European Monitoring Centre
for Drugs and Drug Addiction

EMCDDA INSIGHTS

An overview of cannabis potency in Europe

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Foreword

Cannabis is the illegal substance most commonly used in all countries of the European Union, with many countries reporting lifetime experience of the drug by more than 20% of the general population.

Used mainly by young adults, but also by many schoolchildren, cannabis is a drug consumed by individuals during their formative years, at a time when they may be more vulnerable to the long-term harmful effects of drug use.

The increased use of cannabis during the past decade, during which more attention has also been given to the medicinal use of cannabis, has increased the profile of the drug. So too have legislative changes in some countries, and the more open debate on the costs and benefits of different drug control options. At the same time there is also a concern that cannabis is increasingly mentioned in connection with applications for drug treatment — and this is an issue that will be explored in detail in the Annual Report of the EMCDDA in 2004.

Comments in the media and elsewhere of a large increase in the potency of cannabis have raised concerns that the drug now available is much stronger than that available in the past. A much stronger drug might have implications for both the health and other problems resulting from the use of the drug and for the development of future policy options. However, the information on which the claims of greatly increased cannabis potency have been made is not always clear.

To establish a scientific basis on which to advise policy makers and practitioners in the drugs field, the EMCDDA commissioned an investigation into cannabis potency in Europe. The results of this study are presented here. Changes in the production and sourcing of cannabis products are documented. Information supplied through the Reitox national focal points are added to data from a wide variety of sources to enable a first overview of cannabis potency in Europe. This is discussed in the wider context of information from the United States, Australia and New Zealand, countries where there have also been media reports of increased cannabis potency.

As always when attempting to study illegal substances, the data are incomplete and the conclusions are qualified. Nevertheless, it is now possible to respond with facts and figures to questions about large increases in cannabis potency in

Europe. As the reader will discover, this is not a simple or straightforward issue. This report identifies a number of important questions that require further consideration if we are to understand the implications of changes in patterns of cannabis consumption in Europe. Nonetheless, we hope that the information and analysis contained in this edition of the EMCDDA *Insights* series will make a valuable contribution to a more informed debate about cannabis potency in Europe — and its potential impact.

Georges Estievenart
Executive Director
EMCDDA

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Preface

The cultivation of the hemp plant (*Cannabis sativa* L.) stretches back into antiquity. Although originally produced as a source of fibre, its value as a drug also has a long history. For most of this time, it is likely that little change occurred in the methods used to manufacture the traditional drug products, namely herbal cannabis (marijuana) and cannabis resin (hashish). Yet in the last decades of the twentieth century, interest in cannabis expanded considerably. This was partly driven by the ever-increasing drug use in many countries, some of which was stimulated by new intensive methods of cultivation. But there were other developments: the licensing of commercial cultivation in the EU for fibre production; a renewed interest in medicinal uses; and legislative changes often caused by a need for law enforcement agencies to focus on more dangerous substances. There was also concern about the rising frequency with which cannabis was mentioned in the context of the treatment demand indicator (EMCDDA, 2003), and this will be the subject of a separate publication by the EMCDDA in 2004.

In parallel with these changes, there has been a greater focus on the constituents of cannabis, and in particular the main principle: Δ^{9}-tetrahydrocannabinol (THC). Concerns were raised that the potency of cannabis (i.e. the THC concentration) may have increased so much that the illicit drug now bears little resemblance to the cannabis that was used only thirty years ago. A widely publicised example of this is the statement by the so-called 'drug czar' in the USA, published in the Washington Post, that "Parents are often unaware that today's marijuana is different from that of a generation ago, with potency levels 10–20 times stronger than the marijuana with which they were familiar" (Walters, 2002). In a similar vein, and even more recently, Professor John Henry of St. Mary's Hospital, London, commented on the apparent increase in association between cannabis and deaths recorded as accidents and suicides. He is quoted (Henry, 2004) as saying "until the early 1990s, there was less than one per cent tetrahydrocannabinol in most cannabis. Now the most potent form, skunk, contains up to 30 per cent". As a final example of this alarm, Ashton (House of Lords, 1998) stated that "… a typical 'joint' today may contain 60–150 milligrams or more of THC". However, the potency question is not new. Nearly twenty years ago, Cohen (1986) noted that "…material ten or more times potent than the product smoked ten years

ago is being used, and the intoxicated state is more intense and lasts longer". But Mikuriya and Aldrich (1988) pointed out that the cultivation of sinsemilla and its superiority to other forms of cannabis was well known to the British Government in India in the nineteenth century.

Cannabis in its various forms remains the most commonly used illicit drug in the EU, with many countries reporting lifetime prevalence rates in excess of 20 % of the general population (EMCDDA, 2003). The purpose of the present report is to examine the evidence for changes in the potency of cannabis products in Europe and whether any such changes are a cause for public concern. Comparisons are made with the situation in the USA, New Zealand and Australia, the only non-European countries to have made serious efforts to monitor the quality of cannabis over a number of years. Published data are often in the form of national annual averages. The report examines the types of cannabis consumed and their respective origins, analytical aspects such as sampling strategies, the effect of storage, and the laboratory methods used since these could all be major factors affecting such data.

Information was collected from the published and unpublished (grey) literature and interviews with colleagues in the United Kingdom and the Netherlands. In addition, a questionnaire (available from the EMCDDA on request) was sent via the Reitox focal points to the 25 EU Member States and Norway. Replies from thirteen countries were received, but not all were able to provide data on recent trends in the potency of cannabis products.

Although this review concentrates on matters relating to potency, there is a vast scientific literature devoted to cannabis. The following is not intended to be an exhaustive list of reviews: pharmacology (Ashton, 1998, 2001; Nutt and Nash, 2002), health and psychological effects (Hall et al., 2001), effects of chronic/heavy use (Van Amsterdam et al., 1996), psychiatric illness (Johns, 1998; Rey and Tennant, 2002), therapeutic uses (British Medical Association, 1997; Baardman, 2003), production of cannabis resin (Cherniak, 1995), forensic toxicology (Huestis, 1999), historical development (Booth, 2003), medicinal products (Clarke and Watson, 2000), social and criminal aspects (Plant, 1998a), metabolism and disposition (Hawks, 1982), forensic and legislative aspects (Phillips, 1998), analysis in biological materials (Raharjo and Verpoorte, 2004), global trends in seizures and consumption (UNODC, 1997/1998, 2003) and

epidemiology (Plant, 1998b). Single sources of useful information can be found in the books by Brown (1998) and Iversen (2000) and a British Parliamentary report (House of Lords, 1998). The World Wide Web provides yet further sources of information.

To maintain consistency in this report, the phrases 'herbal cannabis' or 'herbal' are used to describe what original authors may have referred to as 'marijuana', 'grass' or even 'leaf'. Cannabis described in the literature as 'flowering tops', 'nederwiet' or 'skunk' is taken to mean 'sinsemilla', particularly when grown by intensive indoor methods or when a contrast is made by the authors with the term 'seeded', which is here defined as 'imported'. Although imported cannabis can usually be distinguished from other forms, it is possible that in some published reports either no distinction was made, or some overlap between the two occurred. The term 'cannabis resin', or simply 'resin', is used in preference to 'hashish'. 'Cannabis products' or 'cannabis' is used in a generic sense to refer to plants, herbal cannabis, cannabis resin and hash oil. This report does not include any analysis of the potency of 'hemp', that is to say plants of the 'fibre-phenotype' with little THC content, which are grown for non-drug purposes. Certain recommendations on nomenclature are discussed in Chapter 6. The Glossary provides a fuller definition of these and other terms.

Leslie A. King

Chloé Carpentier

Paul Griffiths

Executive summary

1. The potency of cannabis products (a term used in preference to purity) is equivalent to the Δ^9-tetrahydrocannabinol (THC) content. THC is the primary active constituent in cannabis.
2. Information on the potency of cannabis products in European countries was obtained from Standard table 14 of the EMCDDA-REITOX reporting system and by means of a questionnaire sent to experts. Information on THC levels in other countries (USA, New Zealand and Australia) was obtained from the published literature.
3. Herbal cannabis produced by intensive indoor methods (e.g. hydroponic systems with artificial lighting, propagation by cuttings and control of day length) usually has higher THC levels than imported material. Although the potency range of home-grown herbal cannabis may overlap with that of imported herbal cannabis, the average potency of home-grown herbal cannabis may be two or three times greater than that of imported herbal cannabis. The overall increases in potency that have occurred in some countries can be almost entirely attributed to the increased relative consumption of home-grown herbal cannabis.
4. Indoor cultivation of herbal cannabis occurs in all European countries. In the Netherlands, it is estimated that this product represents over half of the cannabis consumed, but for most European countries, imported products are more common.
5. The higher potency of herbal cannabis produced by indoor methods is a reflection of several factors: genetic (selected seed varieties and cultivation of female plants); environmental (cultivation technique, prevention of fertilisation and seed production); and freshness (production sites are close to the consumer and storage degradation of THC is avoided).
6. In the Netherlands, locally produced cannabis resin has particularly high THC levels, but this material is still uncommon in that country and almost unknown elsewhere.
7. Hash oil is uncommon in all countries.

8. The available data do not show any long-term marked upward trend in the potency of herbal cannabis or cannabis resin imported into Europe.

9. The countries of Europe fall into two clear groups according to whether herbal cannabis or cannabis resin is the most commonly consumed product. Of the countries for which information was available, cannabis resin was most common in Germany, Ireland, Portugal and the United Kingdom, whereas herbal cannabis was the most common product in Austria, Belgium, Estonia, Czech Republic and the Netherlands.

10. Information on potency trends and the relative consumption of different products in a particular country can be combined to give the overall trend in THC levels as perceived by the average user. Termed the effective potency, it is derived by weighting the potency of each product by its fractional share of the market and then summing the individual values. The effective potency in nearly all countries has remained quite stable for many years at around 6–8 %. The only exception has been the Netherlands where, by 2001–2002, it had reached 16 %.

11. In the United Kingdom, the amount of herbal cannabis or cannabis resin in cannabis cigarettes has shown no trend in the last twenty years.

12. Statements in the popular media that the potency of cannabis has increased by ten times or more in recent decades are not supported by the limited data that are available from either the USA or Europe. The greatest long-term changes in potency appear to have occurred in the USA. It should be noted here that before 1980 herbal cannabis potency in the USA was very low by European standards.

13. There are major differences in the market between the USA and Europe. In some European countries, cannabis resin, originating almost entirely from North Africa, is more common than herbal cannabis. Herbal cannabis imported into Europe originates from the Caribbean, Africa and the Far East. In the USA, herbal cannabis is either grown domestically or imported from Canada or Mexico, but cannabis resin is more rarely seen. As a consequence, direct comparisons between data in North America and Europe have questionable relevance.

14. There are major differences in the methods of consumption between the USA and Europe. In Europe, both forms are usually smoked in a mixture with tobacco. In the USA, cannabis is commonly smoked alone. These differences have important implications for the interpretation of experimental pharmacological investigations and the health effects of cannabis, particularly when comparisons are made between the USA and Europe.

15. The natural variation in the THC content between and within samples of herbal cannabis or cannabis resin at any one time and place far exceeds any long-term changes that may have occurred either in Europe or the USA. This natural variation is even greater when material from different geographical locations is examined.

16. As well as uncertainties caused by the oxidation of THC during storage and the problems of extracting (inhomogeneous) herbal or resinous material, there are analytical difficulties in the precise and accurate determination of THC. These measurement errors could also be sufficient to mask any small secular changes in potency.

17. If it is accepted that the cannabis resin imported into Europe is a fairly uniform substance that is rarely adulterated, originates mostly from North Africa and has shown no clear trend in potency for many years, then the considerable potency variations reported by different countries could suggest that there are high variations in sampling strategies and/or systematic errors in the quantitative analysis of THC in different laboratories/countries.

18. This study identifies a number of important areas that require attention if cannabis potency issues are to be properly evaluated. These include a need to:

    a. improve information gathering, analysis and dissemination;
    b. develop a consensus on nomenclature that can better identify different cannabis products;
    c. understand better the relative consumption of cannabis products in different markets, and the extent and practice of domestic indoor cultivation;
    d. investigate the cannabis content of cannabis cigarettes;
    e. improve the monitoring of street prices;
    f. improve the standards of laboratory analysis, as well as data collection and data presentation at European level;

g. address information gaps that exist in understanding the relationships between potency, smoking behaviours and blood levels of THC in the European context;
h. investigate the extent to which high-potency cannabis results in increased dose exposure and any possible relationship to either chronic or acute health problems.

19. The conclusion of this report is that there have been modest changes in THC levels that are largely confined to the relatively recent appearance on the market of intensively cultivated domestically produced cannabis. Cannabis of this type is typically more potent, although it is also clear that the THC content of cannabis products in general is extremely variable and that there have always been some samples that have had a high potency. A clear need exists to develop monitoring systems that can assess the market share of different cannabis products and track changes over time. Currently this information is to a great extent lacking. This is important, as a concern exists that hydroponically produced cannabis grown in the EU may be increasing its market share.

20. An important point to note is that the possibility of additional public health problems caused by the use of high-potency cannabis as compared to cannabis products in general remains poorly understood. Nonetheless, a number of clear research questions are identifiable, that would shed light on this issue. These are discussed in the conclusions of this report.

21. This study has implications for both supply and demand side strategies, as well as to the possible costs and benefits of responding differentially to different cannabis products.

Chapter 1: Introduction

Chapter 1: Introduction

The cannabis plant and derived products

The cannabis plant (*Cannabis sativa* L.) is an annual that will grow successfully to a height of 2–3 metres in a wide range of soils in both tropical and temperate climates. The leaves are compound with up to eleven separate serrated lobes. It is dioecious (plants are either male or female), and is the only known natural source of cannabinoids (see section *Cannabinoids*). The cannabinoids are found in resinous material, produced by glandular trichomes situated mostly around the flowering parts. Although some have suggested that there is a separate species (*Cannabis indica* Lam.), most authors consider the genus to be monospecific, but that considerable genetic diversity exists leading to wide phenotypic variability. Plants grown for drug use have traditionally been cultivated outdoors in hot climates. In temperate climates, and even when grown under glass, summers may not be long enough to allow full development of the flowering parts. Apart from the fibrous stem, which was once used for rope manufacture and is still used for other purposes, the two main drug products have been herbal cannabis and cannabis resin. Herbal cannabis is the dried flowering tops with or without variable amounts of leaves, stems and seeds. Cannabis resin is obtained by sieving or otherwise separating and compressing the flowering tops. Cannabis (hash) oil is a derived product made by solvent extraction of either herbal cannabis or cannabis resin. In the past ten to twenty years, a number of horticultural developments such as propagation by cuttings, hydroponics and artificial control of 'day' length have led to the widespread development of indoor cultivation of cannabis. Recent developments in cultivation and product quality have been discussed by Szendrei (1997/1998). The situation in the United Kingdom has been described by Bone and Waldron (1997/8).

Cannabinoids

The major active principle in all cannabis products is Δ^9-tetrahydrocannabinol (THC), the structure of which is shown in Figure 1. The unsaturated bond in the cyclohexene ring is located between C_9 and C_{10} in the more common dibenzopyran ring-numbering system. Although sometimes known as dronabinol (an international non-proprietary name), naturally occurring Δ^9-tetrahydrocannabinol exists in four isomeric forms and is not chemically identical to synthetic dronabinol. Two related

substances, Δ^9-tetrahydrocannabinol-2-oic acid and Δ^9-tetrahydrocannabinol-4-oic acid (THCA) are also present, sometimes in large amounts. Figure 1 shows one of the two positional isomers of THCA. During smoking, THCA is converted to THC, although other substances are also formed (A. Hazekamp, personal communication, 2004) and some is lost by evaporation. The active isomer Δ^8-THC, where the unsaturated bond in the cyclohexene ring is located between C_8 and C_9, is found in much smaller amounts. Other closely related substances that occur in cannabis include cannabidiol (CBD; Figure 1) and, in aged samples, cannabinol (CBN; Figure 1), both of which have quite different pharmacological effects to THC. Other compounds include the cannabivarins and cannabichromenes; they are all collectively known as cannabinoids.

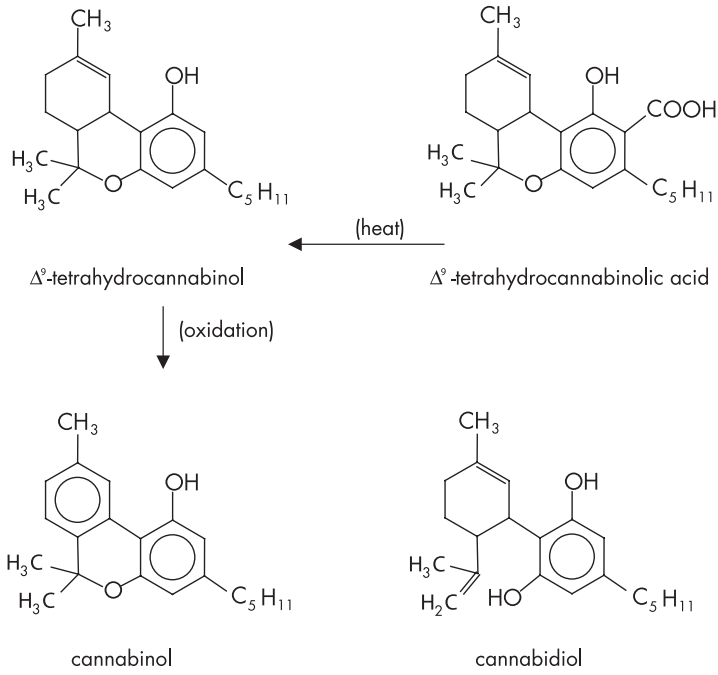

Figure 1: The structures of Δ^9-tetrahydrocannabinolic acid (THCA), Δ^9-tetrahydrocannabinol (THC), cannabinol (CBN) and cannabidiol (CBD).

The highest levels of THC occur around the floral parts of the unfertilised female plant, and this material is then described as sinsemilla (Spanish: without seeds). Fertilisation and the consequent seed production serves to reduce the level of THC. Much lower amounts are present in the leaves, and in male plants, whereas the stalk and clean seeds contain almost none. A distinction is sometimes made between cannabis plants for drug use and cannabis grown for fibre. Thus, cannabidiol is often absent in the former, but is usually found at levels exceeding 0.5% in the latter. As discussed by Maguire (2001), a useful parameter of distinction is the ratio [(% THC + % CBN)/% CBD]. If this is greater than 1.0 then the material is described as 'drug-phenotype' and if it is less than 1.0 it is 'fibre-phenotype'. In the light of the biological diversity of *Cannabis sativa*, these are simply extreme forms in a wide spectrum of different types.

Purity and potency

It is more informative, and indeed more scientifically correct, to talk of cannabis potency rather than cannabis purity. Purity is a concept that is best applied where there is a question of adulteration or dilution of an otherwise pure substance. In this sense, it is correct to refer to the purity of, say, powdered illicit drugs such as cocaine or amphetamine where cutting agents are normally added to the pure drug before it enters the retail market. Cannabis, however, does not represent a pure form of the active ingredient. The range of concentration of cannabinoids in cannabis also undermines the concept of cannabis purity. In addition, although it is alleged that cannabis resin sometimes contains inert fillers such as henna powder, herbal cannabis is rarely adulterated. For these reasons, it is not appropriate to use 'purity' when referring to cannabis. Reviews of the literature also show that 'cannabis potency', defined as the THC concentration, is the preferred term. The publication *Global Illicit Drug Trends* (UNODC, 2003) illustrates the ambiguity caused by the phrase 'purity levels' in relation to herbal cannabis and cannabis resin: values are either clustered around 1–10% and presumably reflect the THC content or they are much higher, typically above 50%, the interpretation of which is unclear, but could reflect some other concept of quality.

In the following report, the THC content of illicit herbal cannabis and cannabis resin only are considered. In the EU, cannabis (hemp) cultivated under licence for fibre contains less than 0.3% THC, and is essentially not usable as a drug. Although some data are available on the THC content of cannabis oil, the potency

is determined not only by the source material, but is also affected by its age, the efficiency of extraction and the extent to which the solvent has been removed. Furthermore, in Europe and elsewhere, hash oil accounts for a tiny fraction of the total quantity of cannabis products consumed. In the United Kingdom, the THC content of hash oil is typically in the range 25–45% and appears to have shown no changes over the years (Baker et al., 1982; Gough, 1991; King, 2001). In the USA, during the period 1980–1997, a similar stability in the THC content of hash oil (typically 12–17%) was reported (ElSohly et al., 2000).

A curious method of increasing the potency of cannabis was discussed by Segelman and Sofia (1973), whereby treatment of cannabis with boiling water removes unwanted soluble components, but not THC. On a weight basis, the THC concentration may be increased by around 30%, although the absolute amount of THC has not changed.

Pharmacological aspects of high-potency cannabis

Cannabis is nearly always smoked. In Europe, it is often mixed with tobacco in a joint, also known as a reefer or spliff, but some is smoked in a water pipe (a bong). By contrast, in the USA, where little resin is consumed, cannabis is usually smoked alone. A recent trend in the USA is the smoking of 'blunts' (hollowed out cigars), which may be filled with 2–3 g of cannabis (DEA, 1999). Nearly all studies on the smoking of cannabis and its relation to potency have been carried out in North America, but it is clear that this research may not translate well into the European situation. Thus Matthias et al. (1997) found some evidence that those who smoke more potent cannabis are less exposed to noxious smoke components than those who use less potent forms. But in Europe, where a reefer cigarette typically contains only 100–260 mg of cannabis (Humphreys and Joyce, 1982; Buchanan and O'Connell, 1998; Bal and Griffin, 2001), much of the tar, carbon monoxide and other combustion products will derive from the concomitant tobacco.

Comparing the effects of marijuana cigarettes at three different potencies, Perez-Reyes et al. (1982) found no qualitative difference between the psychopharmacological effects of consuming large amounts of THC and those caused by consuming smaller amounts. Nevertheless, it is accepted that there is a dose–response curve (Miller et al., 1977). McBride and Thomas (1995) pointed out that psychosis attributed to 'skunk' (Wylie, 1995) is also common in users of 'normal' (or other types of) cannabis. If the potency of cannabis products has shown a marked increase, then it might be expected that the typical user would

need to consume less on a weight basis to achieve the desired effect. Given a choice, users preferred cigarettes with a higher THC content (Chait and Burke, 1994; Kelly et al., 1997). Ashton (1998) also argued that users would not titrate the dose of THC from cannabis in contrast to nicotine/tobacco smokers. However, Heishman et al. (1989) found that those smoking cigarettes with a higher THC content tended to have a lower inhalation rate than control subjects. Yet little research has been conducted, particularly in Europe, to answer a crucial question: Do those smoking high-potency cannabis have higher blood levels of THC?

Pharmacological studies are also compromised by a number of other factors. For example, while smoking is able to deliver a drug rapidly into the bloodstream and hence the brain, it is an inefficient process. Some THC will be destroyed by combustion or lost in the side-stream smoke, and the bioavailability of THC by this route is usually less than 50 % (Moffat et al., 2004). Based on the complete consumption of a cigarette containing 200 mg of cannabis, the amount of THC absorbed will be less than 10 mg in most cases. However, ingestion of cannabis in foods (e.g. spacecake) or infusions leads to an even lower bioavailability, largely because the gut poorly absorbs THC. Cannabis extracts do not lend themselves to injection because THC is practically insoluble in water. A further complicating factor is that some of the major metabolites of THC, such as 11-hydroxy-Δ^9-THC, have long half-lives and are themselves active.

Medicinal cannabis

In the Netherlands, herbal cannabis is available as a prescription medicine (Office of Medicinal Cannabis, 2004). Known as 'cannabis flos', one of the preparations has a nominal THC content of 18 % (±2.7 %) and is locally produced by the same intensive indoor methods that are used for illicit cultivation. It is indicated for multiple sclerosis, certain types of pain and other neurological conditions. Patients are advised to consume the cannabis by means of a hot water infusion. However, Hazekamp (personal communication, 2004) has found that, even in boiling water, the conversion of THCA to THC can take some hours and other by-products are formed. In the United Kingdom, an extract of cannabis is expected to be to licensed in 2004 to GW Pharmaceuticals Ltd. The product, to be known as Sativex, will be supplied in a nebuliser for sub-lingual application at a concentration of well below 1 % THC. Cannabis is not available for licensed therapeutic use in any other European country.

Chapter 2: Analytical aspects

Chapter 2: Analytical aspects

Quantification of THC

There are a number of problems besetting quantitative analysis of THC in cannabis products. Firstly, herbal cannabis, and to a lesser extent cannabis resin, is an extremely inhomogeneous material. As well as the flowering tops of the female plant, where most of the THC is located, a sample may contain varying amounts of stalk, seeds and leaves, none of which contains much active drug. It is to be expected that even within a well-mixed single large batch of crude material and following removal of 'unwanted' matter, different aliquots could lead to quite different analytical results. Yet authors rarely publish information on such intra-sample variance.

Given that a suitably 'cleaned' sample has been obtained and that the THC has been efficiently extracted into a suitable solvent such as petroleum ether, then most laboratories proceed to use gas chromatography (GC), often with flame-ionisation detection (Raharjo and Verpoorte, 2004) to determine THC concentration. This has the merit that the naturally occurring precursor (THCA) is decarboxylated to THC, just as occurs during smoking. Cannabinoids can also be determined by high performance liquid chromatography (HPLC), a method suited to profiling ('chemical fingerprinting') and the separate measurement of THCA. To measure the total THC content by HPLC, the sample must be heat-treated before analysis (Kanter et al., 1979; Lehmann and Brenneisen, 1995; Rustichelli et al., 1998).

Other issues to arise in the analysis of THC concern the precision (reproducibility) and accuracy (closeness to the 'true' value) of the measurement process. Poortman van der Meer and Huizer (1999) claimed that in a series of proficiency tests organised in 1997 for 30–40 European laboratories, the relative standard deviation was about 29 % whereas cocaine and amphetamine gave less than 5 % and 8 % respectively. This means that around one third of results for THC were either more than 29 % greater or more than 29 % below the mean value.
It is clear that even worse precision could be expected if the measurement error, caused by the sampling and extraction process noted above, were to be included.

As a reference standard, THC is usually only available from chemical suppliers in the form of an ethanolic solution and may be labelled, for example, as 'approximately 95 %'. Not only could confusion arise if analysts assume the

concentration to be 100 %, but Poortman-van der Meer and Huizer (1999), using the response of a flame-ionisation detector, found that one sample of a commercial THC solution had only 90 % of the concentration of a different commercial solution. These authors recommended that THC quantification should be based on CBN or CBD as the internal standards and a correction made for the expected detector response from the effective carbon number of the respective substances. They claimed that this method had been used in Germany for the past ten years. It was also the method used by Maguire (2001) to study the cannabinoid content of (mostly fibre-type) cannabis in Ireland. However, as far as could be determined from the questionnaire responses, many laboratories in Europe continue to prepare standard dilutions of stock THC solution to construct calibration curves.

Finally, if precautions are not taken during analysis, THC can be lost from dilute solutions because of its propensity to adsorb onto unsilanised glass surfaces (Moffat et al., 2004). As this can affect both 'pure' reference material and extracts of cannabis products, it is a further source of error in THC determination.

Lability of THC in cannabis products and solutions

Atmospheric exposure of THC causes oxidation to CBN and other substances. In cannabis resin, Martone and Della Casa (1990) showed that, even when stored in the dark, the half-life of THC was often less than one year, and in some cases THC had disappeared almost completely within two years. In a block of resin, this could lead to variations in the THC concentration between the outside and the inside. The rate of THC decomposition in cannabis at room temperature was estimated as 17 % per annum by Ross and ElSohly (1997/8). Since CBN is almost entirely absent from fresh cannabis, these authors suggest that the ratio CBN/THC could serve as a measure of the age of a sample. The relevance of this to questions of potency can be understood when it is realised that some imported products may have been harvested or manufactured many months before consumption or analysis. By contrast, and other things being equal, it is to be expected that domestic (i.e. local) production will lead to a fresher product containing more THC.

Natural variation of THC content in cannabis products

There is a wide range of variation in THC concentrations between different samples of a particular product, be that herbal cannabis or resin. Such variation is

often attributed to the quality of different geographical sources as well as the method of cultivation. Whether geographical profiling has any merit is a separate issue, but it is clear that even within a single geographical source, the potency may rise and fall in time. Figure 2 shows the variation in the THC content of herbal cannabis seized by customs in the United Kingdom in the period 1985–1986. Data were derived from Gough (1991) based on measurements at the Laboratory of the Government Chemist (LGC), and have been frequency-grouped according to the number of samples examined in that period. If this distribution had been based on the original individual THC measurements for each sample, then the spread of values would have been even greater. Thus the lowest and highest values in 1985–1986 were 0.9% and 12.2% respectively. Although not shown graphically here, the lowest and highest values found for cannabis resin in that same period were 0.5% and 26% respectively.

As a further example, the frequency distributions of the THC content of sinsemilla and imported herbal cannabis examined in the Forensic Science Service in 1996–1998 are shown in Figure 3 (King, 1998, 2000). During this period, there was no clear trend in the potency of herbal cannabis, but the inter-sample variance was large.

A difficulty faced by all sampling experiments is whether the materials examined are typical of the population. Even when samples are representative, the methods of chemical extraction are efficient and analysis is precise and accurate, it is still necessary to examine an appropriate number and derive the mean and other statistical parameters. This is particularly true of cannabis where, like many natural products, considerable diversity exists between individual samples. Thus, without knowing the lower value or the mean or even the sample size, statements such as were attributed to the situation in Switzerland (Anon, 2002), that cannabis contains up to 28% THC, are almost valueless. The comment (Henry, 2004) that "…the most potent form, skunk, contains up to 30 per cent" is equally unhelpful.

It is clear that cannabis users have constantly been exposed, in almost random fashion, to unexpectedly high and low amounts of THC in the course of their careers. Perhaps what is more significant is that the natural variation in THC content in both herbal cannabis and cannabis resin could far exceed any changes in the mean potency that may or may not have taken place over certain time-spans.

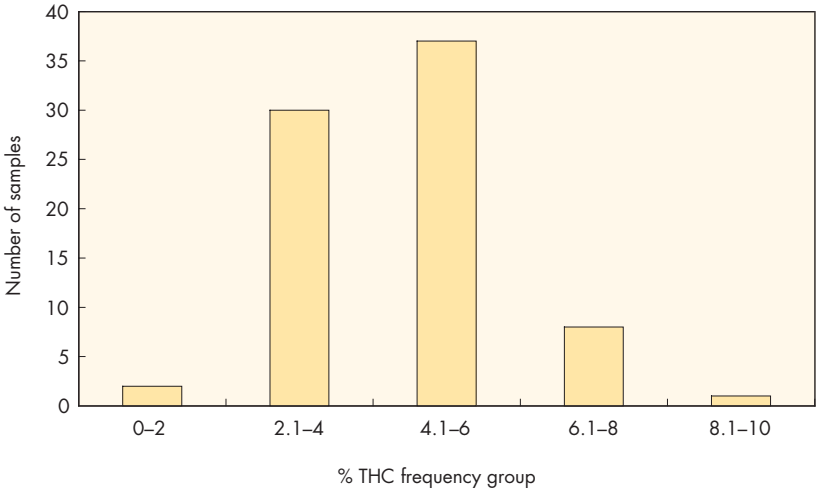

Figure 2: Variation in the mean THC content of imported herbal cannabis samples in the period 1985–1986, weighted by the number of samples from which each mean had been derived (Gough, 1991).

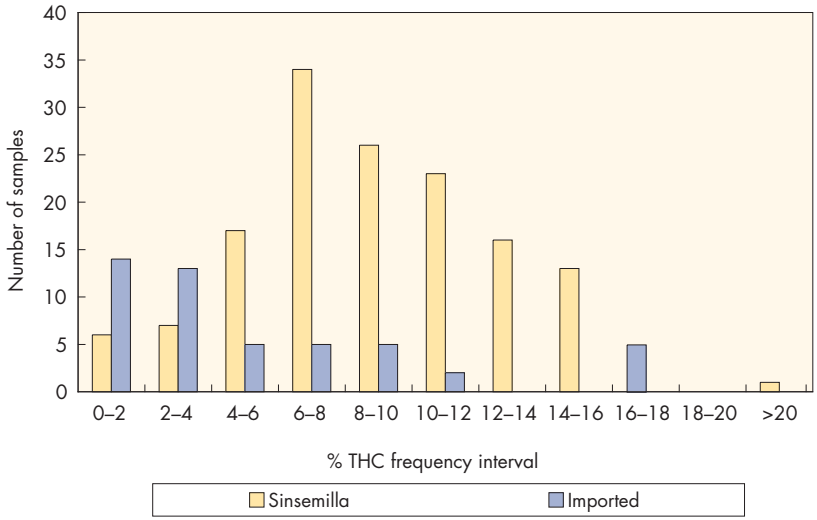

Figure 3: Frequency distributions of THC in herbal cannabis examined in the Forensic Science Service, UK (1996–1998).

Chapter 3: Trends in cannabis potency in Europe

Chapter 3: Trends in cannabis potency in Europe

National reports to EMCDDA (Standard table 14)

Tables 1 and 2 show the mean national potency of cannabis 'leaf' (taken to be herbal cannabis) and cannabis resin respectively in Member States of the European Union and Norway for the period 1996–2001 as submitted to the EMCDDA by the Reitox national focal points in Standard table 14.

Table 1: Mean national potencies (% THC) of herbal cannabis at retail level in Standard table 14 submitted to the EMCDDA (European Union and Norway)

Country	1998	1999	2000	2001	2002
Belgium (i)	–	–	10.4	6.0	6.0
Czech Republic (ii)	–	–	11	11	12
Czech Republic (iii)	–	–	–	1.6	2.65
Germany (i)	–	6.0	6.4	8.6	8.4
Finland (i)	–	–	–	–	2
France (i)	–	–	2	2	8
Hungary (iii)	–	–	–	–	1.1
Italy (i)	8.3	16.9	6.3	5.8	5.5
Latvia (i)	–	–	–	–	1.5
Luxembourg (i)	–	–	–	–	8
Netherlands (i)	–	7.5	10.1	14.6	–
Netherlands (ii)	–	8.6	11.3	15.2	–
Netherlands (iii)	–	5.0	5.1	6.6	–
Norway (i)	–	–	–	–	8
Portugal (i)	1.6	–	–	5.2	3.1
Portugal (ii)	–	–	–	14.6	13.1
UK (i)	7.9	9.5	12.0	9.5	10.7

Notes: Standard table 14 provides herbal cannabis to be reported as (i) cannabis leaves; (ii) nederwiet; (iii) other grass. Data originally listed as '0' or '–' were ignored. Some countries gave separate values for those different forms of herbal cannabis, but all data were used when calculating annual means. Values shown as '<2' by France in 2000 and 2001 were taken as 2. UK refers strictly to England and Wales only. Data for the Netherlands refer to 1999–2000, 2000–2001 and 2001–2002 instead of 1999, 2000 and 2001.

Table 2: Mean national potencies (% THC) of cannabis resin at retail level in Standard table 14 submitted to the EMCDDA (European Union and Norway)

Country	1998	1999	2000	2001	2002
Belgium		–	7.1	13.6	9.7
Czech Republic		15	11.5	11.5	6.3
Germany	–	8.4	10.5	8.6	7.9
France	–	–	7.5	7.5	8
Hungary	–	–	–	–	2.0
Italy	4.9	8.5	8.8	11.2	13.9
Latvia	–	–	–	–	4.5
Luxembourg	–	3.5	8.0	7.1	–
Netherlands	–	12.6	12.8	20.6	–
Norway	–	–	–	8	5
Portugal	4.3	3.7	2.2	5.5	2.6
UK	7.3	2.6	18.1	7.4	–

Notes: Values for resin reported by France in 2000 and 2001 as "5 to 10" are shown above as 7.5. All data were used when calculating annual means. UK refers strictly to England and Wales only. Data for the Netherlands refer to 1999–2000, 2000–2001 and 2001–2002 instead of 1999, 2000 and 2001.

The EMCDDA Standard table 14 lists mean potencies of both herbal cannabis and cannabis resin by country. The original data, upon which the country means were based, were not available. For all years and countries combined, the mean potency values of herbal cannabis and cannabis resin were 7.7% and 8.2%, respectively. Since it is likely that the sample size and sampling strategy varies between countries, these overall mean values should be treated with some caution.

Caution is also required when analysing these data as they are limited to countries where data are available (under-representation of Eastern European countries) and might, for some of them, present reliability problems (e.g. local rather than national data, data not representative of the retail level, uncertainty on the method to calculate averages).

Other national data

The Reitox national focal points were contacted in order to provide names of experts who might be in a position to answer the specific questionnaire developed

for the purpose of this study. For the United Kingdom and the Netherlands, information was obtained by interviewing a number of experts in both countries. Replies to the questionnaire were received from eleven countries: Austria (two sources), Belgium (two sources), Czech Republic (two sources), Estonia, Finland, Germany, Ireland, Luxembourg, Portugal, Slovenia and Spain, but only six countries in total were able to provide potency trend data. The data collected by these means (in 13 countries) are presented below.

Austria

Figure 4 shows the THC content of resin and herbal cannabis in Austria as provided by the Federal Ministry of the Interior. Measurements were made on seizures above 200 g. No distinction was made between imported and domestically produced cannabis, although it was stated that production of the latter was negligible. There is no clear time trend for either product.

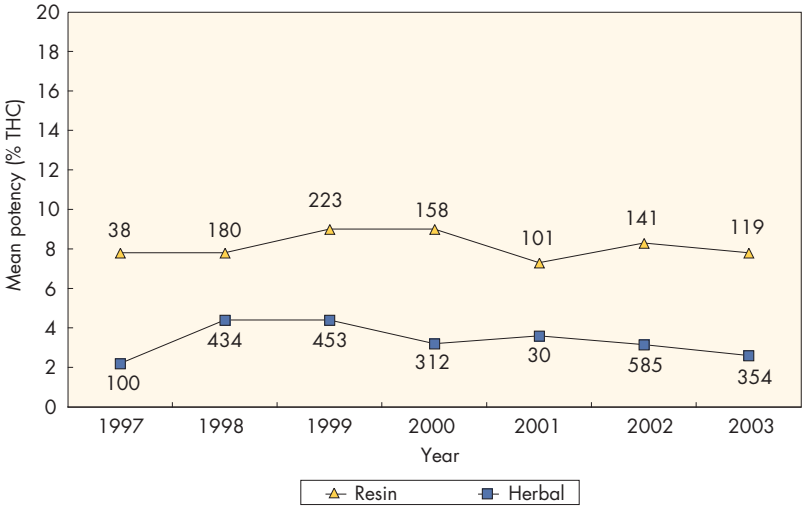

Figure 4: Mean potency (% THC) of cannabis products (1997–2003) in Austria. Values against each point represent the number of measurements.

Czech Republic

Figure 5 shows the THC content of resin and herbal cannabis in the Czech Republic as measured on police seizures and reported by the Institute of Criminalistics. In both cases, there is some evidence that the potency has increased in the period 1997–2003. However, no information was available on the sampling strategy or sample sizes and no distinction was made between imported and domestically produced cannabis.

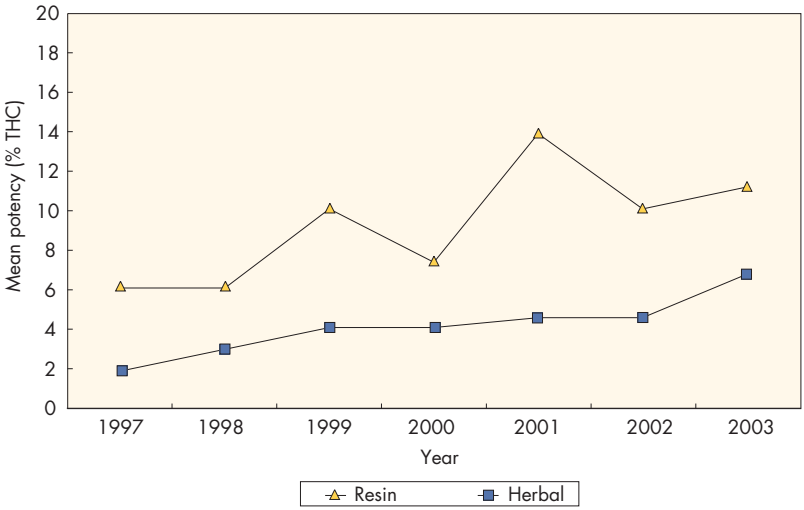

Figure 5: Mean potency (% THC) of cannabis products (1997–2003) in the Czech Republic.

Germany

Figure 6 shows the THC content of resin and herbal cannabis in Germany. The potency of herbal cannabis showed an upward trend in the period 1997–2002, but no long-term trend was obvious for cannabis resin. No distinction was made between imported and domestically produced products. The samples derived from seizures by law enforcement agencies. Each year, the THC content of around 6 000 samples above a weight threshold of 7.5 g were determined by the Bundeskriminalamt, laboratories in the 16 Laender and by five customs laboratories.

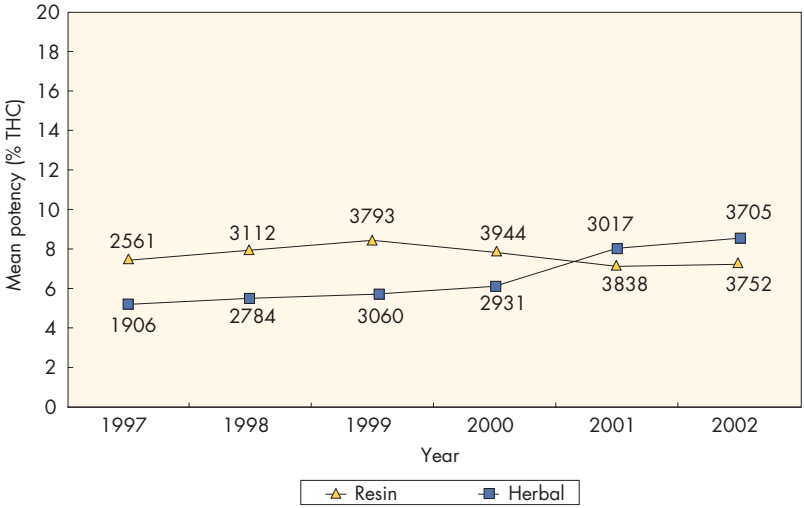

Figure 6: Mean potency (% THC) of cannabis products (1997–2002) in Germany. Values against each point represent the number of measurements.

Netherlands

The THC content of various cannabis products in the Netherlands (Niesink, 2000; Niesink et al., 2002) is shown in Figure 7. Dutch resin (nederhasj) is a locally produced material (see Glossary). Samples were obtained from 'coffee shops'. There are around 800 of these establishments where small-scale supply of cannabis products is tolerated by Dutch law. The total number of samples in the three periods was: sinsemilla = 376; imported herbal = 147; imported resin = 291; Dutch resin = 60. Apart from imported herbal cannabis, the year-on-year increases in THC level were statistically significant ($P < 0.001$).

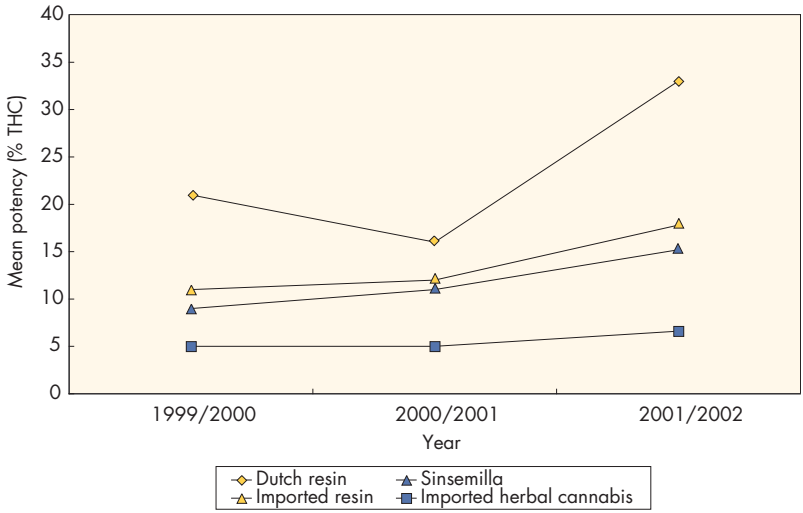

Figure 7: Mean potency (% THC) of cannabis products (1999–2002) in the Netherlands. (Note that scale on the y-axis is twice that for the mean potency in other countries.)

Portugal

Figure 8 shows the THC content of resin and herbal cannabis in Portugal from 1997 to 2003. These were derived from all large seizures (>10 kg) and a random sample of smaller seizures. Although it appears that the potency of cannabis resin has increased, the trend in THC content of herbal cannabis is not clear, particularly because of the small sample size. The value for herbal cannabis in 1999 was not available.

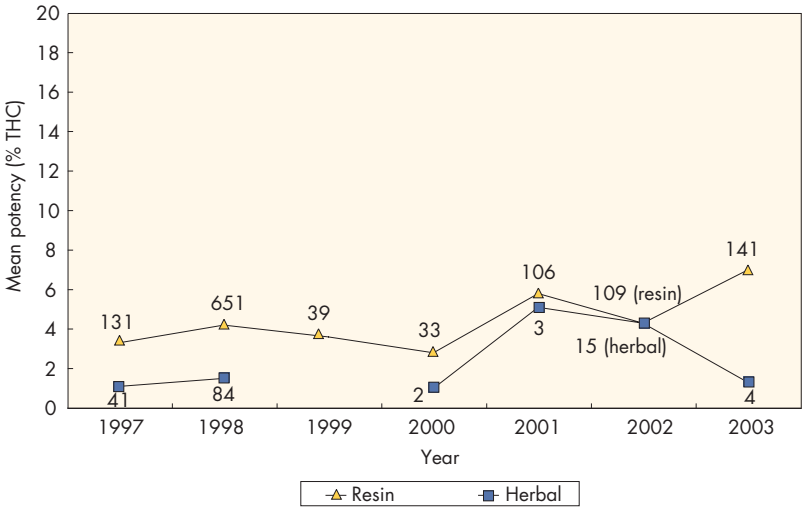

Figure 8: Mean potency (% THC) of cannabis products (1997–2003) in Portugal. Values against each point represent the number of measurements.

United Kingdom

The THC content of various cannabis products examined in the United Kingdom by the Forensic Science Service from 1995 to 2002 (Forensic Science Service, 2003) is shown in Figure 9. The samples derived mostly from police seizures and are judged to be reasonably representative of the material seized for each cannabis product. The total sample size was: sinsemilla = 938; imported herbal = 117; resin = 97. There were no data for resin before 1998 and insufficient data for imported herbal cannabis in 2001 and 2002. There has been a clear trend for an increase in the potency of sinsemilla, but little evidence that the potency of resin or imported herbal cannabis has changed.

For a number of years, the Laboratory of the Government Chemist (LGC) produced data on annual trends in cannabis potency and the variation in THC content of imported material derived from customs seizures (Baker et al., 1980, 1981, 1982; Gough, 1991). Figure 10 shows the THC content of all seized cannabis products in the period 1975–1989 as reported in the most recent publication of the series

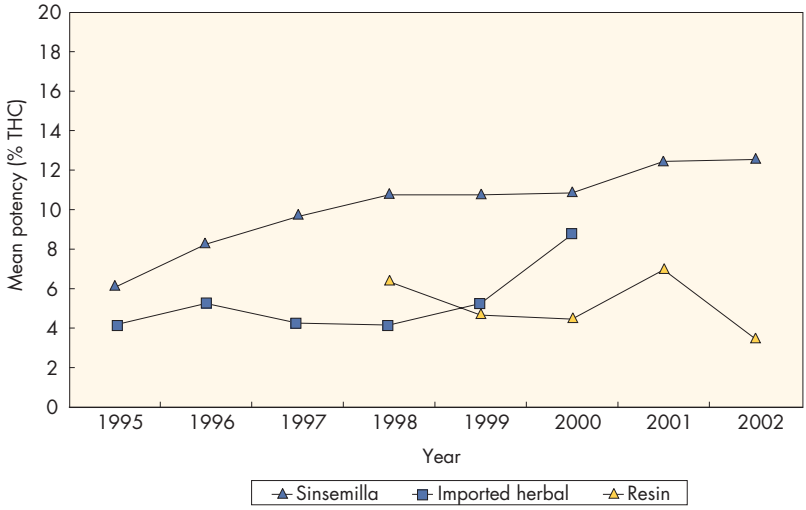

Figure 9: Mean potency (% THC) of cannabis products examined in the UK (Forensic Science Service, 1995–2002).

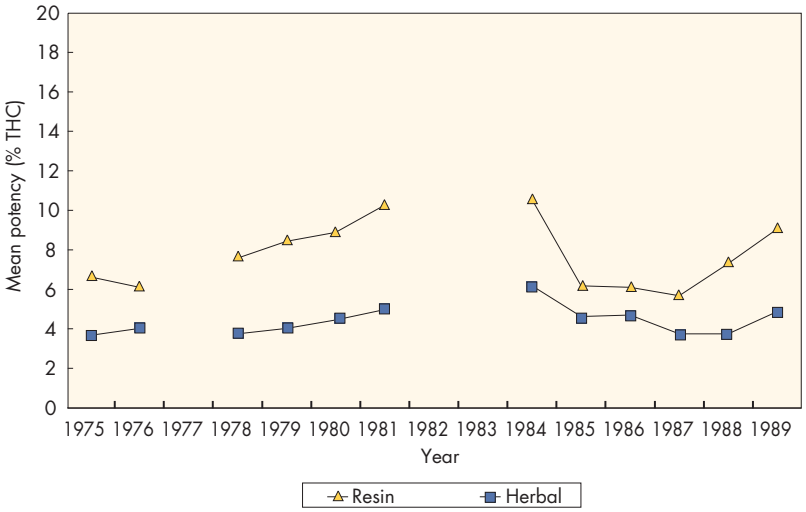

Figure 10: Mean potency (% THC) of cannabis products examined in the UK (Laboratory of the Government Chemist, 1975–1989).

(Pitts et al., 1990). There are major changes on a year-to-year basis, particularly with resin, but no clear overall trend can be discerned for either product. The mean THC content of herbal cannabis and resin was close to 4% and 8% respectively over this period. No data were published after 1989, but information provided by the LGC for 2003 showed that this situation has changed little: the mean THC content of herbal cannabis (type unspecified) was 7.0% (*N* = 23) and for resin was 5.1% (*N* = 6).

Miscellaneous data

Two replies to the questionnaire were obtained from **Belgium**: from the Institute of Public Health and from the Drugs and Toxicology Unit of the National Institute of Criminology and Criminalistics (NICC). Data for 2003 (January to October) only were provided by the Institute of Public Health on the questionnaire. These showed that the mean THC content of resin was 15.2% and herbal 14.2%. No summary of the THC data was provided by the NICC, but it stated that there had been no clear trend in the potency of herbal cannabis or cannabis resin in the period 1995–2002; that during this period both herbal cannabis and cannabis resin had

a mean THC content of around 12%, and in 2003 the mean THC content of herbal cannabis was 13.3% and that of cannabis resin 11.5%.

Although the **Estonian** Police Forensic Science Laboratory occasionally measures the THC content of cannabis products, insufficient data were available to determine trends in potency (source: reply to the questionnaire).

In **Finland**, the THC content of herbal cannabis is determined on request, but no data were provided (source: reply to the questionnaire).

In **Ireland**, analysis of cannabis products for THC is carried out on an occasional basis; the limited data show that the potency of resin has increased from 2.3% in 1981 to 4.2% in 2000. For herbal cannabis, the increase in this period was from 1.4% to 6.2% (source: reply to the questionnaire).

In **Greece**, Stefanidou et al. (1998) reported that the THC content of illicit herbal cannabis seized by customs and police in two areas of Greece ranged from <1% to >4%.

Hungary did not report mean THC levels before 2002 in Standard table 14, or respond to the questionnaire, but the annual national report to the EMCDDA for 2003 notes that the highest THC level found in herbal cannabis has steadily increased since 1996, although even by 2001 this was still a modest 6%.

Analysis of cannabis products for THC is only carried out occasionally in **Luxembourg**; recent samples (type unspecified) contained up to 14% THC (source: reply to the questionnaire).

In **Spain**, the THC content of cannabis products is measured on all seizures above 4 g, but no data were provided in the questionnaire except for the comment that the mean potency of resin had increased from 5.5% in 1994 to 12% in 2002.

Older data on THC levels in European countries can be found in isolated reports, but they provide little useful information on trends. Thus Fairbairn and Liebmann (1974) planted seeds from imported cannabis and allowed them to grow outdoors in southern England. THC levels in the flowering tops ranged from <1% to >7%. The authors concluded that a warm climate with abundant sunshine was not essential to produce substantial amounts of THC. Cannabis plants growing in Jutland (Denmark) in 1988 were found to have mean total THC levels of <1%

(grown outdoors) and 1.35% (grown under glass). In the flowering tops of those grown under glass, the mean THC content was 2.13% (Kaa, 1989). Earlier, Felby and Nielsen (1985) had found mean total levels of 1.55% (range 0.1–4.2%) for plants growing on Bornholm (Denmark). The authors commented that these findings were broadly similar to THC levels of imported herbal cannabis.

Cannabis resin: variations in potency across Europe

To a large extent, and excluding the special situation of locally produced Dutch nederhasj, the cannabis resin consumed in Europe in recent years has originated mostly from North Africa, with smaller amounts coming from south-west Asia. Since resin is rarely adulterated, it could be argued that, in any given year, all laboratories have been measuring broadly similar material. As noted in the section *Natural variation of THC content in cannabis products* (Chapter 2), there is considerable natural variation in the potency of cannabis products even in a single time period. However, if laboratories made sufficient measurements, then the mean potency of cannabis resin in any year should be found to be similar for all countries. In Figure 11, the respective year-on-year trends for cannabis resin potency, already depicted by country in the section *Other national data*, are brought together. Not only is there no overall time trend, but also there is considerable variation in the reported THC levels, both against time in any one country and between countries at any one time. It is not obvious why there should be consistently less THC in cannabis resin in Portugal compared with cannabis resin in, for example, Austria or the Czech Republic. This finding raises questions about the accuracy of measurement of THC in different laboratories/countries. In other words, if all analysts had used the same THC reference standard for instrumental calibration, then these differences might not have occurred.

In the Netherlands, there has been a marked rise in the potency of cannabis resin caused by the domestic production of nederhasj. Figure 12 shows the unweighted mean potency of cannabis resin for the other countries (i.e. excluding the Netherlands). As with the data derived from Standard table 14 (Table 1), there is no clear trend. This diagram (Figure 12) only covers 1998–2002: the years for which all five countries provided data. It is not possible to derive a similar comparison for herbal cannabis in different countries since, in some cases, no distinction is made between two distinct products, i.e. imported and home-grown cannabis.

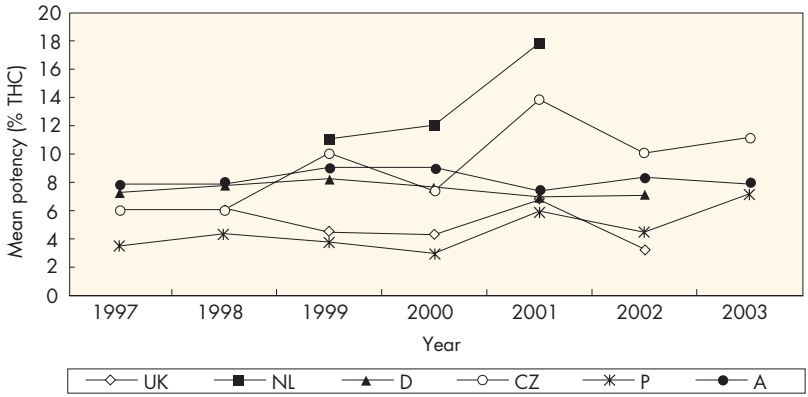

Figure 11: Mean potencies (% THC) of imported cannabis resin in Europe (1997–2003) showing the variation between different laboratories/countries. (UK = United Kingdom, NL = Netherlands, D = Germany, CZ = Czech Republic, P = Portugal, A = Austria.)

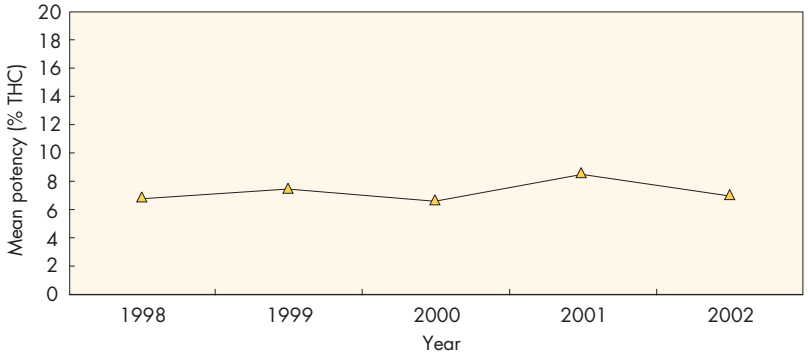

Figure 12: The overall mean potency (% THC) of cannabis resin in Europe (1998–2002) based on data supplied in the questionnaire by the countries shown in Figure 11, but excluding the Netherlands.

Chapter 4: The cannabis market in Europe: potency considerations

Chapter 4: The cannabis market in Europe: potency considerations

The relative consumption of different cannabis products in Europe

The increases that have occurred with time in the potency of some types of cannabis must be put into the context of the relative consumption and production of the various products in different countries. Table 3 sets out estimates of the relative proportion of each cannabis product on the domestic market in recent years in those countries for which data were available in the published literature or were supplied directly in response to the questionnaire or were derived indirectly from the relative number of samples examined. Cannabis oil is uncommon in all countries and is not included in Table 3.

Table 3: Relative consumption (%) of cannabis products in European countries since 1999

Country	Imported herbal cannabis	Cannabis resin	Sinsemilla	Domestic resin
Austria	70 (1)	30 (2)	–	–
Belgium	80 (1)	20 (2)	–	–
Czech Republic	90 (1)	10 (2)	–	–
Estonia	85 (1)	15 (2)	–	–
Germany	40 (1)	60 (2)	–	–
Ireland	5	90	5	0
Netherlands	3	29	67	1
Portugal	10 (1)	90 (2)	–	–
United Kingdom	15	70	15	0

(1) All herbal, imported or not.
(2) All resin, imported or not.

National statistics from law enforcement agencies show a situation where the proportion of resin seized in Europe decreases from west to east. Thus, for the period 1996–2001, resin accounted for 79 % of the total weight of resin and herbal cannabis seized in Western Europe, but in Eastern Europe this proportion was 13 % (UNODC, 2003). This is easily understood when it is recognised that Morocco is the world's largest producer of resin, much of which is destined for Europe. Indeed, the greatest weight of resin is seized in Spain, the first country of transit for this North African material.

However, in relation to the market shares of different cannabis products, seizures may not necessarily parallel availability and consumption, particularly if a country has a large number of small-scale cultivation set-ups that may go undetected by police. Thus, in terms of consumption, the countries of Europe still fall into two clear groups according to whether (a) herbal cannabis or (b) cannabis resin are the most commonly consumed products, but in this division of the countries the east–west split is no longer obvious. The first group (a) includes Belgium, the Netherlands, Austria, Czech Republic and Estonia. In the second group (b) are the United Kingdom, Ireland, Germany and Portugal. The higher relative consumption of herbal cannabis in the Netherlands can be partly explained by the flourishing domestic production of sinsemilla (nederwiet) and the large number of tolerated retail outlets for this product in coffee shops. In the United Kingdom, it is estimated that herbal material comprises only one-third of all cannabis consumed (Atha, 2003) and that around half of this is imported (Hough et al., 2003). The dominance of resin in Ireland is suggested by the fact that over 90 % of reefer cigarettes examined in a survey contained resin (Buchanan and O'Connell, 1988). Maguire (2001) in Ireland also noted that over 90 % of the samples submitted to him by the Garda Drug Unit were resin. The predominant use of herbal cannabis in Eastern Europe is consistent with the pattern of drug seizures (UNODC, 2003), and may reflect the greater separation of these markets from the production sites in North Africa and the local cultivation of cannabis having a greater importance compared to that in Western Europe.

The effective THC level in Europe

The data in the section *Other national data* (Chapter 3) and Table 3 can be combined to give the overall trend in THC levels as perceived by the average user.

This will be termed the effective potency and is derived by weighting the potency of each product by its fractional share of the market and then summing the individual values. For example, if in a given year the THC contents of different products are *a*%, *b*% and *c*% and the respective share of the market is *x*, *y* and *z* (where $x + y + z = 1$), then the effective THC level in that year is given by $(ax + by + cz)$. It is assumed that the market share data in Table 3 were typical for the entire period. Figure 13 shows the effective potency in several European countries. It will be seen that, apart from the Netherlands, there has been no marked increase in the effective THC level in the five other countries. Since the THC contents of imported herbal cannabis and cannabis resin have shown no real change over the years, then, other patterns of behaviour being constant, the typical consumer in countries where most cannabis products are imported (e.g. United Kingdom) will have been partly shielded from the increased potency of sinsemilla. Although not developed graphically here, the United Kingdom data for the earlier period 1975–1989 (Figure 10) suggest that the effective potency in the United Kingdom has been around 6% for the past thirty years. In Ireland, where resin is also the main product, the effective potency in 2000 was closer to 4%.

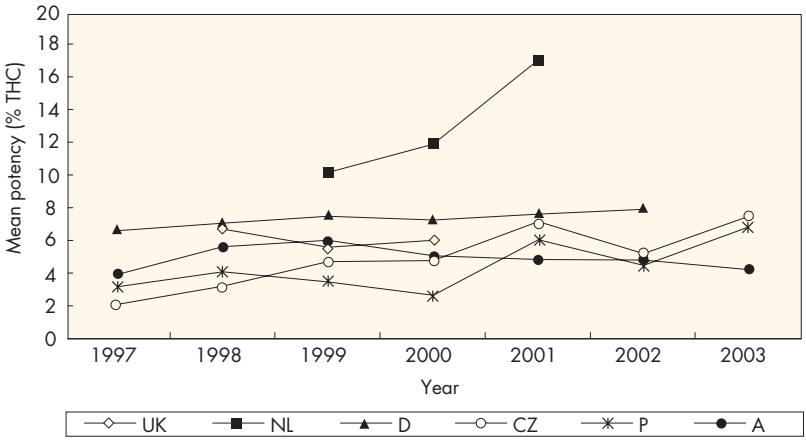

Figure 13: Effective potency (% THC) of cannabis products in several European countries (UK = United Kingdom, NL = Netherlands, D = Germany, CZ = Czech Republic, P = Portugal, A = Austria).

There are two important limitations that must be borne in mind in drawing conclusions from this analysis. First, data are only available from six countries for this analysis. Second, whilst it is reported that home-grown herbal cannabis does not currently hold a major share of the market in countries other than the Netherlands, systematic data to support this contention are limited. This suggests an urgent need to improve our understanding of the relative market share of different cannabis products and track changes in the illicit cannabis market over time.

Extent of cannabis cultivation in Europe

Since cannabis can be cultivated by indoor methods using artificial lighting, it may be grown in all countries. However, the highest level of production in Europe occurs in the Netherlands and to a lesser extent in the surrounding countries. The Institute of Forensic Medicine in Innsbruck claimed that the domestic production of cannabis in Austria is negligible. In the United Kingdom, each year police raid several hundred indoor cannabis cultivation scenes, ranging from rooms in homes to large-scale factories. Although the interception rate is unknown, there are likely to be many thousands of illicit cultivation sites in operation at any one time. Although nearly half of all herbal cannabis consumed in the United Kingdom is of the sinsemilla type, some has clearly been imported and the significance of domestic production is difficult to estimate. In some countries, seeds and specific equipment for indoor cannabis cultivation (e.g. lights, rock wool, nutrient media and irrigation systems) can be bought from retail shops, but the recent trend has been for on-line sales through the Internet.

Although fibre-phenotype cannabis is easily cultivated, even in northern latitudes, the climate in most European countries is not suitable for the economic outdoor production of drug-phenotype cannabis. Domestic production of cannabis resin in Europe is almost entirely located in the Netherlands, where it is produced from herbal cannabis grown indoors. But even here it is a minor contributor to the overall cannabis economy.

Cannabis content of cigarettes

On a weight basis, the content of cannabis cigarettes examined in the United Kingdom and Ireland over the past twenty years has been remarkably constant (Figure 14). Thus, the typical reefer cigarette contains about 200 mg of herbal

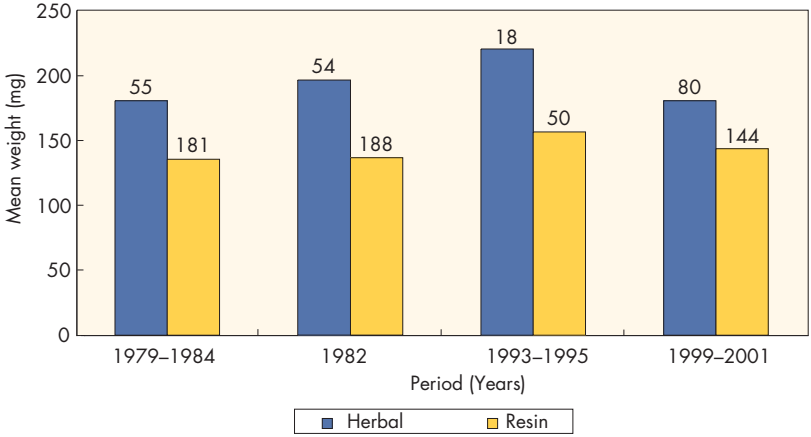

Figure 14: Mean herbal cannabis and cannabis resin content of reefer cigarettes examined in the Forensic Science Service (UK) over a twenty-year period. The sample size in each case is shown above the bar.

cannabis or 150 mg of cannabis resin, equivalent to around 10 mg of THC (Humphreys and Joyce, 1982; Bal and Griffin, 2001). Similar findings were reported in Ireland by Buchanan and O'Connell (1998), where the mean herbal cannabis content of cigarettes was 260 mg (N = 179) and the mean resin content was 102 mg (N = 2 025). The absence of any decline in the amount of herbal cannabis or resin used may suggest that there has been no long-term increase in the THC content of the average cigarette. In other words, users have not felt a need to consume less herbal cannabis or resin in their cigarettes. The assertion by Ashton (House of Lords, 1998) that "… a typical 'joint' today may contain 60–150 milligrams or more of THC", suggests a potency of over 50 %: a value far in excess of even the most extreme samples.

Street prices

In the absence of THC measurements, street prices of cannabis could provide indirect information on changes in the quality of cannabis, particularly if there is a price differential between different forms.

In the Netherlands (Trimbos, 2002) there has been a close correlation between the mean THC content of different products and the price (Figure 15). A correlation also occurs within samples of sinsemilla although factors other than the amount of active constituent, such as variety, may also be involved (Niesink et al., 2002).

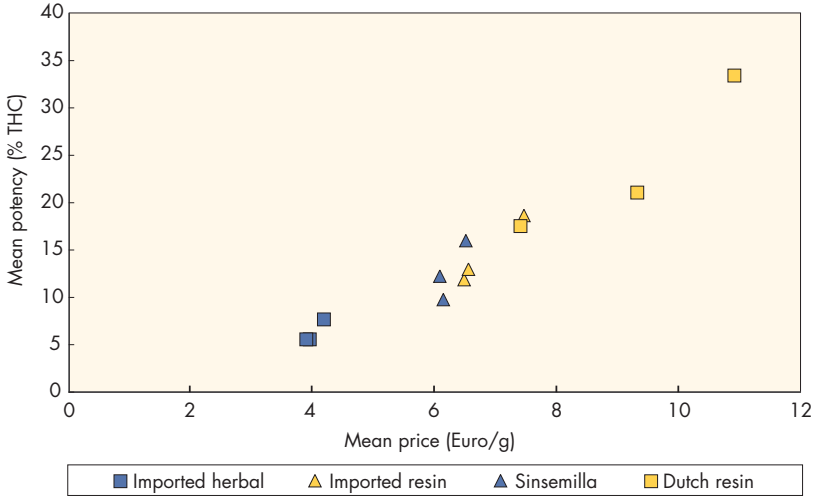

Figure 15: Correlation between price (EUR/g) and the mean THC content of various products in the Netherlands. Three sets of prices/THC levels are shown for each of the four products; they relate to measurements in winter 1999, 2001 and 2002 respectively.

In the United Kingdom, good quality sinsemilla sells for an average EUR 6–7/g, whereas imported cannabis and cannabis resin are mostly priced at an average of EUR 4–5/g (Atha, 2003). This differential (i.e. a factor of approximately 1.5) is consistent with the relative THC concentrations in recent years as shown in Figure 9. In Germany, resin is sold for EUR 4–9/g and herbal cannabis for EUR 5–11/g. In the Czech Republic, sinsemilla costs EUR 6–10 or more per gram, but other herbal cannabis is EUR 3–7/g. By contrast, in Portugal, resin sells for an average EUR 2.49/g whereas herbal cannabis, a lower potency product, sells for EUR 4/g. In Luxembourg, both herbal cannabis and cannabis resin sell for around EUR 8/g.

There was some inconsistency in the estimates of the price of cannabis products at street level between data collected specifically for the purposes of this study (questionnaire) and those provided by Reitox national focal points as part of the EMCDDA ongoing monitoring activities. This discrepancy is perhaps not surprising given the complexities of producing reliable price information on the illicit drug market. Nonetheless, it does suggest the need for more consideration of how methods can be improved to provide a better picture of this important facet of illicit drug use.

Chapter 5: Trends in cannabis potency in other countries

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USA

Data on the THC content of cannabis products in the USA have been collected by ElSohly et al. (1984, 2000) for many years as part of the University of Mississippi Potency Monitoring Project. Samples were submitted by law enforcement agencies and it has to be assumed that they were representative of the market. Mean THC values are shown in Figure 16 for normal herbal cannabis, sinsemilla and resin. The anomalously high value for resin in 1997 (19.24%) has been excluded; it was based on only five values and is over nine standard deviations above the mean potency for the period 1980–1996. Although there has been an increase in the potency of herbal cannabis over the twenty-five-year period, cannabis resin (and hash oil) showed no long-term trends since 1980 when data were first collected. Although the potency of sinsemilla showed a clear upward trend in the final three years of the study, no such trend was obvious when the longer period of 1980–1995 is examined, particularly in view of the wide variations in potency that occurred from year to year (ElSohly et al., 2000). The THC content of herbal cannabis increased from around 1% before 1980 to around 4% in 1997. This increase, when seen in the European context, is deceptive. Before 1980, all mean herbal cannabis THC levels in the ElSohly study were less than 2.4%. By contrast, and as shown in Figure 10, comparable levels at that time in the United Kingdom were twice as great. In other words, it must be assumed that the quality of herbal cannabis consumed in the USA more than twenty years ago was unusually poor, but that in recent years it has risen to levels typical of Europe. So even the modest increase found by ElSohly et al. (2000) may be less significant than it seems. A recent analysis of cannabis seized in Florida in 2002 (Newell, 2003) showed amounts of THC found in samples ranging from 1.41% to 12.62%; the average THC content was 6.20%, which is almost identical to the 2002 value reported by the University of Mississippi Potency Monitoring Project.

However, there are major differences in the market between the USA and Europe. In most European countries, cannabis resin, originating almost entirely from North Africa, is more commonly used than herbal cannabis. Herbal cannabis imported into Europe originates from the Caribbean, Africa and the Far East. In the USA, normal forms of herbal cannabis are either grown domestically or imported from Mexico, with Canada a major supplier of sinsemilla (DEA, 2002). By contrast, cannabis resin is uncommon in the USA. Thus in the latter years of the studies by ElSohly et al. (2000), cannabis resin comprised less than 1% of samples.

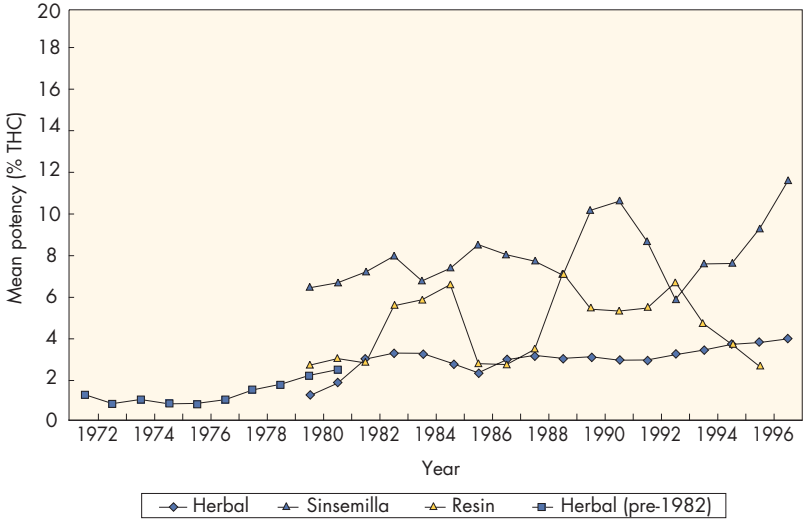

Figure 16: Mean potency (% THC) of cannabis products examined at the University of Mississippi, USA (1972–1997).

The effective THC level in the USA

The effective potency of cannabis products was defined in the section *The effective THC level in Europe* (Chapter 4). In the USA for the period 1980–1997, the approximate mean respective shares of the material examined were: herbal cannabis, 85%; sinsemilla, 5%; resin, 3%; other, 7%, where 'other' includes minor products such as 'ditchweed' (poor quality, locally grown cannabis), hash oil and Thai sticks. Figure 17 shows the effective potency experienced by users in the USA using data published by ElSohly et al. (2000) for the mean THC content of all samples examined. Although there is a slight upward trend over the period 1980–1997, the effective potency of the aggregated cannabis products has been low by European standards, largely as a result of the low proportion of sinsemilla consumed.

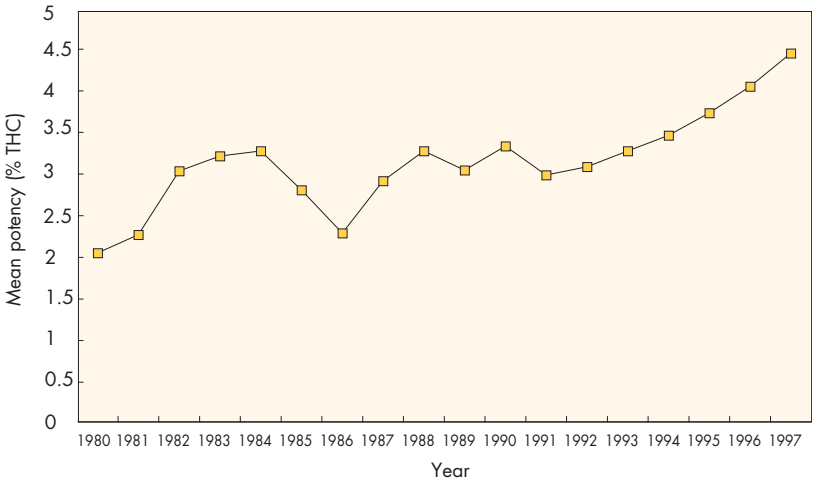

Figure 17: Effective potency (% THC) of cannabis products in the USA.

New Zealand and Australia

Poulsen and Sutherland (2000) reported the potency of cannabis products from 1976 to 1996 in New Zealand. In the earlier years of this study, the material examined was mainly imported cannabis oil and resin, and both local and imported cannabis plant material seized by the police. In later years, little imported material was seized: cannabis plants were grown locally, cannabis oil was manufactured locally and cannabis resin was rarely seized. Cannabis leaf contained on average 1 % THC and the female flowering heads contained on average 3.5 % THC. The average potency of cannabis oil fell from a peak of 34 % THC in 1985 to 13 % THC in 1995. Over the twenty-year period, the average potency of the cannabis products available to the user did not increase. In Australia, Hall and Swift (2000) found only a modest increase in the THC content of cannabis in recent years and suggested that the increase in cannabis-related problems among young Australians was more likely to be due to earlier and heavier use. The absence of any clear time trend in cannabis potency in New Zealand and Australia is similar to the situation reported above for most European countries, but despite the focus on domestic production in New Zealand in recent years, the THC levels are low by European standards.

Chapter 6: Identification of information gaps, priorities for future research and recommendations

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There are a number of areas that require attention at national level if information on cannabis potency is to be collected, analysed and made available in a systematic way including: nomenclature, relative consumption of cannabis products, extent of domestic indoor cultivation, street prices, laboratory analysis, data collection and finally data presentation at the European level.

Nomenclature of cannabis products

At present, a variety of different names are used to describe similar materials. It is suggested that *herbal cannabis* (i.e. not 'marijuana', 'leaf', 'weed', 'grass', 'flowering tops', 'buds', 'drug-phenotype', etc.) should be used to refer to the fresh or (more commonly) dried leaves and flowering tops, but excluding stalk, roots and seeds of *Cannabis sativa*. The term *hemp* should be reserved, if necessary, for cannabis of the fibre-phenotype. When a distinction is required between imported and domestically grown herbal cannabis, then the former should be described as *imported herbal cannabis* and not 'seeded cannabis'. Since cannabis cultivated by intensive indoor methods invariably derives from unfertilised female plants, then this material should be called *sinsemilla* rather than 'unseeded', 'nederwiet', 'skunk', etc. *Cannabis resin* or just *resin* (i.e. imported products) should be used in preference to 'hashish' or 'hash', but when locally produced resin is involved, for example in the case of the Netherlands, *'Dutch' resin* may be more acceptable than 'nederhasj'. *Hash oil*, the term in most common use, and *cannabis oil* are both acceptable for solvent extracts of herbal cannabis or cannabis resin. Given that it is necessary to build a consensus of concerned authorities for the adoption of a common nomenclature, it may be desirable for the EMCDDA to work towards this objective within its work to harmonise definitions and produce standardised data on the European drug situation.

Relative consumption of cannabis products

In most countries, estimates of the relative consumption of different cannabis products are based largely on seizure data. Such data have limits and may not directly reflect drug availability as experienced by drug users or the relative

market share of different cannabis products. Given the importance of this information in estimating the potency of the cannabis being consumed in Europe there is an urgent need to improve data quality in this area. One possible way forward is to complement statistics from drug seizures with data from user surveys carried out at the retail level. Such information is necessary if it is required to track the health impact of cannabis potency, since this is more a function of product type (particularly sinsemilla versus cannabis resin) than other factors. Currently, such activities are limited, but methodologically feasible, and could be accomplished for relatively modest resource investment. Both focused surveys of cannabis users and general population survey approaches could prove useful.

Extent of domestic indoor cultivation

Following on from the previous recommendation, it is important to understand better the extent of domestic cannabis production, the different types of production methods used, as well as the use of domestically produced cannabis products compared to imported products and how this varies within Europe and over time. Experience in the Netherlands suggests that the availability of cannabis produced locally, with more sophisticated techniques and higher yielding varieties, has a major impact on potency, even within a single cannabis product. Even when herbal production is considered, it is important to note the relative potency of the products being produced, changes in overall potency over time and the proportion of the product that is of exceedingly high potency. In wider Europe, it is important to remember that home-produced cannabis may not always benefit from hydroponics or other sophisticated growing techniques. These factors all need to be considered in any comprehensive analysis of the cannabis market in Europe.

Content of cannabis cigarettes

Few countries have published data on the herbal cannabis or cannabis resin content of cigarettes. This information would be useful as a proxy measure for potency as well as a means of tracking methods of consumption (i.e. use with or without tobacco).

Pharmacology

Most pharmacological studies on the effects of cannabis potency have been carried out in North America. Because of major differences in overall potency levels and methods of consumption (i.e. use with or without tobacco) between North America and Europe, it would be useful to conduct similar studies in Europe, reflecting European consumption norms. As well as covering the relationship between smoking behaviour and potency, such studies should also include the relationship between potency and blood THC/metabolite levels. Monitoring over time the methods and practices used by cannabis consumers may also be important. For example, some anecdotal reports exist of a move towards the use of water pipes in some countries, and new smoking technologies have been advertised in the media aimed at cannabis smokers.

Street prices

In Europe, information is collected routinely by the EMCDDA on drug prices at retail level. However, as discussed earlier, the quality and comparability of this information needs to be reviewed and standard methods for collection and reporting developed. Important here is developing classification and reporting standards that distinguish between different cannabis products. Data from the Netherlands suggest a close relationship between potency and price.
It is necessary to explore this issue in other countries and in the context of consumer preferences and other drug supply side information.

Laboratory analysis

The data examined in this survey strongly suggest that there could be problems in the accurate analysis of THC. In the first instance, this suggests it is necessary to organise quality assurance trials to determine both precision and accuracy of laboratory measurements in all member states. From this, recommendations on best practice could be developed. Possible partners in this endeavour would be the European Network of Forensic Science Institutes (ENFSI) and the United Nations Office of Drugs and Crime (UNODC).

Statistical aspects of data collection

When compiling data, many laboratories calculate simple mean values (often called averages: the sum of all values divided by the number of values). In a few cases, weighted means may be calculated (see, for example, ElSohly et al., 1984). The weighted mean takes account of the fact that not all samples may be of equal size. When considering seized material for example, the weighted mean is effectively the mean that would be found if all seizures were to be pooled and thoroughly mixed. Furthermore, few authors consider whether the distribution of potency is normally distributed or if other measures of central tendency such as the median or mode would be better. It is recommended that data submitted to the EMCDDA should always indicate details about the sampling strategy, sample size, the mean, and where possible more detailed descriptive statistical information (e.g. mode and median values, standard deviation, treatment of outliers).

Other policy issues

Statements in the popular media that the potency of cannabis has increased by ten times or more in recent decades are not supported by the data from either the USA or Europe. As discussed in the body of this report, systematic data are not available in Europe on long-term trends and analytical and methodological issues complicate the interpretation of the information that is available. Data are stronger for medium and short-term trends where no major differences are apparent in Europe, although some modest increases are found in some countries. The greatest long-term changes in potency appear to have occurred in the USA. It should be noted here that before 1980 herbal cannabis potency in the USA was, according to the available data, very low by European standards. A caveat here is that there is some question to how far the historical data provide a true representation of the situation. More recently, potency data suggest a convergence with the European situation. For the reasons discussed earlier in this report, caution should be made in drawing direct comparisons between Europe and the USA on this issue.

It should be noted that the modest changes that have occurred in THC levels in Europe appear largely confined to the relatively recent appearance on the market of intensively cultivated cannabis. Herbal cannabis is less commonly consumed than cannabis resin in most European countries, although this may be beginning to change. It should also be made clear that the THC content of cannabis products

is extremely variable and there have always been some samples that have had a high potency. Nonetheless, some hydroponically grown cannabis appears to be consistently of high potency. This product appears to have at present only a relatively small market share in most countries. A note of caution is required because the available data makes it difficult to judge with confidence the actual market share of high potency cannabis or to monitor trends. The issues raised by an increase or potential increase in the availability of high-potency cannabis may make it prudent to consider whether specific targeted demand or supply side activities are needed.

In considering individual dose exposure to cannabis and the relationship to health and other problems, it must be noted that cannabis potency is only one factor and possibly of limited importance. Hall et al. (2001) note that individual exposure to cannabis may have risen but this is more likely to be influenced by earlier initiation and more frequent and intensive patterns of use rather than the potency of the cannabis used in any one exposure. An evaluation carried out by the 'Co-ordination Centre Assessment and Monitoring New Drugs' (CAM) in the Netherlands concluded that higher-potency cannabis products did not pose any additional risk than those present for cannabis products as a whole, either to the individual, to society, to public order or criminality (W. Best, personal communication, 2004). In this respect, it is noted that cannabis with a potency of 18 % is available as a prescription medicine in the Netherlands. Even if some potency increases in illicit cannabis have occurred, the absence of direct evidence of any clear additional health risk should be noted. However, overall, the evidence base in this area is weak. If acute cannabis problems are considered, such as panic attacks, a short-term dose-related impact is plausible. The relationship of cannabis consumption to the development of psychiatric disorders is also poorly understood, and again it would be prudent to consider if high-potency cannabis might be an issue here. In summary, the extent to which high-potency cannabis increases the short and long-term dose to which individuals are exposed remains unclear, as does the evidence of any clear and direct additional health risks. This remains, therefore, a critically important area for future research studies as this information is a pre-requisite to understanding the potential public health impact of high-potency cannabis.

Glossary ([1])

BC-bud: *Sinsemilla* produced in Canada (BC = British Columbia)

Bracts: Structures situated at the base of the flowers of *Cannabis sativa*, which may partly surround a developing seed and which are rich in *glandular trichomes*

Buds: Flowering tops of female *Cannabis sativa*

Cannabidiol: One of several *cannabinoids* in *Cannabis sativa*

Cannabinoid: One of a group of compounds found only in *Cannabis sativa* including *cannabidiol, cannabinol and tetrahydrocannabinol*

Cannabinol: One of several *cannabinoids* in *Cannabis sativa*

Cannabis oil: See *hash oil*

Cannabis resin: Material produced by mechanically separating the resinous parts of the *flowering tops* of *Cannabis sativa* from other vegetable matter

***Cannabis sativa* L.:** Generally regarded as the only species in the genus *Cannabis* and sole source of *cannabinoids*. Classified by Linneaus in the eighteenth century

Ditchweed: Low quality *herbal cannabis* growing wild in North America

Dronabinol: Synthetic preparation of *tetrahydrocannabinol* with medicinal uses

Drug-phenotype: Variety of *Cannabis sativa* where the ratio [(% *tetrahydrocannabinol* +% *cannabinol*)/% *cannabidiol*] is greater than 1.0

Dutch resin: Light green or brown *Cannabis resin* produced mostly in the Netherlands from locally grown *herbal cannabis* using sieves or other separation methods

Fibre-phenotype: Variety of *Cannabis sativa* where the ratio [(% *tetrahydrocannabinol* +% *cannabinol*)/% *cannabidiol*] is less than 1.0

Flowering tops: *Herbal cannabis* excluding leaf. May be used to mean *sinsemilla* or seeded material

([1]) Italicised words and terms are themselves defined.

Glandular trichomes: Microscopic features used to identify *herbal cannabis* or *cannabis resin*. They produce an exudate containing *cannabinoids* and are located mostly around the *flowering tops* of female plants of *Cannabis sativa*

Grass: *Herbal cannabis*

Hash oil: A dark green or black tar-like material made by solvent extraction of either *cannabis resin* or *herbal cannabis*. May contain 30–50 % *tetrahydrocannabinol*

Hashish: *Cannabis resin* (North America and elsewhere)

Hemp: *Herbal cannabis* with low *potency* used for fibre production

Herbal cannabis: Normally restricted to the fresh or (more commonly) dried leaves and *flowering tops,* but excluding stalk, roots and seeds of *Cannabis sativa*

Imported herb: *Herbal cannabis* from non-European, often tropical, sources and generally found as a mixture of *leaf, flowering tops* and seeds in compressed blocks

Isolator (also ice-o-lator): Device consisting of a mesh bag used to separate resinous particles from *herbal cannabis* in the production of *nederhasj*

Joint: A cannabis cigarette (also spliff, reefer etc.)

Leaf: *Herbal cannabis* that may or may not contain *flowering tops*

Marijuana: *Herbal cannabis* (North America)

Nederhasj: See *Dutch resin*

Nederwiet: *Sinsemilla* produced in the Netherlands

Potency: The *tetrahydrocannabinol* content. Used in preference to *purity*

Purity: The proportion of active constituent in a product, but less suitable for cannabis products where *potency* is preferred

Sinsemilla: 'Without seed' (Spanish). The highest *potency herbal cannabis* comprising the *flowering tops* of unfertilised female plants of *Cannabis sativa* produced in open cultivation or, nowadays, by indoor methods

Skuff: Alternative term for *nederhasj*

Skunk: *Herbal cannabis* with a characteristic odour that has been typically grown by indoor intensive cultivation and may have a high *potency*

Spacecake: Cake made using *herbal cannabis* most commonly found in the Netherlands

Tetrahydrocannabinol (THC): The principal *cannabinoid* with sought-after psychopharmacological effects

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