found that an iron concentration above 3.2 m*M* reduced the growth rate of *P. viridicatum*, and that *A. niger* was effected above an iron concentration of 3.8 m*M*. At a final iron concentration of 5.8 m*M* the cultures were still able to grow slowly.
A combination of phenolic terpenoids and iron cations increased the antifungal activity remarkably. In the presence of 5.8 m*M* iron plus 32.5 n*mol* eugenol, an inhibition area of 1590 mm^2 was caused in the *A. niger* culture, whereas in the control culture (without iron) an inhibition area of 615 mm^2 was found. The combination of 32.5 n*mol* carvacrol and 5.8 m*M* iron resulted in an inhibition area of 3420 mm^2 in the *P. viridicatum* mycelium. This means an almost complete stop of growth in the agar medium. In the absence of iron, the control plate revealed an inhibition area of 894 mm^2.

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OXYGENATED MONOTERPENES FROM ESSENTIAL OILS AS A SOURCE FOR PHEROMONES WITH HIGH OPTICAL PURITY

U. Ravid

Chiral oxygenated monoterpenes were isolated from various essential oils in high chemical purity. Determination of the enantiomeric purities of the natural alcohols, acetates and ketones was achieved by ^{1}H-NMR spectroscopy using a chiral lanthanide shift reagent, Eu(hfc)$_3$.

(*S*)-(+)- and (*R*)-(-)- linalool, a pheromone of the female *Ips paraconfusus* and the male *Ips pini*, and the major component of the scent from the lateral reservoir of the cotton stainer *Dysdercus intermedius*, were isolated from coriander and sweet basil oils, respectively. (*R*)-(-)- linalool is a starting material in the synthesis of (*R*)-(+)- frontalin, the pheromone isolated from the hindguts of the male western pine beetle, *Dendroctonus brevicomis*. Terpinen-4-ol, the main component of the essential oil of sweet marjoram, was a mixture of enantiomers, 73% (*S*)-(+)/27% (*R*)-(-). The (*R*)-(-)- enantiomer is released by the male beetles of the scolytid *Polygraphus polygraphus*.

Optically pure (*S*)-(+)- carvone, the synthetic starting material of the pheromone of the female California red scale. *Aonidiella aurantii*, was isolated from caraway and dill oils. Optically pure (*R*)-(-)- carvone, the starting material in the synthesis of a major component of a termite defence secretion, was isolated from spearmint oil. Optically pure (-)-linalyl acetate, a synergist to the pheromone of the female *Pectinophora gossypiella*, was isolated from the essential oils of clary sage, *Salvia dominica*, lavender and lavandin.

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COMPOSITION OF THE ESSENTIAL OIL OF *Salvia pisidica*

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The genus *Salvia* (Labiatae) is represented in Turkey by more than 80 species and some of them are endemic (1). *Salvia pisidica* Boiss. et Heldr. is an endemic plant of southern Anatolia, the essential oil of which hasn't been investigated up to now. For the present study, flowering parts of *S. pisidica* were collected near Elmali (Antalya, Turkey) in June 1985. The plant material was subjected to hydrodistillation in a Clevenger apparatus in order to obtain the essential oil. The chemical composition of the oil was studied by GLC after fractionation by column chromatography under conditions reported before (2).

The content of essential oil was 0.7% (v/w). The majority of the oil (85%) was formed of oxygen-containing components, whereas only a small quantity (15%) of hydrocarbons was present. The main constituents of the oil were sabinyl acetate (28.8%), α- and β-thujone (18.3%), 1,8-cineole (11.1%) and camphor (9.2%). Further analytical data and chromatograms of the sample studied will be presented

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THE ESSENTIAL OIL OF *Calamintha nepeta* (L.) SAVI SSP. *nepeta* GROWN IN TURKEY

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Flowering parts of *Calamintha nepeta* (L.) Savi ssp. *nepeta* were collected September 1983 at three locations in Turkey. The air-dried material was submitted to hydrodistillation for 3 h. The essential oils were analysed by capillary GLC on columns of different polarity. Two of the oil samples, collected in Adana, were very much alike. They were characterized by large amounts of piperitone epoxides (about 50-60%). The third sample, collected in Hatay, showed a totally different fingerprint, since it contained no piperitone epoxides at all, but large amounts of carvacrol (about 60%).
Then we analysed the herbarium specimen of the three samples, as well as the isolated oils by means of headspace GC (HSGC).
Comparison of the composition of the oils with that of the corresponding herbarium samples showed no large differences for the samples from Adana. Only piperitenone epoxide was found in a lower concentration in the herbarium samples analysed by HSGC.
The fingerprint of the herbarium specimen collected in Hatay was totally different from that of the oil and from the samples collected in Adana.

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SOME CHEMOTYPES OF *Ocimum* SPECIES GROWING IN RWANDA

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Rwanda is a small, montainous country in central Africa. Like in many Third World countries, there is a treasure of traditional medicines. A recent study revealed the important role of aromatic plants, which are used as infusions and for inhalation of their aromatic vapours; they are also used to obtain a pleasant odour in houses and public rooms as well as for flavouring of beer and wine.

Plants of some *Ocimum* species which grow in Rwanda and are used in traditional medicine or otherwise in that country, were collected during the last four years. The essential oils were isolated by hydrodistillation using a Clevenger-type apparatus, and subsequently analysed by a combination of chromatographic techniques, *i.e.* liquid-solid chromatography, capillary gas chromatography and, when necessary, gas chromatography-mass spectrometry and headspace gas chromatography.

The oils of some species contained other main components than those reported in the literature, indicating the occurrence of new chemotypes. In some cases, no chemical data on the species in question could be found in the literature. A number of oils showed such a content of their main component that they may serve as valuable sources of fine chemicals.

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MONOTERPENES OF *Picea abies* - INFLUENCE OF NEEDLE AGE, NEEDLE POSITION AND TREE CONDITION ON INTERNAL NEEDLE CONCENTRATIONS AND EMISSION RATES

R. Schönwitz, R. Steinbrecher and L. Merk

An isolation and analysis procedure was developed for the monoterpenes from needles of *Picea abies* (L.) Karst. The crude pentane extract was analysed by GC on capillary column after PTV injection (1). The composition and amounts of monoterpenes depend on tree specific factors, like genetic disposition, needle age and position within the tree, and on environmental factors. Concerning the forest decline phenomenon, our studies did not reveal a correlation between needle loss and monoterpenes within the remaining needles, but in yellow needles there was a lower concentration of monoterpenes than in green needles of the same tree.
To determine the emission rates of monoterpenes of about 50 mm long undisturbed twigs (remaining on the tree), the twigs were enclosed within controlled gas exchange chambers under natural conditions. The terpenes were concentrated on Tenax and thermally desorbed. The emission rates were strongly influenced by the stomatal movements. If the stomata were open, the emission rates increased by 100%. Depending on stomatal resistance as well as on tree specific and environmental factors, the emission rates varied between 42 ng and 420 ng total monoterpenes/sec x m^2 (needle surface). The total amount of monoterpenes present in the needles would therefore be exhausted within 5 to 10 days.

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MONOTERPENE GLYCOSIDES OF DIFFERENT LAMIACEAE*

G. Schulz and E. Stahl-Biskup

It has been shown that monoterpene glycosides evidently are involved in the formation, transport, and accumulation of essential oils in plants (1). However, so far little is known about the systematic distribution of monoterpene glycosides.

The composition of glycoside fractions was investigated for some Lamiaceae: *Hyssopus officinalis, Lavandula angustifolia, Melissa officinalis, Ocimum basilicum, Rosmarinus officinalis, Salvia officinalis, Origanum vulgare.*

By means of HPLC on RP-18, 5-8 monoterpene glycosides were detected in all species studied. The terpenoid moieties were identified, after hydrolysis by β-glucosidase at pH 6.5, by GC and GC-MS.

The experiments showed that even when the major components of an essential oil have a hydroxylic group, they do not always occur as glycosides. This suggests various roles of the glycosides in question.

1. E. Stahl-Biskup, Monoterpene Glycosides, State-of-the-Art, Flavour Fragr. J., in press

* Part of the thesis of G.S.

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TWO NEW NATURALLY OCCURRING BOURBONANE DERIVATIVES FROM SCOTCH SPEARMINT OIL

H. Surburg

Although a detailed study of the constituents of Scotch spearmint oil (*Mentha* x *cardiaca* Ger.) was reported sixteen years ago (1), only little is known about the oxygen-containing sesquiterpenoids of the oil (2). In addition to viridiflorol, the only sesquiterpene alcohol found so far, we identified more than ten other components of this class; two derivatives had a bourbonane skeleton: β-bourbonenol and bourbonol. They seem not to have been detected in nature previously. The first one is the main sesquiterpene alcohol of Scotch spearmint oil (about 0.05%).

1. L. Canova, The Composition of Scotch Spearmint Oil, Lecture given at the V. International Congress of Essential Oils, Sao Paulo 1971
2. B.M. Lawrence, Perfum. and Flavor., 5 (Aug./Sept.) (1980) 6

Haarmann and Reimer Research Laboratories, 3450 Holzminden (F.R.G.)

ANALYSIS OF SOME THYMOL DERIVATIVES IN THE ESSENTIAL OIL OF *Arnica montana* L.

J.J. Vos and P. Brul

Our study of *Arnica montana* L. was performed in order to judge the quality of cultivated *versus* wild growing *Arnica* in behalf of anthroposophical and homeopathic medicine. Biological, chemical and clinical aspects were considered. The study of the essential oil will be presented. The essential oils were isolated from *Arnicae radix* from cultivated plants, during the season and in the summer from plants from different cultivations and natural areas in the Netherlands. The essential oils from leaves and flowers were isolated in the summer from cultivated and wild growing plants.
Willuhn (1) detected methylethers of thymol, $\Delta^{8,9}$-dehydrothymol, 4-hydroxythymol and $\Delta^{8,9}$-dehydro-4-hydroxythymol in the essential oil of *Arnicae radix*. By means of GC analysis these compounds were found in all the essential oils investigated. Their relative quantities were determined. Content and relative quantities of the compounds mentioned in the essential oil of *Arnicae radix* of wild growing plants showed a good agreement with the results of Willuhn. The content in cultivated plants was mostly lower. In the composition, however, there were small differences between the oils of *Arnicae radix* of different populations. However, when comparing the relative quantities of the various compounds in different plant organs, there was a considerable difference. In the aerial parts the more oxidated compounds dominated, in the underground parts the more reduced compounds. The seasonal influences on the composition of the essential oil of *Arnicae radix* were relatively small; however, in the summer the amounts of the more oxidated compounds increased slightly.
The results and their interpretation will be presented.

1. G. Willuhn, Planta Med., 22 (1972) 1-33

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MORPHOGENETIC VARIABILITY OF *Salvia officinalis* L., *S. triloba* L. AND *S. sclarea* L. CULTIVATED IN TURKEY AND GERMANY

M. Zangl*, M. Özgüven[O] and G. Buchloh*

The essential oils from leaves and from flowers of *Salvia officinalis* ssp. *minor*, *S. triloba* and *S. sclarea* were investigated. The samples of *S. officinalis* were collected in the Botanic Garden of the University of Hohenheim and in the garden of the firm Kytta in Alpirsbach (Black Forest). *S. sclarea* was obtained from the University Çukurova in Adana (Turkey) and from Hohenheim. The samples of *S. triloba* were from the University Çukurova, too. The harvest was done when the plants were in full bloom. The yield of the essential oil was determined according to the European Pharmacopoeia. The analysis of the essential oils were carried out by GC-MS.

The highest content of essential oil was found in the samples of the flowers of *S. sclarea* (1.17%). The leaves of *S. officinalis* and *S. triloba* contained 0.62% and 0.64% of essential oil in average. A lower percentage of oil was found in the flowers of *S. officinalis* and *S. triloba* (0.42% and 0.34%). The leaves of *S. sclarea* contained 0.35% in average.

The main component of *S. officinalis* was α-thujone (flowers: 17%; leaves: 23%). The typical component of *S. triloba* was 1,8-cineole with 41% in the oil of flowers and leaves. Linalyl acetate was characteristic for the flowers of *S. sclarea* (29%) but was not found in its leaves. The main component (29%) of the leaves of *S. sclarea* could not be identified.

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18TH INTERNATIONAL SYMPOSIUM
ON ESSENTIAL OILS

SEPTEMBER 24-26, 1987

LEIDEN UNIVERSITY

THE NETHERLANDS

Organizers
A. Baerheim Svendsen and J.J.C. Scheffer
Division of Pharmacognosy
Center for Bio-Pharmaceutical Sciences

PROGRAMME

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PROGRAMME

The 18th International Symposium on

Essential Oils is held at the

Leeuwenhorst Congress Center,

Langelaan 3, 2211 XT Noordwijkerhout,

The Netherlands; telephone: (02523)-78888

Wednesday - September 23rd

18.00 - 19.00 Registration at the Congress Center

19.30 Dinner at the Congress Center

Thursday - September 24th

8.00 - 18.00 Full day, botanical excursion to the 'Delta storm surge barrier' in Zeeland

18.30 - 19.30 Registration at the Congress Center

19.30 Dinner at the Congress Center

20.30 Get-together party

Friday - September 25th

8.30 - 9.00 Registration at the Congress Center

9.15 Welcome address

D. Lamparsky and I. Klimes:
Heterocyclic Trace Components in the Essential Oil of *Coriandrum sativum* L.

D. McHale, W.A. Laurie and J.B. Sheridan:
Transformations of the Pungent Principles in Extracts of Ginger

10.00 Coffee break

10.30 H.L. de Pooter, J. de Laet, P. Goetghebeur and N.M. Schamp:
The Essential Oil of Five *Nepeta* Species. Try-out for Chemotaxonomic Use

M.H. Boelens and R.J. Sindreu:
The Chemical Composition of Bitter Orange Peel Oils from Living Fully Developed Unripe and Ripe Fruits and from Dead Fruits

E.A. Aboutabl:
GC-MS Analysis of Volatiles from Some Asteraceae Species Growing in Egypt

11.50 - 12.30 Poster show

The poster show is intended to inform the participants about the posters to be presented in the afternoon. During the poster presentation the authors will be present for discussion.

12.30 Lunch at the Congress Center

14.00 G. Buchbauer, H. Spreitzer, A. Worm, W. Bauer and S. Zabern:
Formation of 7-syn-Hydroxycamphene

H. Vuorela, Y. Holm, T. Harvala, A. Laitinen and R. Hiltunen:
Supercritical Extraction of the Volatile Oil in Chamomile Flowerheads

P. Chatzopoulou and S.T. Katsiotis:
Influence of the Distillation Period on the Yield and Composition of the Essential Oil of *Achillea millefolium*

15.15 Coffee break

15.45 Poster presentations

S. Abdo, M. De Bernardi, G. Marinoni, G. Mellerio and G. Vidari:
GC-MS Analysis of the Essential Oil of *Lasiocephalus ovatus* (Compositae)

T. Adzet, R. Vila, C. Ibáñez and S. Cañigueral:
The Essential Oil of *Thymus glandulosus*

T.A. van Beek, M.A. Posthumus, G.P. Lelyveld, H.V. Phiet and B.T. Yen:
Analysis of the Essential Oil of Vietnamese Ginger

R. Bos, L. Kutter and H. Friedrich:
Volatile Constituents of the Underground Parts of *Melissa officinalis* L.

S. Cañigueral, C. Ibáñez, J. Iglesias and R. Vila:
The Essential Oil of *Salvia candelabrum* Leaves

M.M. Carmo and S. Frazão:
The Essential Oil of Cypress

P. Chatzopoulou and S.T. Katsiotis:
Preliminary Study on the Chemical Composition of the Essential Oil of *Achillea millefolium* Grown Wild in Greece

O. Ekundayo, I. Laakso and R. Hiltunen:
Constituents of *Ocimum canum* Oil

Y. Holm, K. Jokinen, E. Saarikko and R. Hiltunen:
The Quality of Peppermint Oil in Micropropagation Experiments

R. Huopalahti, H. Kallio, A. Ojala and A. Nykänen:
Volatiles in the Root of *Angelica archangelica*

K.-H. Kubeczka, I. Bohn and
W. Schultze:
The Composition of the Essential Root Oils from *Pimpinella saxifraga* L. Aggregate and Chemotaxonomic Implications

K.-H. Kubeczka, W. Schultze and
A. Viernickel:
The Essential Oil of *Laserpitium siler* L.

B. Kühne and E. Sprecher:
Enhancement of Fungal Terpene Production Employing Different Adsorbents

18.30 Dinner at the Congress Center

Saturday - September 26th

9.15 K. Knobloch, A. Pauli, B. Iberl,
H. Weigand and N. Weis:
Antibacterial and Antifungal Properties of Essential Oil Components

K.J. Hartmans and A. van Es:
Essential Oils as Sprout Inhibitors for Potatoes

10.00 Coffee break

10.30 L. Kutter and H. Friedrich:
Environmental Effects on the Yield and Composition of the Essential Oil of *Melissa officinalis* L.

K.-H. Kubeczka, G. Schmaus, W. Schultze
and I. Ullmann:
The Essential Oil of *Peucedanum lancifolium* and its Chemotaxonomic Value

S. Kokkini and D. Vokou:
Carvacrol Rich Plants in Greece

11.50 - 12.30 Poster show

12.30 Lunch at the Congress Center

14.00 G. Bicchi, A. D'Amato, P. Sandra and F. David:
Direct Capture of Volatiles Emitted by Living Plants (Part II)

G.C. Galletti and G. Bonaga:
Chromatographic and Spectroscopic Techniques in the Chemical Characterization of Lavandin (*Lavandula hybrida* Rev.) Essential Oil

K.-H. Kubeczka:
The Selective Gas Chromatographic Determination of Oxygenated Compounds in Essential Oils with the O-FID

15.15 Coffee break

15.45 Poster presentations

D. Kuštrak, Z. Martinis, J. Kuftinec and N. Blažević:
Composition of the Essential Oil of Some *Thymus* and *Thymbra* Species

I. Laakso, O. Ekundayo, T. Seppänen and R. Hiltunen:
The Essential Oil of *Blumea lacera* DC (Compositae) from Nigeria

IJ.M. Merkx and A. Baerheim Svendsen:
Glycosidic Bound Volatiles in Some Lamiaceae

A. Pauli and K. Knobloch:
Enhancement of the Antifungal Activity of Carvacrol and Eugenol in Combination with Iron Cations

U. Ravid:
Oxygenated Monoterpenes from Essential Oils as a Source for Pheromones with High Optical Purity

E. Şarer:
Composition of the Essential Oil of *Salvia pisidica*

E. Şarer, A. Looman, J.J.C. Scheffer and A. Baerheim Svendsen:
The Essential Oil of *Calamintha nepeta* (L.) Savi ssp. *nepeta* Grown in Turkey

J.J.C. Scheffer, L. Ntezurubanza and A. Baerheim Svendsen:
Some Chemotypes of *Ocimum* Species Growing in Rwanda

R. Schönwitz, R. Steinbrecher and L. Merk:
Monoterpenes of *Picea abies*, Influence of Needle Age, Needle Position and Tree Condition on Internal Needle Concentrations and Emission Rates

G. Schulz and E. Stahl-Biskup:
Monoterpene Glycosides of Different Lamiaceae

H. Surburg:
Two New Naturally Occurring Bourbonane Derivatives from Scotch Spearmint Oil

J.J. Vos and P. Brul:
Analysis of Some Thymol Derivatives in the Essential Oil of *Arnica montana* L.

M. Zangl, M. Özgüven and G. Buchloh:
Morphogenetic Variability of *Salvia officinalis* L., *S. triloba* L. and *S. sclarea* L. Cultivated in Turkey and Germany

17.15	Final discussion - Proceedings symposium 1987 - Organisation symposium 1988
19.30	Symposium dinner at the Congress Center

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