AN UPDATED REVIEW OF THE POTENTIAL USES OF PLANTS GROWN FOR EXTRACTS INCLUDING ESSENTIAL OILS AND FACTORS AFFECTING THEIR YIELD AND COMPOSITION (DECEMBER 1996)

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AN UPDATED REVIEW OF THE POTENTIAL USES AND MARKETS OF PLANTS GROWN FOR EXTRACTS INCLUDING ESSENTIAL OILS AND FACTORS AFFECTING THEIR YIELD AND COMPOSITION

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1. EXECUTIVE SUMMARY

Rationale for the study

1.1. The desk study identifies potential markets for high value plant extracts. It suggests some directions for research in support of these markets, and forms part of the support by Government through the Ministry of Agriculture Fisheries and Food for industrial crops. The exploitation of these markets will lead to an increasingly buoyant processed herb (and other plant) extract trade in the UK. It will stimulate rural industries and create wealth for growers, processors and retailers of the end products.

1.2. The world production of essential oils is estimated at over £600M per annum. The annual value of the UK herb and spice market, imported as dried material or essential oils is c. £60M per annum. The retail value of fresh and dried culinary herbs is approximately £45M, with the bulk of supplies imported. The total consumption of culinary and medicinal herbs is increasing at 10 and 30% per annum (K Svoboda, Scottish Agricultural College, pers. comm.). Sales of herbal remedies have increased in recent years and some five million people in Britain use alternative therapies regularly (New Scientist July 1996). In discussion with contacts within the industries, there is scope for developing processing techniques for herbs and other crops, which grow well in the UK, toward supplying existing markets and for potential new markets based on research. There is scope for working with contacts in other countries, including those from non-temperate regions, towards supplying plants and extracts for herbal medicine, natural insecticides, and many other uses. These contacts are developing, partly through the co-ordinating role of the MAFF Alternative Crops Unit.

1.3. This updated review (of Runham, 1995) gives a more detailed account of the potential and actual markets for high-value, low-volume plant extracts. In this study,

a) companies were contacted,
b) information obtained from this and the earlier MAFF-funded study was collated,
c) a bibliography of literature was prepared and
d) a data base of the crop and likely markets was set up.

Scope of the review

1.4. This review document presents a wide range of factual information about uses of plant extracts grouped under headings:

- essential oils
- herbal products
- pharmaceuticals

- food flavourings
- perfumery
- cosmetics
- aromatherapy
- herbal beverages
- novel uses (e.g. pesticides, antioxidants, sprout suppressants)

1.5. Information was obtained by literature searches and discussions with consultants, researchers and industrialists, visits to companies, processing facilities and to the trade exhibition Helfex'96 (run by the National Association of Health Stores and the Health Food Manufacturers' Association). The review ends by making general recommendations on how new markets could be stimulated further in the UK and encouraged by appropriate R & D.

1.6. This study excluded looking at oils for large-scale industrial use, such as fuel and lubricants. At present, the European chemical industry annually imports 1.7 million tonnes of vegetable fats and oils but a high proportion is of tropical origin. There is scope for arable farmers to diversify into temperate substitutes for these tropical crops. There are oil crops which are under-utilised and could be grown in N Europe (M Askew, ADAS, pers. comm.). However, it must be noted that the essential oils of some 'herb' crops are being evaluated for potential industrial use (A Capelle, Cebeco-Handelstraad, pers. comm.). For example, there have been intensive performance tests on species (for example, caraway, coriander, calendula) under Central European conditions. Some herb crops are becoming of importance for industrial uses. For example, Jojoba oil, which is used in cosmetics, is now the subject of an American initiative to use it as a source of hydrocarbons. Research, funded by MAFF, on species such as *Lunaria, Crambe abysinica*, is of interest for both industrial and high value plant extract markets.

Development of the markets-general

1.7. The economics of growing crops for plant extracts in the UK can be reconsidered in the context of modern cultural preferences for natural products. There is scope to develop small, local industries producing natural medicines or food flavourings. There is scope to specialise, to get to know the product well, and to offer a new angle to assist in the development of the market (T H Hempson, Potters of Wigan, pers. comm.). Each attempt to penetrate the market will require a cost-benefit appraisal, a determination to continue to develop the market and close liaison between the producer and processor. The main market opportunities for the development of these crops results from the potential to develop dedicated producers supplying users on a long term basis (S Caiger, High Value Horticulture, pers comm.; and discussion with many potential outlets at the Helfex '96 exhibition).

1.8. For each crop, or each technological development which is appropriate to more than one crop (for example a novel extraction technique), an evaluation of the market potential for developing the crop/technique should be made. In this, there are considerable recent data from foreign research which are relevant to UK production.

In calculating the worthwhileness of setting up a new enterprise based on extraction from plants, the whole plant, comprising valuable extracted products and less valuable residues, must be accounted for, both to maximise the revenue from the industrial processes and to minimise waste materials. For example, caraway seed is imported for use in bird seed and baking, but it can be distilled for valuable commodities such as carvone, limonone and useful by-products including a residue cake for cattle feed.

1.9. Several UK growers and companies have expressed interest in the development of UK essential oil industries and producers of herb plants should liaise closely, where appropriate. Increasing the size of the UK essential oil industry would stimulate rural industries and contribute towards sustainable economic growth. There are large projects such as the Objective 5b Fenland Crops Alternative Technologies (FACT) by County Councils in East Anglia. There are smaller project proposals, such as the development of the UK rose essential oil industry (P Wilde, Wilde and Co., pers. comm.). With respect to developing the industry based on recent research and industrial innovation, the author is liaising with the MAFF Alternative Crops Unit and with several companies and growers (including the British Herb Trades Association). A database of the industry contacts made has been set up by ADAS Arthur Rickwood and it may be useful to combine the data with other existing databases.

Developments in the markets - specific

1.10. There have been several specific developments in the markets in the following areas within the last year, which are worth pursuing.

Pharmaceuticals:

galanthamine extracted from narcissus (there are detailed discussions between growers, consultants and the pharmaceutical company)
thymol extracted from thyme
gamma linoleic acid from evening primrose (an increase in the demand)
chinese herbal medicine from UK plants

Essential oils:

chamomile
lavender
peppermint
rose
clary sage
ccoriander oil

Food preservatives - using extracts of thyme, and rosemary

Crop protection:

carvone from caraway
Calceolaria andina as an insecticide, developed at Royal Botanic Gardens, Kew

Herbal beverages - eg elderflower cordial from the Bottle Green Company. There is scope to develop the herbal drink range.

Herbal products generally - dried and extracted: There is scope to develop a range of products. There are 150 species that are traded that could be grown here (M Brooks, Hambleden Herbs, pers. comm.). Some could be grown organically with a premium, making them more viable- economically.

Aromatherapy: rose and sevroseerrose and several other oils whcih grow well in the UK. These initiatives include a secondary processing of jasmine extract in Yorkshire by Advanced Phytonics and Wilde and Co. There has been interest expressed in testing the English grown product of a range of plants from several companies. Several UK based farmers and growers are interested in developing this aspect as a project.

Developing projects and project proposals

FACT Fenland Alternative Crops Technology, a project proposal by Norfolk and Cambridge County Councils to develop rural industries based on herb products under the Objective 5b scheme. This project is now underway, starting with thorough market research of crops short-listed from discussions with keen buyers.

National Herb Centre Members of the British Herb Trade Association aim to set up a Centre of Information about fresh and processed herbs.

James Barn Farm Estate Here a fairly new extraction technique based on super-critical carbon dioxide extraction is under development. This method provides extracted plant constituents which are different (perhaps superior in being "more natural") compared with standard techniques of steam distillation. The continued development of this technique during 1996 is making it an attractive proposition (Roger Michael, pers. comm.).

Advanced Phytonics has developed a novel UK-designed processing technique (receiver of a CRAFT award) which has advantages over existing methods of processing. It is now at the stage for offering to growers a contract processing service or direct sale of 'mobile' processing facility.

Development of the dried herb market for UK produce, with training in June 1996 (M Brooks, Hambleden Herbs, pers. comm.).

Development of the frozen herb trade (D Tiffin ADAS, pers. comm.).

There are several other groups of farmers, growers and processors who are starting on new projects based on Merseyside, in Cornwall, possibly in Yorkshire and in Shropshire. Efforts will be made to co-ordinate such initiatives and to develop the overall trade. The aim works closely with existing processed herb businesses where possible.

Research

1.11. In terms of further research required the areas identified included:

Productivity

To improve all aspects of productivity of crops for essential oils to maximise output and reduce the cost of production thereby improving the competitiveness of UK-grown herbs and improving the suitability of some species for industrial oil production. For example, the re-development of the chamomile industry in the UK requires work on harvesting technology, seed selection, breeding, distillation technology, organic production (Caiger, 1993). The plants which are in demand and which could be grown in the UK are given in Appendix 1. The principal temperate volatile oil species are shown in Appendix 2. It is worthwhile concentrating the efforts on those plants which are in demand. There are research data on many species, mostly outside of the UK. This research should be reviewed before a project on a new species is developed. The research required to develop these plants in the UK is considered to be species-specific in the main.

Processing

To improve the quality and productivity of the processed herb product. The key to development of many of the markets in herbal products and essential oils is the need to process the crop by drying or extraction. There is scope for research towards improving the productivity of herb plants, for example to find the optimum timing of harvesting plants for processing.

There are several new processing facilities in the UK (for example a supercritical carbon dioxide plant, R Michael, James Barn Farm Estate, pers. comm.) and a novel solvent extraction technique (P Wilde, Advanced Phytonics, pers. comm.) for plant extraction which are likely to be available for contract processing. There are several other projects in the offing which will have a form of processing as the mainstay to their development. There are many unknown factors about the method of processing for a particular market. Most processing of crops for their oils is by steam distillation, but both of these relatively new techniques offer advantages which could be explored in strategic research.

There is considerable interest in drying herbs. An open day at Hambleden Herbs, Somerset, in June 1996 was attended by over 100 people to discuss

drying of UK- grown herbs. It is likely that greater penetration of the dried herb market will be achieved by selling the product as higher quality, with control of the microflora contamination, with improved shelf life, produced according to set guidelines (with few or no pesticides) and with a guaranteed level of active ingredient of the herbal product.

Screening

To explore a wider range of uses of natural plant extracts for their potential medicinal, pesticidal, flavouring properties etc.

Determining the roles of essential oils as natural food preservatives or medicines based on their antioxidant properties. There are many organisations working in these fields of research. There may be scope to supply crops for these developing markets in the near future. For example, the use of essential oils for food preservation is being developed in conjunction with novel food packaging techniques (I Tatt, Inco Mulches, pers. comm.) with ADAS and involving Nottingham University.

Scientific basis for herbal products

To determine a scientific basis for claims made in folk medicine for activity of herbal products. There is concern about the lack of testing of products that are sold as herbal medicines. A study of the side-effects from herbal remedies (among other complementary medicines) was made by Professor Ernst of the Centre for Complementary Health Studies at Exeter University. This bridging of the gap between folklore and science is part of the remit of the first UK- based degree course in herbal medicine at Middlesex University (J Wilkinson, pers. comm.). Chinese herbal medicine is founded on research, such that pharmaceutical companies refer to the data from this country in the development of licensed medicines (R Dixey, Phytopharm, pers. comm.).

Labelling and accreditation

To define more exact standards for herbal products, and to ensure that the product meets the customer requirements. The active ingredient in the product should be present and at guaranteed levels, such that the efficacy of the product is assured. The product should be labelled clearly with dosage and risks. A report on 'toxicology of herbal medicines' for the period 1 April 1994 - 31 March 1996 raised issues of concern, for example contamination in some herbal medicines. Several companies are adopting stringent (+ costly) approaches to quality control (T Hempson, Potters and R Fraser, Neals Yard, pers. comm.).

Databases

To improve existing databases to include the ever-increasing and wide ranging uses of plant extracts. This is progressing as various organisations are collecting this information. Databases include one set up by ADAS on behalf of the Ministry of Agriculture covering a wide range of alternative uses of plants (J Stevenson, ADAS, pers. comm.), one set up by the Scottish Agriculture College as part of a contract under EU funding, which spans the high value low volume plant extract industry across European markets. There is also the ACTIN database, aiming to co-ordinate initiatives in the field of alternative crops generally (J Collins, Liverpool John Moores University, pers. comm.).

Determining the effects of production method on levels of natural toxicants in plants and in the final product after extraction (and possibly concentration of toxins).

Plant collections

To improve collections and information about the genetic composition of plants with potentially useful extracts to prevent their extinction. The Royal Botanic Gardens, Kew has been granted £21.6 million from the Millennium Commission towards a Millennium Seed Bank project. The project target is the conservation of seed samples from 25,000 species by the year 2010 (Kew Scientist, April 1996).

2. OBJECTIVES

Overall objective

To identify opportunities for improving the range and productivity of UK-grown plants which contain valuable plant extracts (for example as an essential oil or an alkaloid).

Specific objectives

a) To produce an updated review as a follow-up to Runham, 1995 (this report).

b) To create a database of industry contacts and markets in this specific area.

c) To produce a bibliography of published literature on species suited to the UK (separate report).

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3. INTRODUCTION

The first study

3.1. An initial feasibility study was initiated at the request of the MAFF Chief Scientists Group against the background of plans announced by the Minister of Agriculture in a News Release on 4 July 1994 entitled 'Minister launches action on alternative crops'. The plans aimed to increase MAFF R & D funding of alternative crops, to initiate a consultation document (Anon., 1994a; 1994b) to pull together ideas from industrialists, processors, farmers, researchers etc. In addition, a new Alternative Crops Unit was set up within MAFF to act as an information exchange. This first project was a desk study aimed to determine the scope for developing the UK production of essential oils by examining three areas, which were,

a) looking at the scope for using modern technology to overcome some limitations of the climate,

b) to identify opportunities for adopting modern agronomic practices to maximise the season of production, and

c) to investigate new methods of processing these crops which improves the extraction of oils.

This second desk study gives an updated account of the development of the markets and the scope for UK growers to satisfy market demands, in some cases with supporting research.

Plant extracts

3.2. A large number of plant species contain secondary plant product chemical compounds which can be extracted, some are termed essential oils. They are produced in small quantities and are typically 'small in volume - high in value' fine chemicals. Plants may contain 0.01 to 20% of extractable compounds based on the weight of the fresh plant. The products of distillation are always mixtures of organic compounds (alcohols, esters, ketones, etc.). There are several ways to extract these valuable organic compounds. These include steam or hydro- distillation, solvent extraction and masceration. In some plants, the oils are produced by secretory tissues but in other plants the oils do not show until the plant is crushed, dried or distilled. Some experts have considered these essences to be waste products which the plant is trying to excrete. Now, it is thought that they are an important part of the plant's metabolism (e.g. a certain stage in the synthesis of hormones or vitamins).

3.3. These plant extracts have many uses as natural flavourings, natural fragrances, medicinal drugs in pharmacy, physiotherapy as in folk medicine, cosmetic preparation constituents, aromatherapy, herbal beverages.

Estimation of sizes of markets

World trade in essential oils and herbal products

3.4. The world trade in essential oils is increasing with a 40% increase from 1984 (£475M) to 1990 (£667M) see Appendix 3. In addition, there is a trend towards the use of natural flavour and fragrance compounds; a market which was worth over £3.5 billion in 1990. The Health Product Market was worth £800M in the UK in 1995 (source Helfex'96). Of this, 48% is from non-food supplements, herbal remedies and complementary medicines. The trade has increased at over 6% per annum from 1991 to 1995.

3.5. There are high volume products such as oils of citrus, litsea cubeba, eucalyptus, citronella and lavandin (Appendix 4). There are also high unit value crops such as rose, jasmine, sandalwood, vetiver, patchoulis and bergamot. Overall, citrus and mint tend to predominate.

3.6. The market for herbal products in 1993 was worth £5,600M, comprising 12% N America, 30% EU, 6% rest of Europe, 25% Japan, 19% S E Asia, and 8% India and Pakistan (P Houghton, London University, pers. comm.). The industrial level in the UK is relatively low, with small volume use by herbalists of such crops as henbane and belladonna. The industry was once much larger, for example valerian from Chesterfield and liquorice from Pontefract. It has become cheaper to import. India is the world's largest producer of medicinal plants. There is interest from some Indian Companies in working with UK growers and processors towards satisfying the herbal product markets.

EU trade in essential oils and herbal products

3.7. Western Europe was a traditional production area for many crops but production has now decreased. The bulk of traditional western European essential oils is now imported from outside Europe. (Eastern Europe is a major production area for several crops, e.g. coriander, anise and chamomile). There are some 40,000 hectares of medicinal herbs grown in Western Europe, mainly in Spain.

3.8. Spain is the largest producer of herbs in the EC with 28,000 ha (Verlet, 1992). Its main production is of capsicum, lavandin or lavender, and thyme (as both leaves and essential oils). Other important herbs for medicinal use include anise, saffron, and poppy.

3.9. In France, the consumption of herbs has risen from 10,000 tonnes in 1970 to 32,000 tonnes in 1989 (Verlet, 1992). France is the second main European producer with 23,000 ha. Some 400 ha are harvested from wild plants. France imports 60%, of its medicinal herb requirement, (Germany and UK 90%). Reports of a French growers co-operative in Verchery gives a turnover of £300,000 per annum from 250 acres of medicinal herbs (Anon., in the Furrow, 1988). In France 4,000 hectares is grown under contract (poppy, fennel, ergot, wild rose, gingko biloba and gentian). In addition, there are 2,700 hectares of herbs which are lavender (450 ha), psyllium

(310 ha), tarragon (310 ha), thyme (300 ha), mint (240 ha), chamomile (90) and smaller ones of *Matricaria*, hyssop, chervil, caraway, lemon balm, borage, angelica and lovage.

3.10. There has been an increase in public interest in medicinal plants for conventional drugs, cosmetics and phytotherapy. In Germany, 30% of drugs are for herbal medicines. There is research to improve the productivity of medicinal plants. Research continues to identify new drugs from crops, or to develop traditional therapies, such as feverfew. The world market for herbal remedies in 1993 was over £5,000M . In Europe, the trade is growing at 5-10% per annum. The EU imports some £270M p.a. of essential oils (43% of world imports) and exports £83M (16% of world exports) according to Verlet, 1993.

UK markets and production

3.11. Prior to the First World War, most UK herbs were home grown. It gradually became uneconomic to produce herbs due to the high labour costs, and the UK sourced its herbs from the European continent. There was a small revival of the industry during the Second World War in the search for natural medicines (Laura Hastings, Royal Botanic Gardens, Kew, pers. comm.). The total area of herbs grown outdoors in the UK reduced to less than 1000 ha, although this information is not published.

3.12. The major culinary herbs are parsley, basil, marjoram, mint, oregano, rosemary, sage, savory, tarragon and thyme. The annual consumption of these nine is over 1,000 tonnes and growing at about 10% per annum (Svoboda *et al.*, 1993*)*. Most of the UK herbs and spices are imported either as dried material or essential oils. Some 60% of culinary herbs are imported (P Turner, Lighthorne Herbs Ltd, pers. comm.).

3.13. England was the home of mint production and renowned for its chamomile and lavender. English production of these oils still gains a premium on the market although volume is small. (e.g. 50 hectares of lavender producing around 250 litres / ha of oil on average). There are large variations in the yield of oil from season to season with up to eight fold differences between seasons for lavender oil. There is interest in English clary sage (C Wells, Essentially Oils Ltd, pers. comm.).

3.14. Herb companies import 'large' quantities of herbs which grow in abundance in the wild in the UK. For example, red clover, nettles, borage, couch grass, dandelions, chickweed, yarrow and yellow dock. The value of this trade is estimated at £6 m per annum.

3.15. The imports of essential oils from 1993 to 1995 are shown in Appendices 5 to 7. The value of these imports ranged from £34M in 1994 to £47M in 1995. The value of non-citrus imports, of oils most suited to UK production, ranged from £13M in 1994 to over £26M in 1995. The vast bulk of these imports are in the 'other' category i.e. not identified.

3.16. The UK imports essential oils of many plants which could be grown here, e.g. mint and lavender and, to a lesser extent, chamomile, clary sage, rose, coriander, angelica and others. In addition, there is scope to export extracts of those species which yield reliable quantities under UK climatic conditions. Current imports of some herbal products could be replaced by UK crops on set-aside land (for example, at current levels of essential oil imports, mint species could occupy an additional 18,000 hectares : mint and lavender cannot be grown on "set-aside" land). As plants become exploited for a wide range of natural medicines, flavourings, pesticides and cosmetics the land required could increase.

3.17. The UK trade in some dried herbs and spices in 1994 and 1995 is shown in Appendices 8 and 9. The trade was more valuable in 1995 than 1994, showing the variation from year to year. The trade in both essential oils and dried herbs/spices can be carried over from one year to the next due to their prolonged shelflife.

3.18. The UK herb and spice market had sales of £62M in 1993. The dried herb and spice sector was worth £46.1M in 1993, a growth of 41% since 1989. The UK retail market for dried herbs was worth £16.3m in 1993. Some 9.4 million tonnes of dried herbs and spices were imported in 1994-95 (source MAFF Statistics). The specified categories included coriander, caraway and wild thyme. The unspecified categories include the small quantities of medicinal herbs with a value of some £6M. These import figures do not relate to the value of the medicinal herb trade estimated at £110M in 1995 by the National Association of Health Stores and the Health Food Manufacturers Association for the Helfex'96 exhibition. The difference may be explained by the form and the description used for the imported product. In discussion with many company representatives, most, usually all, herbal products are imported.

Herb crops grown in the UK

3.19. There are no official statistics for the area of herb crops grown in the UK. In 1992, it was estimated at 1,262 ha, comprising 992 ha of culinary herbs (mainly parsley. coriander, mint, sage and lower acreages of thyme. dill, basil, chives, horse radish, rosemary and tarragon), and 270 ha of medicinal herbs, mainly chamomile, with lower areas of lavender, witch hazel and fenugreek (source ADAS). These figures did not include evening primrose or borage. These two crops are estimated at 1,500 ha in 1995. There appears to be an increase in the crops grown for medicinal purposes with some additional 200 hectares of rosemary, chamomile and thyme recorded. It is thought that there may be up to 200 ha more established during 1996 for essential oil extraction. In addition, it is thought that some 200 ha of coriander has been established in 1996. The total herb acreage is over 3,000 ha. This is low compared with the potential to replace imported herbal products.

3.20. The value of the 1,262 ha in 1992 was £5M at the farm gate, estimated by C Spencer (formerly of ADAS) in 1992. The retail value of herbs is over £20M per annum. The British Herb Trade Association (BHTA) with 80 members, represents

the main categories of the market, the cut herb trade, fresh frozen, dried and pre-packed, the pot plant sector (75% of their members) and the medicinal herb market.

3.21. The imports of culinary herbs are between 500 and 1,500 tonnes per year out of season between October and May. The UK relies on imports of fresh herbs from Israel and other countries with suitable climates. The BHTA has been the lead body in the formation of the European Herb Trades Association. The aim is to co-ordinate fresh herbs from home-grown and imported sources, including non-EU trade.

3.22. Complementary medicine in Britain is increasing. A Mintel report of 1993 revealed a 57% increase in the purchase of medicinal herbal remedies. The UK is one of the fastest-growing markets for natural remedies. At least £1M per annum of NHS funds is spent on alternative medicine. Two in three health authorities and GPs now buy in some form of complementary service for their patients, including herbal remedies. One in four Britons uses complementary medicine compared with one in two in France and Germany, and one in three in the USA. A recent article in the Daily Mail (Wednesday, 17 January 1996) discussed the effect on private insurance policies. Several of the plants required in complementary medicine could be grown in the UK. The number of practitioners of alternative therapies is increasing at an estimated 10 % p.a. (Carter in New Scientist, 13 July 1996). The industry is largely unregulated, although there are Associations (for example, the British Homeopathic Association).

4. USES OF HERBS OR ESSENTIAL OILS

Fresh herbs

4.1. The fresh herb is the favoured form for most consumers, but these have a very short shelf life. Many fresh herbs in the UK are cultivated for industrial uses as ingredients in food preparations (vinegar, mustards etc.). Fresh aromatic plants are supplied in small packages for the consumer and have an increasing share of the market, but demand an all-year-round supply. In France, growers can achieve year-round production of some species using glasshouses in winter and plastic tunnels in autumn and spring. Arrangements may be made to obtain supplies from warmer climates (e.g. Israel) during winter months to complement the N European climate. This co-ordination of supplies is becoming increasingly well-established in the UK.

Frozen herbs

4.2. 'Fresh frozen' chopped herbs are prepared for immediate use and then frozen by the customer, and used within one to two weeks. This method prevents noticeable alteration in the flavour and colour due to the enzyme action which occurs in frozen products, but helps level out the supply and demand peaks. These fresh frozen herbs should not be confused with frozen herbs which may have been processed a year or more before release to the store. Frozen herbs have played a role in the food industry for a long time but the appearance of a whole range of frozen products for the consumer is new and there is scope for expansion. This section of the herb market is under investigation by ADAS and herb growers (Long, in Grower 18 April 1996; D Tiffin, ADAS, pers. comm.).

Dried herbs

4.3. Most commercially available herbs are in this form. Where herbs are available in the wild, under-developed countries are able to compete due to low cost of labour for harvesting. It is difficult for developed countries to compete where wild-harvesting is possible, due to relatively higher labour costs. However, problems have arisen due to the high bacterial counts, and this may mean that prices have to rise in the future if standards of growing and cleaning the product are to be improved. Intensive cultivation with irrigation, adoption of improved varieties and better methods of dehydration have led to improvements in productivity of dried herbs. This has enabled farmers in developed countries to compete, especially where there are contracts for production (e.g. DUCROS contract production of thyme at a relatively high price in France).

4.4. Herb drying is capital intensive so few growers do their own drying. Artificial drying is necessary in the UK to improve the keeping quality of herbs. UK growers are embarking on a process of developing the dried herb market. A seminar, organised by the British Organic Farmers (BOF) and Hambleden Herbs was held in

June 1996. This provided an opportunity to encourage prospective growers of (organically grown) herbs for drying, and to identify possible openings for trade for UK-grown herbs. The importance of quality, of tracing the source, of low levels of heavy metals and low microbial counts were stressed.

4.5. The UK market for dried herbs is growing (Anon., 1994). Most dried herbs used in the UK are imported due to the low labour costs in some countries. Several wholesalers (for example, Potters of Wigan and Ixion Ltd of Durham) are prepared to look at samples of UK-grown culinary and medicinal herbs.

4.6. The UK has some capacity to process essential oils and herbs for drying (Appendix 10). There is interest in increasing this capacity, and it is likely that there will be several more processing plants in the UK in the near future.

Synthetic or natural flavours

4.7. The USA is the largest producer and user of flavours and fragrances. France has historically been the largest producer and exporter of fragrance materials for the upmarket fragrance and skin care product industries. The consumption of flavours and fragrances world-wide is £7,000M with £1,200M from essential oils and natural extracts (Somogyi, 1996). As many as 800 companies participate world-wide. There are only a few major international flavour and fragrance houses which manufacture and market the whole range of products. The largest in the flavour and fragrance market is International Flavours and Fragrances (IFF), a US-based public company. Most flavour and fragrance houses world-wide tend to be smaller (less than £30M turnover), have a specialised product orientation, confine their operations to domestic markets and purchase virtually all of their raw materials.

4.8. The European market for flavours including spices and herbs, but excluding flavour enhancers, totalled 164,000 tonnes, worth £658M in 1994. This is forecast to rise to £680M by 1998 (Food Ingredient Analysis, Dec/Jan 1995). The leading product category within this sector is flavours for dairy drinks and soft drinks. The most important end use market for the flavours industry is the soft drinks sector, 28% of the overall market. In the market for fragrances, sales are currently valued at £1,084M, predicted to rise to £1190M by 1998.

4.9. In many cases, isolation and identification of flavour molecules has been followed quickly by synthesis. Advances in the field of chemical synthesis have been great and it has been suggested that the need for natural essential oils could eventually disappear. In 1950s, synthetic citral, geraniol, nerol and linalool became economically viable alternatives to the essential oils of lemongrass, citronella and rosewood. There are new techniques being developed to lead to the reconstruction of fragrances emanating from living plants.

4.10. The industrial sector has experienced a very substantial expansion on a world scale, particularly for the flavour sector. Even so, the trade in essential oils from

plants has not weakened. The trends are not consistent and vary depending upon the sector of use.

4.11. There has been a consumer demand for natural flavours and manufacturers prize the natural origin of flavours to fulfil consumer requirements. Sales departments of flavour industries have called for the naturalisation of existing synthetic versions. For example, a large company such as Nestle use 75% of natural flavours, 12.5% of enhanced natural, 7.2% of 'nature identical' flavours and only 5.3% of artificial flavours.

4.12. The search is on for new sources of natural flavours and for improvements in existing products. There is a trend towards more sophisticated uses of natural materials by blending them for novel flavours.

4.13. In a review, Verlet (1993) reported an increase in demand for flavours (97%) and fragrances (62%) from 1985 to 1990. The maintained and increased demand for 'natural' flavours has led many companies to adopt a renaturalisation policy. These policies may be costly. There are searches for new sources of natural flavours, improvement in the quality and yield using existing crops and the development of new extraction techniques. Verlet (1993) suggested that any increase in usage of plant volatile oils for the fragrance sector will be for those marketed with a natural product image.

Pharmaceutical uses

4.14. The Association of British Pharmaceutical Industries (ABPI) was approached in the search for companies committed to sourcing natural plant extracts. The ABPI could not suggest any member company in particular, but made reference to Scotia Pharmaceuticals. This company sources evening primrose and borage direct from UK growers. There is scope to develop the evening primrose market, with perhaps potential for UK growers to assist in developing other novel crops (Peter Lapinskas, pers. comm.).

4.15. Other pharmaceutical companies put considerable resource into screening plants from all over the world (such as Glaxo Wellcome, pers. comm.). In general, the most cost-effective source of medicines is sought, whether from plants or synthesised .

4.16. There is an increase in public interest in medicinal plants for conventional drugs as well as phytotherapy both for traditional plants such as feverfew and from ‘new’ crops such as Yew and Narcissus (P Houghton, London University, pers. comm.). There is research to improve the productivity of medicinal plants.

4.17. The medicinal value of plants is founded on centuries of experience. There has been recent research to determine a more scientific basis for the medicinal activity of plants. There are many examples in recent literature. For example, *Lippia javanica* (Verbenaceae) has been used in South Africa as a folk medicinal herbal tea for

coughs. Laboratory experiments have shown that extracts of Lippia relaxed muscle which may explain its value in folk medicine.

4.18. During the 1930s and 1940s there was considerable research on plant-based drugs but this was phased out as pharmaceutical companies developed synthetic alternatives. The late 1980s and 1990s have seen a swing back to the search for drugs from plants. There are several reasons including the failure of synthetic drugs to alleviate important diseases such as cancer and AIDS. There is also a greater understanding of the chemical variation within plants. There is a growing realisation of the need to conserve the diversity of plant species, with fifty per cent grown in rain forests and at risk from deforestation.

4.19. The process of developing pharmaceutical products from plants is very costly, and a sufficiently large market is needed. Crop development and marketing may take up to £10M over several years. In addition, licences from governments are required which cost many millions of pounds.

4.20. Examples of recent developments are:

Poppy - Intensively cultivated in France under commercial contracts to 'Sanophi' a French pharmaceutical company. The price offered to the producer is estimated annually in order to ensure the producer a net margin at least equivalent to growing alternative crops (for example, maize, alfalfa).

Ginkago leaves - Tanakan
Production has been started in France to ensure a reliable supply of 'Tanakan' a pharmaceutical for headaches. Previously, Ginkago leaves were supplied by China and Korea.

Taxol from Taxus (yew)
"Taxol" is a new anti-cancer drug registered in USA in 1992 for the treatment of ovarian cancer. There is considerable research by a U.S. company on the production of Taxol. (Piesch and Wheeler, 1993).

Galanthamine from Narcissus bulbs
This extract is being developed for treatment of Alzheimer's disease by a pharmaceutical company in the UK. There is potential to develop this industry to a similar size as the existing narcissus industry. The new industry will not jeopardise the existing bulb/cut-flower narcissus industry. (Paul Ashton, director of Lingarden, pers. comm.). This market is being developed.

Chinese herbal medicine from a range of chinese herbs, some of which could be grown in the UK. A company which developed a new drug based on chinese herbs was recently floated on the stock market for £60 million. The scope for working with the company to develop this industry in the UK is being discussed (C Nye, CN Seeds , pers. comm.)..

Phytotherapy

4.21. It is important to distinguish between medicinal plants produced for the extraction of an active ingredient for the 'classical' pharmaceutical industry from plants used in phytotherapy. Phytotherapy includes the herbal product, not medicinal, range and the medical herbalist approach of using whole plants in treatment.

4.22. This market is developing and fashion plays a part. Some plants can be commercialised rapidly following the publication of new books or articles. There is a reduction in the fashion effect and a growing seriousness by traditional mainstream medicine in its approach and acceptance of physiotherapy. In Germany 30% of prescriptions are for herbal medicines. The market for herbal remedies in 1993 was estimated at £5,000M and the growth in this market in Europe 5-10% per annum (P Houghton, pers. comm.).

4.23. There are 2,000 specialised health product stores. The specialist health product industry is served by 350 suppliers, supported by many others who have specialised products within their range. The retail sector is made up of c. 1,400 independent health stores, comprising the Holland and Barrett chain (350 outlets) and a number of other retailers with significant specialist health product sections.

4.24. The most popular products are available through multiples, chemists and drug stores.

These lines are garlic, ginseng, evening primrose oil.

4.25. Specialist health products were worth £850M in 1995, up from £700M in 1991. Some 5% of health foods are culinary herbs. Of these, some 53% of health products are non-foods with 35% as supplements, 13% herbal remedies and cosmetics 5%.

4.26. A quarter of the German population take plant-based medicines. One drug manufacturer in five produces herbal remedies. This market is increasing at 10% per annum. There is a similar increase in the UK with five million people using complementary medicines.

4.28. The two main herbal product manufacturers, according to the Health Food Manufacturer's Association are Gerard House Ltd and Potters of Wigan.

Gerard House Ltd buys in products in tablet form from any source, and does not mind which country supplies them provided they meet the Company requirements. They do not purchase from UK growers, although the company had looked into this some 18 months ago and found that it was not economic. The company buys in the ready-processed product. The products used by Gerard House contain UK plant material such as celery, cranesbill and garlic.

Potters Herbal Supplies Ltd of Wigan are the largest licensed herbal medicine manufacturer in the UK. They contract growers around the world to grow for them. They use accredited seed and mainly grow organically or to protocols with specific insecticide and pesticide allowance found, from research, not to contaminate the end product. There are stringent requirements to licence herbal medicines, far greater than food regulations. There is concern over the high levels of contamination in herbs, for example heavy metals such as arsenic in chinese herbs. There is an increasing need for well-cultivated herbs, with known inputs of pesticides.

Herbal product standards

4.29. A vast quantity of knowledge concerning the therapeutic properties of many plants has accumulated over the centuries. Since 1965, work has proceeded with the preparation of definitive, authentic monographs of medicinal plants used at the present time in the UK (Hyde Herbal Clinic brochure). This work is covered in the British Herbal Pharmacopoeia, published by the British Herbal Medicine Association. The description of each plant is prepared by pharmacognicists from the University of London and the therapeutic section is derived from the recorded observations of senior herbal practitioners recorded. A considerable amount of research is in progress to define more exact standards for herbal remedies to complement assays that are required by pharmacopoeias. There are qualitative and quantitative standard assays which are performed on each batch of crude or processed material used in the trade. The therapeutic value of the plant extract may be less than the value of the plant as a whole. Examples of whole plant administration include *Ephedra sinica, Taraxacum officinale* and *Convalleria majalis* (Hyde Herbal clinic).

4.30. There are British Standards (BS 7087) for the sale of dried herbs. So far there are 20 parts. For example, the specification for dried mint (part 10) gives details of how much foreign matter is allowed. Companies, such as Ixion of Durham which procure dried herbs would expect the herbs to conform to these standards.

4.31. In France, sale in a drugstore of a product as a remedy requires a licence and this requires clinical and toxicological research data costing £0.5M. This procedure is not possible for physiotherapy specialities, especially as patent procedures are difficult.

4.32. Since 1989, another type of licence was introduced in the EU for 112 medicinal plants which are recognised as non-toxic. These can be sold in pharmacies as remedies with instructions for dosage and indications of their therapeutic value. The licence costs c. £10,000 but there must be 'quality guarantees' for plants. There are no prescriptions for these, so doctors tend not to recommend them. The goal is to standardise the licensing arrangements across Europe. The Treaty of Maarstricht 1992 gave the European Community the responsibility of continuing towards a high level of human health protection. There are many Directives concerning ‘food for special purposes’. These Directives have caused concern to the Health Product Manufacturers’ Association, which has worked with the European Health Product

Manufacturers' Association to protect special health products and their distribution. The new product labels include much more information on dosages, manufacture and safety so that the purchaser can identify the quality and efficacy of the product.

4.33. The first UK degree course in herbal medicine has been set up at Middlesex University (J Wilkinson, pers. comm.).

Perfumery

4.34. It is easy to substitute essential oils used in detergents and air fresheners with synthetic products. The natural status of the compounds is not considered to be a real advantage for this kind of product in terms of economic advantage. This may be worth investigating in view of the allergic reaction of many people to certain aromas. The source of fragrances depends on relative production costs and on the intrinsic properties of the essence. Several formerly important plant volatile oils have been replaced by synthetic analogues. At the same time other natural oils have not yet been produced synthetically and are still significant in the market (Verlet, 1993). It is unlikely that there will be an increase in demand for plant volatile oils for the fragrance market other than those marketed with a natural product image.

4.35. Essential oils which were at the centre of the fine alcoholic perfumery at the start of the perfume industry are now experiencing difficult times. The series of floral fragrances containing hydroxycitronellal and many new molecules do not exist in nature and are protected by patent and have replaced traditional oils.

4.36. Some oils like rose and jasmine have benefited from advances in extraction techniques, pioneered by a firm from Grasse, France. There have been developments by a UK consortium to grow rose oil, extracted by a novel solvent extraction techniques, for the perfume industry (P Wilde, pers. comm.).

4.37. Essentially Oils Ltd obtains chamomile from Sussex, which meets with its quality requirements. They require more English chamomile and pay a premium over other sources. The English is a quality product. The company also uses English lavender, clary sage, rosemary, amongst others. The product has to be processed before the company can use it. The company cannot use the product from the Middle East, but use the French type at the moment due to lack of availability of the English product. The price for the English product would be higher than that from other countries. There is also interest in English mint. This oil is a major import, and has large world-wide sales.

4.38. There is interest from a range of companies in sourcing plants or products from UK growers, for example

"There is scope to develop the UK essential oil industry for lavender, chamomile, jasmine and rose. There is a premium for English produced oils. There is always room for a specialist niche market. Can you use the waste crushings for animal feed as a by-product?"(Stephen Pearce, Britannia Natural Products). This company

sources little from the UK. They procure a few hundred kilos of lavender and juniper for one or two major customers. Most come from south Africa where they harvest hundreds of tonnes of fresh herbs and it is distilled there. Then it is imported and re-distilled in the UK. Mr Pearce did not think that there is a large gulf in specification for the English and foreign material, but that the English is unlikely to match on price.

Cosmetic

4.39. Botanical products have traditionally been used in the dermato-cosmetic field due to biological activities that have been ascribed to them such as anti-irritation, anti-microbial, skin protection.

4.40. There are many data from ethnobotanical sources but they lack a scientific basis concerning the activity of essential oils on the human skin. Originally, essential oils were used for their fragrances but now other properties are considered towards assessing their value in cosmetic preparations (for example, good skin penetration and solubility). They are considered as environmental products. Often, their beneficial properties are verified by testing on human volunteers as opposed to other cosmetic products tested on animals.

4.41. There are efforts to improve the scientific basis for claims about their cosmetic value and these requirements are encouraged by researchers in UK industry (for example, Barbara Brockway, Research Manager of the Body Shop, pers. comm.).

4.42. There are research data available in the area of cosmetic research. A notable reference is the work of Manou and Barel from Belgium. There, modern instruments have been developed for dermato-cosmetic research. These instruments provide researchers with numerical values for the effects of skin care products. These measurements compliment visual evaluation which was the method previously used, and which tended to be subjective and not always reproducible.

4.43. The cosmetics industry requires small quantities and a regular supply of products with a three year shelf life. There are problems of pesticide residues, and aflatoxins.

Aromatherapy

4.44. Aromatherapy is a mixture of ideas and products that generally refer to the use of essential oils for relaxation and stress. Aroma is becoming more important to aromatherapy, rather than massage. The metabolic pathways are not clearly defined. The trend is more towards individual oils (Kusmirek, 1993)

4.46. Many producers (for example, in France) have specialised in essential oils of high quality with carefully controlled, specific chemical properties in order to satisfy the upper end of the aromatherapy market, which is currently expanding.

4.47. There are scientific investigations into this area of essential oil use. For example, inhalation experiments with mice have been performed using pure fragrance compounds and essential oils with ascribed stimulating effects (e.g. thymol, carvone, and essential oils of peppermint, eucalyptus etc.) in order to control their properties in an aromatherapeutical dosage.

Herbal drinks

4.48. Tea is the favourite drink in the UK with an average consumption of nearly 4 cups per day and a total consumption of 162,000 tonnes per year. Indian, Chinese or African teas have a mix of chemicals that endow distinctive flavour to each. The flavoursome chemicals include theaflavins and therabugins. Chinese and Japanese teas are more bitter largely due to catechins

4.49. More deliberately, scented teas are now sold. For example, Earl Grey uses bergamot oil which is sprayed onto the dried leaves before packing. Other scented teas use essential oils of lemon or rose. Sometimes the tea leaves are blended with flower petals like chrysanthemum or spices like cinnamon and cloves or other dried herb leaves.

4.50. Standard teas contain caffeine which may be harmful to people susceptible to its heart stimulation effects. Herb teas could be used instead. Certain herbs have well-known stimulatory or calming effects and are sold as teas e.g. chamomile tea, peppermint and fruit teas. Peppermint, apple or cinnamon tea may be used to help relieve colds. Herb teas are the simplest form of herbal medicine.

4.51. Herbal teas are reputed to alleviate some ailments. For example, blackberry and parsley leaves in diuretic herbal drinks. Limeflower, dandelion, sage, parsley, rosemary or elderflower are reputed to act as tonics. Peppermint and chamomile teas help indigestion.

5. **NOVEL USES OF ESSENTIAL OILS**

Sprouting suppression

5.1. Caraway (*Carum carvi*) seeds contain 4-6% of essential oils with S-carvone as the main compound. S-carvone is a common constituent in food and perfumery products. It can have anti-fungal activity as well as suppressing sprouting in potatoes. Some 3-4 million tonnes of potatoes are held in store in the UK annually, awaiting sale or processing. Most of these require repeated treatments with a sprouting suppressant, usually clorpropham or tecnazene; it is estimated that some 130 tonnes of the suppressant were used in 1990 and almost twice as much in 1988 (MAFF Pesticide Usage Survey No. 92). Some concern, not yet resolved, has been expressed over the safety of these two chemicals. Carvone however, has GRAS (Generally Regarded as Safe) status in the USA. This had led to the commercial development of carvone preparations as alternative treatments by Dutch industrial concerns, and it is expected that the formulations will be officially registered in 1994. Considerable research effort has been expended in The Netherlands in selecting caraway plants with a high yield of carvone and suitable agronomic properties. Luxan UK is the company which will develop carvone in the UK (Murphy and Palmer, Luxan UK Ltd, pers. comm.). This potential industry is to be included in a new project proposal under European Union regional aid (Objective 5b) (A Winter, ADAS, pers. comm.).

5.2. It was thought possible that carvone could also be used to replace maleic hydrazide for sprouting suppression of onions. Maleic hydrazide has had bad publicity and much research has been done to replace it. However, carvone is applied to potatoes in storage whereas maleic hydrazide is applied to onions in the field. It is not thought acceptable to introduce a post-harvest 'chemical' treatment to replace the current pre-harvest treatment in onions.

Allelopathy

5.3. Plants may produce substances which inhibit the growth of nearby plants so reducing the potential competitive effect There may be scope to extract the essential oils of plants to act as weed suppressants to replace synthetic herbicides (Sombrero, Hadlow College pers. comm.)

5.4. An example is the essential oil of *Micromeria fruiticosa* containing pulegone (70% of the essential oil) which inhibited growth of wheat seeds in Israel (Dudai *et. al.* 1993).

5.5. Several papers at the Second International Weed Control Congress in Denmark, 1996 covered the topics of allelopathy in several species, such as rice, sorghum and sunflower (contact John Terry at Long Ashton Research Station).

Pest and disease control

5.5. There is an increasing awareness of some negative effects of chemical pesticides used in crop production. There is research to identify natural alternatives. For example, antifungal activity was observed by *Thymus capitata* essential oil to *Penicillin digitatum* on citrus fruit in Italy and oregano oil showed good activity against several species of stored product insects and fungi. There were differences in sensitivity to different active oils exhibited by insect species at various stages of their development, In France there has been research on the use of aromatic oils for fumigant effect against kidney bean pests. Essential oils of rosemary, thyme, basil have shown promise for this purpose. Extracts of *Geraniaceae* species have been tested for their insecticidal and antimicrobial activity. Recent studies have been made on *Tagetes minuta, Lippia javanica* and *Agathosma betulina.* Agathosma was the most effective anti-microbial essential oil. Lippia essential oil was an effective antifungal oil. There was no significant insect repellent action of the essential oils.

5.6. At the Brighton Crop Protection Conference in 1994, the use of essential oils to control pests and diseases was included as part of a session. The topics covered included:

- control of fungal storage diseases of potatoes,
- protection of flower bulbs using antifungal plant,
- plant volatiles as part of an integrated system for control of aphids.

5.7. Two new compounds, both naphthaquinones, active against aphids, whitefly and mites, major crop pests, have been isolated from *Calceolaria andina* in a collaborative research project by Royal Botanic Gardens, Kew, University of Chile, the Institute of Arable Crops Research and the University of Southampton with support of the British Technology Group (Kew Scientist, April 1996).

Antioxidants for healthcare and food industries

5.8. Essential oils have a role to play in modern health care and food preparation. For example, research at the Scottish Agricultural College is showing the value of thyme oil in reducing the levels of degenerative diseases of old age (in laboratory mice and rats). It is claimed the oil slows the onset of ailments of old age such as memory loss, dementia and fading eyesight. It is also said to counter wrinkling. SAC have made a development agreement with Efamol Research Institute, part of the Scotia Holding Group. The company will manufacture thyme oil capsules (Stanley Deans, pers. comm.).

5.9. Component essential oils thymol (from thyme) and carvacrol (from winter savory) showed the greatest inhibition of growth of 25 micro-organisms in experiments in N Italy. The research showed that numerous plants of the Italian flora could be of biological interest as a source of essential oils with antioxidant

properties for applications in food and beverages, pharmaceutical and agricultural industries. Similar studies have been done with herbs in Scotland.

5.10. Some food manufacturers are now using rosemary extracts as an antioxidant. (Independent on Sunday article, 20 March 1994, and discussion with technical personnel at Leatherhead Food).

Dye plants

5.11. Woad, madder and weld have been used for thousands of years as sources of dyes of blue, red and yellow. There is research in the UK looking at the suitability as crops for the UK. A MAFF-funded review by Mary Hancock of ADAS is looking into the markets for these crops. Modern breeding and processing could make them viable. There is a demand for natural dyed textiles, estimated as 5% of the market now. This may increase to 15% of the market in 10 years, according to staff at Long Ashton.

Nutraceuticals or functional foods

5.12. There is scope for growers to specialise in a particular crop, or select group of crops, to supply information about the 'medicinal' value in addition to nutritional information. An example is that of salad cress, sold as a fresh vegetable 'containing a wide selection of vitamins and minerals' and also 'the best source of iron and sulphur' (Creative Promotion Ltd advertisement feature).

5.13. There is a trend towards convenient forms of regulating and supplementing the diet which will fit into a busy lifestyle. There is interest in improving health and well-being and a growing understanding of the role that diet plays. There is interest in phytoprotectants, chemicals from plants that are thought to confer protection against cancers and cardio-vascular disease. There are functional foods such as tea, garlic and many herb products. The efficacy is not always scientifically demonstrated, and there is a growing legislation to protect and inform consumers.

5.14. Functional foods have a market value of c £170M in the USA alone according to a Canadian report on the Internet (New Scientist 18 May 1996). Several universities in the USA have major research programmes on functional foods

5.15. At Helfex'96, many companies exhibited a nutraceutical range. An example is Nutra-Life from New Zealand, which exports products containing many herb plants. These include evening primrose, feverfew, echinacea, celery, willow, linseed. Another is Bioforce of Switzerland which uses sage, hawthorn berries, valerian, pansy, echinacea, comfrey and coffee substitute containing chicory and figs, with wheat, barley and acorns.

6. FACTORS AFFECTING PRODUCTION AND COMPOSITION OF ESSENTIAL OILS

Essential oils as a by-product

6.1. The main interest in the cultivation of any crop for its essential oil is the maximisation of economic yield returns. A crop may be grown solely for its essential oil or for both essential oil and other products. One recently-researched example is that of blackcurrant which can be used for its berries, its buds for valuable essential oil (very expensive and currently used in luxurious perfumes) and also its woody stems as biomass (renewable energy). Exploiting crops for a range of resources would affect the economics of their production for essential oils. For example, there is interest in nettles for their fibre and their medicinal value. This aspect of crop research is under review at Middlesex University (J Wilkinson, pers. comm.).

Maximising yield of essential oils

6.2. To optimise production of the plant and its essential oils requires:-

a) a chemotype (and a population/crop of this) with a stable biosynthetic pathway for production of the essential oil.

b) the agronomy must be straightforward and fit into rotations and mechanisation of the farm and should be grown to give maximum essential oils.

c) the drying or processing of the plants must be in such a manner to maximise production of the essential oil.

Taxonomy of plants grown for essential oils

6.3. Among the gymnosperms it is the Coniferopsida and Taxopsida which store essential oils. In angiosperms, essential oil containing taxa are widespread within its whole range of 111 families. All of these are important in terms of chemotaxonomic evaluation. From the economical point of view, only 67 families and 187 genera are utilised as sources of essential oils. The plant kingdom has been explored by widespread screening programmes. The number of plant species has been estimated at 800,000; the greater proportion of these has not been examined phytochemically.

6.4. In chemotaxonomic studies, it is important to state the collection period of the plant material under study because that information can be helpful for a correct evaluation of the results. It is also greatly influenced by several other environmental and agronomic conditions.

6.5. The chemical composition of essential oils is determined by the genotype of the plant. It is known that plant material used for the extraction of essential oils is very variable. Commonly grown plants are often studied to investigate whether different chemotypes within a species do exist which may possess interesting new oil compositions.

6.6. There are considerable research data from recent years on improvements to plants by breeding. Overall, in the literature there are many examples of improvements to species by screening, selecting and breeding processes. Some example are given below:

6.7. Thyme. In France, wild harvesting was the main source of supply but in 1970 research at Montpellier University lead to the cultivation of thyme. Clonal selection has been used to obtain a regular supply of thyme with a high yield to suit the market. The main trader in thyme in Europe, DUCROS then contracted with producers at a relatively high price. Improvements have been made to thyme for cultivation by farmers in France, enabling the crop to compete with wild thyme from developing countries (Verlet, 1992a).

6.8. In Switzerland, Rey (1992) selected clones of **thyme** to produce higher levels of essential oil. From these clones, hybrids have been produced which can be used in seed production to overcome difficulties of vegetative propagation.

6.9. **Chamomile.** There are different genotypes of chamomile with late maturing, winter resistant types producing high yields of essential oils from autumn sowing (Letchamo, 1992).

6.10. In Austria, the herbs **poppy, caraway** and **mustard** gave varying yields and qualities of essential oils and warrant further breeding work (Dachler, 1992).

6.11. The cultivation of wild ***Tanacetum vulgare*** is being attempted in Hungary. Some 33 different chemotypes have been identified (Dobos *et al.*, 1992)

6.12. Basil is an important economic crop, producing annually c. 100 tonnes of essential oil world-wide. It is widely used in systems of indigenous medicine. There is confusion surrounding Basil taxonomy with several forms having different attributes being recognised under the same name. Chemical studies at Royal Botanic Gardens Kew suggested that the profile of dominant essential oils could be used alongside standardised descriptors to provide a unique characterisation of plants. Such a standardisation is required if the full economic and medicinal potential of this herb is to be developed (Kew Scientist, April 1996).

6.13. World-wide taxonomy studies

- Achillea - Hungary
- Amaranthus - Hungary
- Basil - Yugoslavia, Hungary
- Camomile - Germany, Poland
- Colchicum (colchicine) - Turkey
- Gentian - Italy
- Hyssop - USA
- Lavender - Italy

- Lavandin - Italy
- Lemon Basil (citral 12.6 to 32.4% content in essential oil) - USA
- Marjoram - Austria
- Merendera - Turkey
- Monarda (horsemint) - Canada
- Oregano - Israel
- Pinus - Yugoslavia
- Poppy - Hungary
- Sage - Italy / Austria
- Tagetes - Hungary
- Tanacetum - Hungary

Climatic/seasonal variation

6.14. The geography of essential oil crops is very diverse and most countries have some production. Each species includes ecotypes which have become adapted to different environments. Overseas, herb growers have the edge on their British counterparts due to climate advantages. Much of Europe has a longer growing season than Britain. There are many references to the effects of climate on the quantity and quality of plant extracts.

6.15. Chamomile was evaluated in Finland and compared with crops grown further south in Europe. It was found that the quality of the flower and essential oil of the Finnish crop was as good as the Southern Europe product provided it was dried properly (Galambosi and Szebeni-Galambosi, 1992a). The development of chamomile plants depends upon the climate. Less time was required by chamomile flowers to complete the flowering cycle in Ethiopia than in temperate regions of Europe. The mean yield components, essential oil and straw yields of different genotypes of chamomile varied in the locations grown, either in Africa or in Europe (Letchamo, 1992a; 1992b; Letchamo and Vomel, 1992).

6.16. The seasonal variation in the composition of the essential oil of sea fennel was studied by Barruso *et al. (*1992) and showed that all compositions of the oil showed fluctuations in their relative amounts throughout the period under study. It is important to mention the collection period of the plant material particularly when the information is used for chemotaxonomic purposes.

6.17. The environmental conditions influenced significantly essential oil composition and content of chervil growing wild in Hungary (Petri *et al.*, 1993).

6.18. The effects of weather on production of essential oils of caraway has been evaluated in the Netherlands (Bouwmeester, 1992). A six-fold difference in essential oil yield between years was recorded. Essential oil content increased with increasing solar radiation and decreased with average wind speed.

6.19. Seasonal and geographical variation in bog myrtle (Myrica gale) was observed in experiments (Carlton *et al.*, 1992).

6.20. The pattern of oil accumulation in olive is determined by cultural and environmental conditions and is not cultivar dependent. The oil accumulation pattern will change considerably under limiting environmental or stress conditions (Lavee and Wodner, 1991).

Agronomy - general

6.21. A search of the literature showed a large influence of agronomic factors on essential oil composition. For example, the planting date, nitrogen fertilisation, timing of crop harvest all affected yield or content of essential oils of peppermint (Piccaglia *et al.,* 1992). Ageing of the crop causes changes in essential oil composition. Growing and environmental conditions and ontogenetic developments influence the biosynthetic pathway of the oil constituents (Piccaglia *et al*., 1991).

Seed Treatments

6.22. There are germination / dormancy problems which could be overcome by research into seed treatment / priming in techniques that have been used for other vegetable crops (for example, Gray *et al.* (1992).

Plant propagation, planting date and plant density.

6.23. Propagation method affected yield of essential oil of mint (Zheljazkov and Topalov, 1992b).

6.24. The yields of essential oils of mint were enhanced by increasing the density of planting and were also affected by planting date (Zheljazkov and Topalov, 1992c). Plant density affected the yield of morphine from poppy (Chung, 1992).

Weed Control

6.25. Herbs must be pure, and not contaminated with weeds. Separating herbs from weeds is not easy since weeds may be growing up through the plant. This is particularly the case for biennials. Weed control is critical to the success of a dried herb operation. Many growers use polythene mulch which is excellent for some crops. Black porous plastic (for example, Mypex) has been used successfully to control weeds in perennial herb crops. Alternatively, growers may use a brush hoe in organic systems of production. There are herbicides which can be used in herb crops, but many uses are not label recommendations on the product. The may be a need to extend 'off -label' uses of herbicides in the development of new crops in the UK.

6.26. In Finland, herbs have to be cultivated without chemicals. Weed control is one of the biggest problems. There are two methods of non- chemical weed control; the use of either black plastic mulches or ridges as for potato growing. Both mulches

and ridges assisted weed control in herb production (Galambosi and Szebeni-Galambosi, 1992b).

6.27. The quality of aromatic oils from herbs is not affected by application of herbicide provided the crop is tolerant of the herbicides and in some cases quality of oil is even improved (Pank, F, 1992; Zheljazkov and Topalov, 1992a).

Soil Nutrients

6.28. The oil composition of a plant appears to be modified by the levels of nutrient in the soil (Scheffer, 1992). The growth and essential oil contents of aromatic plants are considered to be influenced by nutrients in the soil (Takano, 1992).

6.29. An increase in nitrogen fertilisation in pot experiments with chamomile increased the yield of essential oil but did not affect the composition of the oil (Letchamo, 1992b). Herbs responded to nitrogen application in work in Austria by Dachler, (1992). He evaluated poppy, caraway, mustard and linseed. Japanese mint responded to 100 kg/ha of nitrogen and 60 kg/ha of phosphorus fertiliser applications in the field which also gave the best economic return of essential oil from the crop (Munsi, 1992).

6.30. In sulphur- deficient soils, application of sulphur to poppy increased the yield of oil (Subrahmanyam *et al.*, 1992).

Irrigation

6.31. Essential oil yields of fully irrigated and partially irrigated crops of peppermint increased 57 and 38% respectively (4 year average) over the non-irrigated controls. While slight changes were noted in essential oil composition, water deficit and irrigation treatments did not alter terpene composition in a manner that affected oil quality (Alkire and Simon, 1992a). Irrigation had a major effect on poppy yield and yield of morphine (Chung, 1992).

6.32. Infra red thermometry (IRT) has showed promise as a rapid and non-destructive method to determine water stress in peppermint (Alkire and Simon, 1992b). This technology is under investigation in a current MAFF LINK project.

Plant development and timing of harvest

6.33. The use of plants for herbal remedies requires a degree of standardisation. The constituents of plants is variable thus their therapeutic potency is variable (within limits). The composition spectrum of oil derived from the juniper leaf varies with the stage of growth (Horster, 1974). Capsaicin, a neurone blocking agent and stimulant to prostaglandin production is present in higher concentrations in the summer fruits than in the autumn fruits of Capsicum minimum (Collier *et. al.*, 1975).

6.34. In plants of *Ocimum gratissimum* the total essential oil content and total geraniol content increased with leaf development and expansion until the leaves were fully mature and then decreased (Charles and Simon, 1992). Of the 17 essential oil constituents identified in the oil, most were present in all leaf development stages.

6.35. Maximum production of artemisinin from *Artemisia annua L.* was more closely associated with the specific photoperiod than with a specific stage of plant development (Morales *et al.,* 1992).

6.36. Timing of harvest affected the concentration of essential oils of chamomile in experiments in Germany (Letchamo, 1992b). There are differences between the oil collected from the leaves of *Achillea Millefolium* during the flowering period and the oil from the leaves collected during the vegetative phase of the plant (Figueiredo *et al.*, 1992).

The essential oils of *T. capitellatus* isolated either from flowers or from leaves of the plant during its vegetative phase showed a more or less similar composition. The corresponding oils from *T. lotocephalus* showed marked differences (Figueiredo *et al.,* 1993).

6.39. The time of sampling the plant material may have large influence on the composition of the essential oil isolated (Scheffer, 1992). In research studies, it is important to mention the collection period of the plant material under study, particularly for chemotaxonomic purposes.

6.40. The production of catmint was significantly influenced by the time of harvesting. In a study by Hornok *et .al.*, (1992) the optimum time of harvesting fell at the beginning and at full flowering in the two year old plantation. Timing of harvest affected composition of oil of *Thuja* species in Czechoslovakia (Buben *et al.*, 1992). Locality and time of harvest affected the production of toxic compounds. Timing of harvest affected yields of essential oils of *Digitalis lanata, Catharanthus roseus, Artemisia annua, Glycyrrhiza glabra* and *Panax quinquefolium* in Tasmania (Laughlin, 1992). Timing of harvest affected yield of peppermint and composition of essential oils (Marotti *et al.*, 1993) in Italy. In early flowering stages the oils were present in the leaves of basil, but from full and late flowering they concentrated in flowers (Hungarian Research).

Mechanisation

6.41. There are examples of mechanising the production of crops for essential oils. One example is the mechanisation of production of oregano in Israel (Verlet, 1992). In the USA, Piesch and Wheeler (1993) describe the intensification of production of *Taxus* spp for their essential oil which requires mechanised handling of the crop.

6.42. The mechanisation of herb crop production for essential oils or dried herbs in the UK will be a key to the economic viability of production. For example, hand-

harvesting of chamomile flowers only may be too time consuming, and it may be more worthwhile to harvest the stems, leaves and flowers together by machine (M Gahagan, pers. comm.).

7. PROCESSING AND EXTRACTION OF HERBS OR ESSENTIAL OILS

Fresh Green Herbs

7.1. This is considered to be the best form for food processing, with the best aroma and flavour. These are prepared whole, washed and prepared for garnish, washed and chopped as required by the customer (for example, chive rings, fine strips of basil), as blends of fresh herbs and as blanched fresh herbs. Fresh green herbs are vulnerable to accelerated senescence due to a high rate of metabolism which is increased after harvesting and handling. Most herbs keep better a low temperatures (around 0°C). Modified atmosphere (MA) packaging and applications of gibberellic acid prior to harvest retarded senescence and decay of fresh herbs in Israel. Herb crops will be more valuable to the grower is he can do a form of processing such as freezing, drying, extraction etc. Some processing facilities are listed in Appendix 10. There is negligible international trade in the fresh herb.

Frozen herbs

7.2. These are normally field grown and machine harvested during the English season and frozen in bulk. They are good for lower price dishes, but there is a noticeable difference in flavour when used in place of the fresh herb. Some herbs can be prepared as though for immediate use then fast frozen by the customer, and used within one to two weeks. This prevents any noticeable alteration in flavour and colour due to the enzymic action which occurs in frozen products. These 'fresh frozen' herbs should not be confused with the frozen herbs which may have been processed more than a year before being released from the store.

Drying Herbs

7.3. The traditional dried form of herb production is still the most common way of preparing herbs for market. There is a great variation depending on the source. Traditionally these have always been cheap, but problems have arisen due to quality control requirements and the need to reduce the bacterial count. There may be price rises in the future if the standards of growing and cleaning the product are to be improved.

7.4. Herb drying is capital intensive and the cost of equipment sufficient to handle up to 1 tonne of dried material per year is likely to be £5-10,000. Contract dryers are used by many herb growers.

7.5. There is not a standard method of drying herbs. Individual growers have developed their own system. The process usually involved stacking flat trays of herbs in a room with a dehumidifier similar to that used in timber drying. Herbs contain a great deal of water. Five to ten tonnes of fresh herbs will yield one tonne of dried herbs. The dried material is cut, rubbed (de-stalked) or powdered so chopping and milling equipment is required.

7.6. The traditional dried form of herb production is threatened by new methods of extraction, both for individual consumption and in industrialised uses (Verlet, 1992).

7.7. Drying method can affected the volatile oil content and microflora of aromatic plants. The duration and temperature of drying are crucial factors for herb quality. For each species, there should be a maximum temperature for drying to maximise volatile oil yield and quality. The higher the drying temperature the greater the killing effect of micro-organisms.

7.8 Solar drying of herbs has been tried at Hoheheim University in Germany. Mint, sage and hops have been dried in a plastic covered glasshouse. The solar drying has given better colour, texture and content of the active ingredients than conventional store dryers.

Extraction of Essential Oils

7.9. The composition of an essential oil depends upon the method of extraction. The most common is steam or hydro-distillation (approximately 90% processed in this way). Distillation takes 3-4 hours usually but different periods of distillation can cause changes in composition of essential oils.

7.10 Solvent extraction is a different technique which can give different results from steam distillation (Scheffer, 1992). Solvent extraction can be used to extract at lower temperatures which is an advantage where composition of oil could be changed by heat. There may be difficulties in separating essential oils from the solvent and this could involve an extra stage in the extraction process. Hydrodistillation apparatus of European Pharmacopoeia is standard research apparatus and this is useful for comparisons. However it may not be most suitable for example, for thermally labile components which may re-arrange if temperature exceeds 40°C during extraction. For these, a solvent mix (e.g. pentane + diethyl ether) may be used for the extraction. This may lead to contamination and difficulty, or expense, of separation by chromatography.

7.11. The use of microwave ovens is a relatively recent technique used to isolate essential oils. The advantages are that relatively small amounts of plant material can be processed, and the short extraction period. This is useful as a research tool to sample plants at a range of times during the day. The qualitative composition of the oils is the same as for steam distillation but the percentage composition varies significantly.

7.12. The microwave-assisted process (MAP) has been used to produce extracts from fresh and dried herbs to give extracts identical to currently commercially available products. Also novel extracts have been produced which demonstrate the versatility of MAP over conventional extraction processes (Paré *et al.,* 1992)

7.13. The composition of the isolated oils may differ from the composition of the volatiles present in the plant material.

7.14. Herb growers may consider distilling their crops to add value to the produce. However, usually only larger companies can distil as the distillation processes are complex. There may be very low yields for essential oils. For example lemon balm may yield as little as 2.5 litres / ha. Lavender may yield 250 litres / ha.

7.15. There are new extraction techniques being developed which may improve upon existing techniques. Some apparatus may be developed for research purposes, but may also have commercial relevance.

7.16. Compressed carbon dioxide has been used to extract essential oils for 12 years by Universal Flavours Limited, Bletchley, UK. The technology involves high pressures and low temperatures in an energy efficient process.

Herb oleoresins

7.17. These are made by percolating a volatile solvent, such as a chlorinated hydrocarbon through the ground herb. The solvent is then evaporated off and may be recycled for further extraction. The residue is the oleoresin. These products are uniform, potent and free from micro-organisms. These oleoresins may be used either as a concentrated liquid or dispersed onto a neutral carrier. These dispersed herb oleoresins are direct substitutes for the dried herb. They are sold as equivalent in strength and weight to the dried herb. Those which are widely used in the food industry are celery seed and sage herb oleoresins.

Pelleting

7.18. This is a method of processing that reduces the bulk of the herb crop suitable for transportation. This has been suggested as a way of transporting herbs to a processing plant, for specialised processing.

8. FACTORS AFFECTING THE FUTURE DIRECTION OF THE ESSENTIAL OIL INDUSTRY

General Findings

8.1. There is a continual interest in finding new essential oil-yielding plant species, and the number of species studied for their volatile components is continually increasing. Many development programmes have been initiated throughout the world in the field of herbs, spices and essential oils (particularly for mint, sage, lavender and chamomile).

8.2. All available data show a regular increase in the market for natural products. There are more countries producing crops for essential oils. In recent years there has been an increasing interest in the use of natural substances and some questions concerning the safety of synthetic compounds have promoted more detailed studies on plant resources.

8.3. The potential for increased production of essential oils in Eastern European will have a bearing on future trade.

8.4. British consumer tastes are increasing their appreciation of culinary flavours and the use of herbs for a range of purposes. The markets for herbs in the UK warrant further investigation, and this is underway at present. There is considerable interest in developing these markets.

8.5. The major market opportunities for the development of these crops relies on dedicated producers supplying products to a standard and uniform specification and complying with Food Hygiene specifications. (Products may be produced to relevant international specification, but product quality varies and often users cannot obtain what they require on a long-term basis).

Intellectual property rights

8.6. It is now possible to patent entirely new uses for known chemicals. For example, the Scotia group has over 20 patents covering pharmaceutical uses of gamma-linolenic acid (GLA), the key ingredient of evening primrose oil.

8.7. Most western countries, therefore, now have a situation where an unprotected product which wins a drug licence can be protected in the market-place. The EU has good protection which applies in all countries for 10 years. Changes in patent and marketing laws have given impetus to the development of drugs from natural products.

Natural Toxicants in essential oils

8.8. Essential oils are biologically active compounds and can have adverse effects (De Smet *et al.*, 1992). Some herbal teas, such as comfrey, contain potentially harmful

pyrrolizidine alkaloids that can cause liver damage (Independent on Sunday article, March 1994)

8.9. A programme of research on natural toxicants of plants was instigated at the Institute of Food Research, Norwich in the 1970s.

8.10. A Naturally-Occurring Toxicants Information Systems (NOTIS) is being compiled around naturally occurring toxicants in plants. It is hoped to develop the database to take into account the effects of genetics / agronomy / environment and processing on the compositional variation of natural toxicants in plants (not specifically relative to essential oils at this stage). There is also the PLATO database at the Royal Botanic Gardens, Kew which is used to identify toxic plants - for use by doctors.

8.11. Levels of toxicants produced by plants are affected by soil type, climate and time of harvest (Ruben *et al*., 1992).

8.12. For European pennyroyal, there were high variations in the oil composition, depending on the part of the plant or the age of the plant material. This resulted in a quite different degree of toxicity when the oil or the herb is used therapeutically or as herbal tea (Stengele and Stahl-Biskup, 1993).

Role of new technology

8.13. New technology will make a large contribution to improving the production and extraction of plant extracts making them more viable in modern industries. Some examples of developments are given below:-

8.14. In some crops, e.g. safflower and sunflower (industrial oil categories) simple chemical mutagenesis (blocking biosynthetic processes by genetical means to prevent favoured oils being transformed into less favoured derivatives) and selection have been sufficient to develop new cultivars in a relatively short time.

8.15. There is a need to reduce reliance on oilseed rape as a candidate crop for gene transfer and use a wider range of other crops which could be developed for their valuable oils. This could apply to essential oils as well as industrial oils (Robbelen, 1993).

8.16. Genetic engineering of horticultural crops (not necessarily herbs) to produce medicines by Dr Paul Christou of John Innes Centre at Norwich.

8.17. Scottish Crops Research Institute are targeting honesty for production of oil which contains nervonic acid which can help in the treatment of degenerative brain disorder.

8.18. Modern molecular biological techniques provide powerful tools for study of the environmental and developmental factors which control the production of plant

extracts (personal communication with Mark Chase of the Royal Botanic Gardens, Kew).

Micropropagation

8.19. Micropropagation of a medicinal plant *Zingiber cassumunar* Roxb has been used as a method to produce large numbers of pathogen-free plants (Poonsapaya and Kraisintu, 1992). Micropropagation can be used to rapidly propagate species for extraction of valuable compounds, particularly where the plant is rare or difficult to obtain (personal communication with Mike Fay of the Royal Botanic Gardens, Kew). The large scale production of *Hymenocallis littoralis* by tissue culture is described by Backhaus *et al.* (1992). This is an effective source of panoratistin, a powerful anti-cancer agent. Large quantities of *H. littoralis* bulbs could be grown using tissue culture and subsequent greenhouse propagation and the technique is now being developed.

8.20. Tissue culture of *Datura Stramonium* (Solanaceae) which provides important anticholinergic drugs hyoscyamine and Scopolamine is described by Demeyer *et al.* (1992). Tissue culture of Lavender has been used in Spain towards selecting strains producing large amounts of essential oils (Jordan *et al.*, 1990).

8.21. Essential oil content of leaves and bracts of *Origanum dictamus* L. (Cretan dittany) grown in Nutrient Film Technique (NFT) culture was always higher than that from the same plant population grown in the wild (Economakis, 1992).

Databases

8.22. Existing databases include:

AGRICOLA English language abstracts of research data
AGRIS Abstracts of research data.
CAB ABSTRACTS - wide range of material on herbs as research abstracts
NOTIS - Naturally occurring toxicants information system
PLATO (Plant Toxins) - computerised identification for toxic plants. Run by National Poisons Unit at Guy's Hospital, London and Kew.
SPECIES - Survey of Plant Exploitable as Crops for Industry and Energy Supplies. Italy.
ACTIN (Alternative Crops Technology Interaction Network) is a database set up to link potential industrial users of non-food crop products and technologies with researchers in this area.

The University of Liage has set up a database on medieval medicinal herbs

John Innes Institute has set up an interdisciplinary network including chemical companies to research oilseed crops, fibres and starch.

The Scottish Agriculture College, with Liverpool John Moores University , is undertaking a networking of markets for herbal products throughout EU.

There is a need to create databases to cover:

a) whole plant exploitation where, perhaps, a plant may be used for a range of purposes (for example blackcurrant) - an economic model. This is explored at Middlesex University.

b) Plants, their constituent essential oils and the range of uses, including new uses which is regularly updated.

9. DISCUSSION

9.1. There are several ways in which both the herb and plant extract (including essential oils) markets can develop in the UK. There are numerous data from developed countries on improvements in plant productivity for essential oils from breeding, agronomic practices, timing of harvest and extraction techniques. There is interest in developing markets for a range of products. The feasibility of production of crops in the UK can be estimated from the literature. The alternatives for processing for given markets may also be assessed. It is possible to take samples of crops and test for suitability by laboratory and commercial scale determination. Many companies are prepared to test the samples and give an opinion prior to setting up contracts for supply. Most companies approached were concerned about the commitment of UK growers to supply the market on a long term and with large quantities of material. The co-operation of growers and processors will help to meet the market requirements.

9.2. The fresh, dried and frozen herb markets can be reviewed in the light of recent developments across Europe to improve the season of availability of high quality products. For many species, a review of the literature would reveal new varieties, methods to extend the season to overcome some limitations of the UK climate and several ways in which the agronomy can be manipulated to increase the productivity of herb crops for essential oils. There are innovations in handling and drying crops as well as improvements in essential oil extraction. Farmers and growers should attempt to produce crops suited to the market under UK conditions, bearing in mind the many cultural and climatic factors referred to in previous sections. Working with existing UK producers will reduce the market development time, but in most cases, the grower will be working in a new area. There is scope to work with growers elsewhere in the EU, and this networking is an objective of the study lead by the Scottish Agricultural College. The British Herb Trade Association has strong links with its European counterparts, and this should be developed. There are support schemes to develop these markets (MAFF Alternative Crops Unit Crops for Industrial and Energy Uses, produced in April 1996).

9.3. Not all recent innovations are included in the literature. Many research units have data that have not been published. Some work is privately funded by companies. Producers who wish to exploit their herb crops further will need to keep abreast of these developments as they become available, through for example the MAFF Alternative Crops unit, by individual contacts with researchers in universities and other units. Some such organisation include:

SCRI- coriander, cuphea, lunaria (industrial oils)
SAC- herb crops, particularly thyme
Reading University
Middlesex-herbal medicine
John Innes Research Institute
John Moores University, Liverpool
London University

Royal Botanic Gardens, Kew

9.4. In most cases development of the research towards utilising UK plants is confidential. By liaising closely with researchers, growers may be involved at an early stage with crop production

9.5. The industries for medicines, flavours and fragrances are receptive to using more natural materials where appropriate, either where there is a reliable supply of plant extracts of a high quality and at a price competitive with alternative synthetic products, or where the consumer is prepared to pay a higher price for an environmentally friendly product. In this case, the production of the crop may be according to certain standards, such as organic production, or require some form of accreditation. Many contacts with the market outlets for herbal products have been made in the course of this study. These contacts should be developed further by, for example, supplying samples of fresh and processed herbs to ascertain whether the UK product is indeed suitable. In the first instance small plot studies are suggested to enable a range of samples to be produced each meeting different criteria.

9.6. Traditional uses of plant extracts are reconsidered in the context of the many advances in plant culture and extraction. Those uses described in this study include flavours, medicines, perfumes, cosmetics, aromatherapy, herbal beverages, sprouting suppressants, weed suppression, pesticides and food preservatives. There are potentially others which will be explored in future, such as more large-scale industrial uses. The economics of production of essential oils is affected by advances in technology, and these reflect the involvement of a wide range of science and engineering researchers. The advances in technology may affect markets for herb products. For example, a prototype crop of tobacco plants has been engineered to produce useful fatty acids such as gamma linoleic acid (GLA), which when included in the diet, seems to reduce the risk of cholesterol-related disease, a form of functional food. The production of seed oil crops with commercially viable levels of GLA is one or two years away according to Terry Thomas of Texas A&M Unversity (New Scientist, 8 June 1996).

9.7. Some traditional uses of plant extracts require scientific evidence to back claims for their efficacy. Such research would ensure that products are safe to humans and will also lead to improvements in product efficacy and formulation. There is a move to collate information on the potential toxic properties of some plant extracts, which can be aggravated when concentrated in a herbal product. Overall, a greater understanding of the effects of traditional "medicines" will be of huge benefit to humans.

9.8. It is important to safeguard the genetic diversity of the world's plants and plant collections or seed banks must be comprehensive whilst the natural habitats are vulnerable. There are plant collections of preserved species used for identification, but which may not be available for genetic research. Molecular biology can be used to screen material for databases. The RBG Kew received £21.6M towards the Millenium seed bank project by the Millenium commission. The projects aim is the

conservation of some 25,000 species by the year 2010. There are other groups interested in plant conservation, including those given in Appendix 12.

10. **RECOMMENDATIONS**

Recommendations for Developing Markets

10.1. There is scope to reintroduce or develop crops which were once grown more widely in the UK (for example, coriander, anise, chamomile, lavender, mint, peppermint, rose, thyme). The feasibility of this should be increased by the application of modern technology (modern techniques of seed selection, improved agronomy, mechanised distillation technology and better crop production systems). The culture of herbs for processing is under study by a range of groups and individuals, and several project proposals and business plans are in preparation.

10.2. Growers and processors should examine in detail relevant recent research, mainly from Northern Europe, to derive maximum benefit from improvements which have been made to certain crop species. In the literature, there are many examples of improvements to species by screening, selecting and breeding processes. Then, producers should produce samples from a range of genetic sources given different cultural and climatic regimes to show to the prospective buyers. This will lead to the setting up of a closer liaison, and eventually to production to specification under contract.

10.3. There are large season-to-season variations in the yield of essential oils. For example, a six-fold variation in production of caraway oils has been recorded from year to year, and an eight-fold variation in oils of lavender. If this variation could be minimised, the natural product would compete better with synthetic substitutes and imported oils. The availability of better cultivars, careful attention to agronomic requirements (including choice of harvest date) and method of extraction may help to reduce the variation in yield of oil. Research in Finland showed the benefits from careful drying of chamomile flowers; this enabled Northern European produce to compete with higher quality produce from Southern Europe.

10.4. Producers should organise structured groups, perhaps including both Northern and Southern European components, which are capable of responding quickly to changing market conditions and technological innovations. This could be encouraged by the setting-up of an EU funded Network. This is explored currently by the British Herb Trade Association.

10.5. Potential customers and prices should be researched carefully, and contracts obtained. This may be directly with the processing company or indirectly through for example, a co-operative. There may be grants to set up a market intelligence network through the MAFF marketing Development Scheme (contact MAFF Market Task Force, Room 615, Nobel House, 17 Smith Square, London SW1P 3JR (Tel: 0171-238-6600/5642), or through grants from the Department of Trade and Industry (by contacting a local Technical Enterprise Council).

10.6. Producers can add value to their existing products by further processing, such as drying, making herbal teas, powders or ointments. There may be scope for using

a mobile distillation unit to extract oils. Producers might be encouraged to form groups with a view to purchasing up-to-date extraction equipment with a higher extraction capacity.

10.7. There are new research areas (medicines, flavours, perfumes) which are already yielding information of value to producers to develop their markets. Producers will need to keep abreast of these developments.

10.8. There is interest in developing herb crop markets in the UK. This interest comes from existing herb growers, members of the British Herb Trade Association, from farmers with and without experience of herb growing, from the markets and from entrepreneurs. There are new uses of plant extracts developing which will require material from known sources (e.g. with organic status for medicines and food preservatives). A database of contacts is under preparation at ADAS. There are focal points for development of the markets in the South West, East Anglia, the Midlands, and other projects are under way.

Recommendations for research

10.9. Research on new crops must include an evaluation of the economic and technical feasibility. The overall strategy should be market orientated when considering whether to introduce a new crop or a new production or processing technique. An investigation of existing information relevant to the crop should be done.

10.10. There should be an interdisciplinary network for a strategic approach to research on essential oils. This will look at the scope to develop minor crops using technology developed for major oil crops. There are initiatives to develop such networks by, for example, researchers at John Moores University, Liverpool and at the John Innes Centre, Norwich. These initiatives should be developed towards developing valuable new industries for UK and the rest of Europe.

10.11. There is value in developing economic models for 'whole crop production', for example for a crop such as blackcurrant where the fruit can be used, the essential oils of the buds extracted or the whole plant harvested for biomass. This approach should be pursued at the strategic research level by MAFF or BBSRC.

10.12. National collections should now be made for a greater number of herbal species to safeguard the diversity of genetic material. There are national collections for some herbs, e.g. oregano and marjoram. There are national collections at the Museum of Natural History and at the Royal Botanic Gardens, Kew. The author discussed this with staff at Kew in April 1995. Interested organisations include those listed in Appendix 11.

10.13. For most herb crops, breeding for the production of essential oils is still in its infancy. There is considerable scope for simple genetic improvements to crops to

increase the contents of essential oils. One example is that of *Digitalis lanata* which has been improved by research at the French National Institute (ITEIPMAI).

Increased production of essential oils in Europe will require the introduction of modern technology in production. Further research work is needed in:

Breeding for high oil content and adaption to UK climate.
Seed selection, seed treatment
Planting and growing schedules
Detailed development work on the interaction of soil fertility and fertiliser use on oil quantity and quality.
Harvesting timing and method
Development of extraction technology to maximise oil extraction and minimise distillation time.

10.14. Essential oils have an important role in pharmaceutical as well as physiotherapeutical products, with the necessary scientific studies to support sales. Some UK research institutions and companies are actively involved in this area. The scope for developing plants for pharmaceuticals should be reviewed in the light of recent trends in the industry towards alternative, natural medicines.

10.15. The essential oils of plants may have toxic properties. The levels of toxicants in plants is affected by many factors, for example, location and climate. The effects of production method on levels of toxicants should be researched. Producers and users of essential oils must be made aware of possible toxic effects.

10.16. New crops should be developed with the support of research investment (for example, blackcurrant, *Mentha citrata*, narcissus bulb, thyme).

10.17. Crops grown for their essential oils should be evaluated for potential industrial oil production as alternatives to oilseed crops.

Specific areas for investigation

10.18. Carvone from caraway should be thoroughly researched and developed for sprouting suppression of potatoes and other uses. This is in progress by Cebeco-Handelstraad in The Netherlands. An evaluation of an industry based on carvone production in the UK.

10.19. The production of herbs in the UK should be redeveloped by initiating work on seed selection and breeding, on harvesting technology and on extraction technology. There may be scope to develop organic production (Caiger, 1993). It is important to focus R&D on crops for which there is a demand and which are suited to UK.

10.20. Weed control in herb crops is a problem as there are relatively few approved herbicides; however, crops must be kept free of impurity. Research should therefore

include an evaluation of alternatives to herbicides such as mulches, (especially new types of paper mulch), or brush hoes.

10.21. An evaluation of modern harvesting techniques for herbs, (for example the combine stripper head for chamomile flowers) should be made.

10.22. Alternative extraction methods for rose oil should be developed further; both for rose and, possibly, other UK-grown species. Such new methods of extraction may give a purer commodity, but the extract may be different from existing market specifications, which may be difficult to overcome. It may be possible to use other outlets to sell the oil.

10.23. The drying regimes required for individual species should be identified to maximise yields of essential oils and to minimise contamination from micro-organisms.

10.24. There is a need for research in the field of cosmetics, for scientific back-up to ethnobotanical claims and for improvements to natural products such as colouration and shelf life stability.

10.25. The role of essential oils as natural sources of food preservatives can be explored further. The author has contacted some Food Research Units, but others may be actively involved in this area.

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Sally R Runham
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Appendix 1

Plants for which there is a demand

Chamomile	Barberry	Devils claw
Lavender	Bayberry	Slippery elm
Rosemary	Catmint	Celery
Clary sage	Burdock	Raspberry
Sage	Chickweed	Garlic
Thyme	Coltsfoot	Cranesbill
Caraway	Comfrey	Couchgrass
Evening primrose	Dandelion	White willow
Borage	Marigold	Milk thistle
Lemon balm	Basil oil	Inula
Peppermint	Elderflower	
Parsley	Nettles	
Feverfew	Cleavers	
Echinacea	Verbena	
Yarrow	Hyssop	
Skullcap	Red clover	
Angelica	Lady's mantle	
Valerian	Tansy	
Golden rod	Shepherds purse	
Saxifrage	Crateagus	

Appendix 2

The principal temperature volatile-oil species.

Species	English Name	Major oil component of main chemotypes (terpene or phenylpropene)
Annual labiates		
Ocimum basilicum L.	(Sweet) basil	Methyl chavicol / linalool (European) camphor (Reunion) eugenol methyl cinnamate
		Carvacrol
Satureja hortensis L.	Summer savory	
Perennial Iabiate herbs		
Majorana hortensis Moench. (also annual)	(Sweet) Marjoram	Terpinen-4-ol sabinene
Melissa officinalis L	(Lemon) Balm	Geraniol / geranial
Mentha x piperita L	Peppermint	Menthol / menthone
Mentha spicata L	Spearmint	Carvone / carvol
Shrubby labiates		
Hyssopus officinalis L (also herbaceous)	Hyssop	Isopinocamphene / pinocamphone / pinocarvone
Lavandula angustifolia Mill. (also Lavandula x Intermedia)	Lavender	Linalool / linalyl acetate
Origanum vulgare L	Oregano	Carvacrol thymol
Roseamarinus officinalis L	Rosemary	∝-Pinene / verbenone eucalyptol camphor / borneol
Salvia officinalis L	Sage (geographical types)	Thujone camphor
Satureja montana L	Winter savory	Thymol carvacrol
Thymus vulgaris L	Thyme	Thymol carvacrol
Annual umbellifers		
Anthriscus crerfolium (L) Hoffm	Chervil	Methyl chavicol
Coridandrum sativum L	Coriander	Linalool
Cuminum cyminum L	Cumin	Cuminaldehyde
Pimpinella anisum L	Anise	Anethole / chavicol

Species	English Name	Major oil component of main chemotypes (terpene or phenylpropene)
Biennial and perennial umbellifer herbs		
Anethum graveolens L	Dill	Carvone
Angelica/Archangelica L spp	Angelica	∝-Phellandrene / ∝-pinene
Carum carvi L	Caraway	Limonene carvone
Foeniculum vugare Mill	(Sweet) Fennel	Anethole / fenchone / linonene
Levisticum officinale Koch	Lovage	Umbelliferone / carvacrol / eugenol
Petroselinum crispum (Mill) Nyman	Parsley	Ocimene apiole myristicin
Perennial composite		
Artemisia dracunculus L	French tarragon	Methyl chavicol

Source: reproduced from Hay and Svoboda (1993)

Appendix 3

World-wide merchant sales of fragrances and flavours by product categories, 1984-1990.

Product Categories	1984		1990		Growth rate
	£M	Share %	£M	Share %	1984 to 1990 %
Fragrance compounds	1047	35.5	1526	35.0	6.5
Flavour compounds (artificial and natural)	953	32.3	1465	33.6	7.5
Aroma chemicals (artificial and natural)	475	16.1	702	16.1	6.5
Essential or plant volatile oils and other natural[1] products	475	16.1	667	15.3	5.5
World total	2950		4360		6.5

Source: Caiger, 1993 (converted dollars to sterling)

Appendix 4

Estimates of world production of plant volatile oils (£000's)

Peppermint	64300	*Litsea cubeba*	11000	Patchouli	8500
Cornmint	38600	*Eucalyptus glob.*	11000	Lavandin	7600
Rose	26800	Jasmine	11000	Cedarwood	7400
Spearmint	22000	Sandalwood	9000	Lime	7000
Lemon	20000	Citronella	8700	Bergamot	6900
Orange	18000	Vetiver	8700	Geranium	6700
Value > 1000					
Coriander	6000	Lemongrass	3000	Grapefruit	1100
Lavender	5000	Nerole	2500	Olibanum	1000
Ylang-ylang	4700	*Eucalyptus citr.*	2300	Tarragon	1000
Clove leaf	4700	Roman chamomile	2000	Basil	1000
Bois de rose	3800	Dill	1900	Cedar leaf	1000
Anise seed	39000	Ginger	1900	Pimento leaf	1000
Petitgrain	3600	Palmarosa	1700	*Cananga*	900
Blue chamomile	3600	Fennel	1600	Garlic	800
Clary sage	3600	Marjoram	1400	Juniper berry	800
Mandarin	3600	Cinnamon bark	1300	*Amyris*	800
Cinnamon (China)	3600	Sage	1300	Lovage	800
Rosemary	3400	Camphor	1300	Thyme	750
Sassafras	3200	Celery	1250	Bitter orange	730
Star anise	3000	Onion	1200	*Calamus*	670
Nutmeg	3000	Copaiba	1200	Pine	670
Tangerine	3000	Clove	1200	Cinnamon leaf	670
Cascarilla	3000				

Value > 100

Cumin	640	Cardamom	330	Cabreuva	170
Artemisia sp	640	Gaiac	300	Buchu	160
Valerian	500	Tea tree	270	*Galbanum*	160
Spike lavender	500	Oregano	270	Bergamot mint	160
Styrax	500	Fir	270	Ho	160
Bay	480	Hop	270	Hyssop	150
Birch tar	440	Parsley herb	240	Tagete	150
Pepper	440	Laurel leaf	240	Spanish sage	150
Davana	400	Pimento bay	220	Elemi	130
Parsley	400	Carrot	200	Pennyroyal	120
Peru balsam	400	Caraway	200	Myrrh	100
Cajuput	330	Cypress	170	Rue	67
Angelica	330	Myrtle	170		

Value < 100

Cade	56	Gurjum	54	*Chenopodium*	30
Opoponax	54	Dill seed	50	Gingergrass	17
Niaouli	54	Savory	30		

Source: Adapted from Verlet (1993)

World trade in plant oils which could be UK-produced

Category	Value (£000s)	Category	Value (£000s)
Peppermint	64300	Tarragon	1000
Cornmint	38600	Basil	1000
Rose	26800	Garlic	800
Spearmint	22000	Juniper Berry	800
Jasmine	11000	Thyme	750
Lavandin/Lavender	12600	Oregano	270
Geranium	6700	Hop	270
Coriander	6000	Parsley	240
Blue chamomile	3600	Carrot	200
Clary sage	3600	Caraway	200
Rosemary	3400	Others	1000
Dill	1900		
Fennel	1600		
Marjoram	1400		
Sage	1300		
Celery	1250		
Onion	1200		

Appendix 5

Imported spices and oils in 1993

Category	Total Imports £000s	From EU £000s	From Non-EU £000s
CITRUS			
Bergamot Orange	426	408	18
Orange	3,136	643	2,493
Lemon	7,302	6,158	1,144
Lime	3,213	1,042	2,171
Other Citrus	974	218	756
Total	15,051	8,469	6,582
NON-CITRUS			
Geranium	1,324	558	766
Jasmine	158	116	42
Lavender/Lavandin	1,444	1,293	151
Peppermint	11,295	622	10,673
Other mints	3,664	551	3,113
Vetiver	596	54	542
Clove, Niaouli and Ylang Ylang	1,450	677	767
Other	18,947	4,981	13,966
Total	38,878	8,852	30,020

Source: MAFF Statistics (AC) C.

Appendix 6

Weight (T) and value (£) of total imported essential oils in 1994.
Source MAFF Statistics (AC) C

Type	Weight (T)	Value (£000s)
Citrus		
Bergamot	55	513
Orange	4724	4718
Lemon	1285	13369
Lime	323	1204
Other	214	1773
Total citrus		21577
Non citrus		
Geranium	59	2259
Jasmine	2	105
Lavender	149	1924
Peppermint	1308	578
Other mints	507	469
Vetiver	189	961
Clove, Niaouli Ylang Ylang	206	1311
Other	2915	4974
Total non-citrus		12581
Overall total value		34158

Appendix 7

Weight (T) and value (£) of total imported essential oils in 1995.
Source MAFF Statistics (AC) C

Type	Weight (T)	Value (£000s)
Citrus		
Bergamot	38	420
Orange	2790	2354
Lemon	852	3813
Lime	302	3726
Other citrus	253	2902
Total citrus		13215
Non citrus		
Geranium	59	1381
Jasmine	8	188
Lavender	160	1980
Peppermint	887	1414
Other mints	606	450
Vetiver	6	365
Clove, Niaouli Ylang Ylang	210	1322
Other	3309	26499
Total non-citrus		33599
Overall total value		£46814

Appendix 8

UK trade in medicinal plants in 1994
Source MAFF Statistics (AC)C

Type	Total imports £000s	Total exports £000s
Pepper	139	11
Vanilla	9823	242
Cinnamon	1607	111
Cloves	205	51
Nutmeg	9	25
Anise	107	19
Badian	82	19
Coriander	1363	151
Caraway	2	3
Fennel	10	-
Saffron	753	71
Tumeric	1025	192
Thyme	736	186
Bay leaves	268	55
Curry	1488	4552
Fenugreek	244	108
Other	3138	2397
Total value	20999	8193

Appendix 9

UK trade in medicinal plants in 1995
Source MAFF Statistics (AC)C

Type	Total imports £000s	Total exports £000s
Pepper	292	11
Vanilla	716	75
Cinnamon	1170	86
Cloves	201	84
Nutmeg	3	26
Anise	100	58
Badian	280	14
Coriander seed	1225	104
Cumin seed	1	5
Caraway seed	8	2
Fennel Seed	4	-
Saffron	588	86
Tumeric	883	149
Thyme	379	303
Bay leaves	419	72
Curry	1447	4599
Fenugreek seed	205	95
Others	2947	3024
Total	10868	5769

Appendix 10

PROCESSING FACILITIES IN THE UK.

Peter Jarvis - Hadleigh, NR Ipswich
Process by Maceration to obtain Essential oils for cosmetics

Bush Boake Allen - Longmelford Sudbury, Suffolk
Distil for Fragrance and flavour

Weleda - Ilkeston, Derbyshire.
Distil for natural medicine

Neals Yard, Battersea, London
The company buys Herb's from abroad and does its own processing

R C Treatt & Company Limited
Bury St. Edmunds, Suffolk Tel: 01284 702500
The company imports essential oils, re-distils and fractionates them if required to standardise quality.

John King, Coggleshall, Essex
This company processes oils, mainly industrial

Ransomes, Hitchin (Tel: 01462 437615) - John Whitehead
They buy in, dried herbal products and make extracts.

Lionel Hitchen, Winchester, Hants (Tel: 01962 760815)
This company produces essential oils in the UK

Firth Farms, Basingstoke (Tel: 01635 298355)
This company produces chamomile oil. A small company They have 3 stills.

Wessex Impex Ltd
Stonebridge Farmhouse, Breadsell Lane, Crowhurst, St Leonards, E Sussex
Tel: 01424 830659 Contact: Michael van Moppes

Advanced Phytonics
Leeming, North Yorkshire Contact: Peter Wilde

High Barn Farm, Sussex
Contact: Mick Gahagan

James Barn Farm Estate, Cotswold
Tel: 01451 850787 Contact: Roger Michael

Hambleden Herbs, Somerset
Tel: 01823 401205 Contact: Mike Brooks

Norfolk Lavender, Norfolk
Tel: 01485 570384 Contact: Henry Head

Appendix 11

Species discussed in report

Common Name(s)	Family	Latin Name
Anise	Umbelliferae	*Pimpinella anisum*
Amaranth		*Amaranthus spp*
Apple	Rosaceae	*Malus pumila*
Basil	Labiatae	*Ocimum basilicum*
Bay		*Laurus nobilis*
Bergamot	Labiatae	*Monarda spp*
Blackberry	Rosaceae	*Rubus fruticosus*
Bog Myrtle	Myrtaceae	*Myrica gale*
Borage	Boraginaceae	*Symphytum uplandicum*
Calendula		*Calendula officinalis*
Caraway	Umbelliferae	*Carum carvi*
Catmint / Catnip	Labiatae	*Nepeta cataria*
Chamomile	Compositae	*Chamomilla recutita L.*
Chervil	Umbelliferae	*Anthriscus cerefolium*
Chrysanthemum	Compositae	*Chrysanthemum spp*
Cloves	Myrtaceae	*Eugenia caryophylla*
Colchicum (Colchicine)	Lilaceae	*Colchicum Spp.*
Coriander	Umbelliferae	*Coriandrum sativum*
Dill	Umbelliferae	*Anethum graveolens*
(Digoxine)	Schrophulariaceae	*Digitalis lanata*
Elderflower	Caprifoliaceae	*Sambucus nigra*
European Pennyroyal	Labiatae	*Mentha pulegium L.*
Fennel (sweet + bitter)	Umbelliferae	*Foeniculum vulgare*
(French) tarragon	Compositae	*Artemisia dracunculus*
Garlic	Liliaceae	*Allium sativum*
Honesty		*Lunaria*
Horsemint / Bee Balm	Labiatae	*Monarda fistulosa*
Japanese mint	Labiatae	*Mentha arvensis L.*
Jojoba		*Simmondsia chinensis*
Lavender	Labiatae	*Lavandula officinalis*
Lemon	Rutaceae	*Citrus limon*
Limeflower	Tiliaceae	*Tilia spp*
Linseed (oil flax)	Linaceae	*Linum usitatissimum*
Liquorice	Leguminae	*Glycyrrhiza glabra L.*
Marjoram	Labiatae	*Majorana hortensis*
Mustard	Cruciferae	*Sinapsis alba (Brassica spp)*
Olive	Oleaceae	*Olea europea*
Parsley	Umbelliferae	*Petroselinum crispum*

Common Name(s)	Family	Latin Name
Peppermint	Labiatae	*Mentha piperita L.*
Pinus	Pinaceae	*Pinus peuce/P.silvestris*
Poppy	Papavereae	*Papaver somniferum L.*
Portugese thyme	Labiatae	*Thymus capitellatus* *Thymus lotocephalus*
Roman chamomile	Compositae	*Anthemis nobilis L.*
Rose	Rosaceae	*Rosa spp*
Rosemary	Labiatae	*Rosmarinus officinalis L.*
Sage	Labiatae	*Salvia officinalis L.*
Savoury	Labiatae	*Saturheja hortensis L.*
Sea fennel		*Crithmum maritimum L.*
Sweet Marjoram	Labiatae	*Majorana hortensis*
(Tanakan)		*Ginkgo biloba*
Thyme (Garden)	Labiatae	*Thymus vulgaris SL*
Vetiver		
Wild bergamot	Labiatae	*Monarda spp*
Yarrow	Asteraceae	*Achillea millefolium*
Yew	Taxaceae	*Taxus baccata L.*

Appendix 12

ENVIRONMENTAL CHARITIES

Bio-regional development group, Surrey
Martin Evans
Tel: 0181 773 2322
This is an environmental charity which is running a project to revive the essential oil industry especially lavender and peppermint in South West London. The aim is to work with growers and processors. Martin Evans has contacts with companies. He is looking for funding from the Millennium fund.

Silphion Project
Tel: 01623 634860
This project is working for the conservation of the world's medicinal plants. The aim is to protect the world's native wild herb plants and to lobby to prevent excessive wild harvesting. The project aims to encourage ex-situ cultivation by trade growers.

Phytera, Sheffield
Contact Michael Fowler

Plant Europa
Proceedings of September 1995 conference £18
Plantlife, Natural History Museum, Cromwell Road, London, SW7 5BD
This group of wild plant experts are concerned with how best to conserve Europe's endangered flora, estimated at 2,500 species.