

THC concentrations in weed, Dutch weed and hash in Dutch co-ee shops (2021-2022)



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(2021-2022)

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Preface

At the request of the Ministry of Health, Welfare and Sport, research was conducted into the strength of cannabis products as offered for sale in Dutch coffee shops. For the research, cannabis and hashish products were anonymously purchased in fifty coffee shops in the Netherlands in December 2021 and January 2022. The samples have been analyzed by our permanent laboratory for the percentage of THC, CBD and CBN.

This research is an annual monitor of the content of hashish and weed, as purchased by consumers in the coffee shop. The first study took place in 1999. The results in this report come from 23^e annual measurement. A second special edition, given the corona measures still in force during the sampling, because the coffee shops were only pick-up locations, it was possible to talk to the staff for less time.

Our thanks go to everyone who participated in this study, including the staff at the addiction care institutions who helped purchase the samples. Last but not least, we are indebted to the staff and owners of the coffee shops we visited as part of this research. We are grateful to them for their cooperation in providing information about the products purchased from them.

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Resume

This report describes the results of the twenty-third annual study into the strength of cannabis products as offered for sale in Dutch coffee shops. The research was carried out at the request of the Ministry of Health, Welfare and Sport. 50 Dutch coffee shops have been randomly selected from the most recent list of tolerated coffee shops. For the purpose of the research, 61 samples of Dutch weed (most popular variant), 62 samples of foreign hashish, 4 samples of weed of foreign origin and 19 samples of hash prepared from Dutch weed (nederhash) were purchased. Also, 49 cannabis samples were purchased that were designated by the employees of the coffee shops as the “most strong” and 6 cannabis samples were purchased that were said to mainly contain CBD. The purchase was made anonymously. It is therefore impossible to determine which cannabis sample came from which coffee shop. The coffee shops did not know in advance about the visit of employees of the Trimbos Institute or the addiction care institutions. After purchasing the samples, the coffee shop owner was informed of the purpose of the research and was asked whether some additional questions could be asked about the purchased samples.

Traditionally, hash contains more THC than weed. This is because hash is a concentration product of cannabis. Imported hash contains on average more THC than imported weed (26.8% versus 2.4%) and Dutch hash (nederhash) contains on average more THC than the most popular Dutch weed (35.7% versus 17.2%).

The average THC percentage in the most popular (and therefore most sold) Dutch cannabis was significantly higher this year than in the previous measurement: it increased from 14.6 to 17.2%. This fits in with the trend of the past 15 years, in which the THC content of the most popular Dutch cannabis fluctuates between approximately 15 and 18%. The average THC concentration in cannabis purchased as the “most strong” did not differ significantly from last year (17.0% in 2020/2021 versus 17.5% in 2021/2022). Here too, a fluctuation between approximately 15 and 18% has been noticeable for years. The average THC percentage in the strongest Dutch cannabis sold does not differ significantly from that of the most popular Dutch cannabis. Imported cannabis contained on average less THC than the other cannabis products (2.4%), which is not significantly different from last year's measurement (4.0%). The number of coffee shops that sell imported cannabis is very limited.

Dutch hash contained an average of 35.7% THC. With Dutch hash, the average THC content fluctuates over the years between approximately 25 and 35%, a wide range. This is probably due to the limited number of samples that could be purchased in this category in the past. This year's significantly increased average content is undoubtedly a better reflection of reality, because a larger number of samples have been collected. The THC percentage for imported hashish averaged 26.8% last year. This does not differ significantly from the 24.3% measured last year. Over the past 10 years, the THC content of imported cannabis has gradually increased from approximately 15% to approximately 25%. Over the years, the average THC content in imported hash was often comparable to that of Dutch weed. The most striking difference in composition between the two types is that imported hashish, in

Unlike Dutch weed, it also contains a significant amount of CBD (median 3.2% versus 0.0%). Although the median CBD content in imported hashish has increased significantly over the past year compared to last year's measurement (2.2%), this is still considerably lower than the median levels of a number of years ago. These often exceeded 7.5%. These changes in THC and CBD levels could be explained by a further shift from traditional hash-making methods to methods using Dutch cannabis-like plants. The modern (high THC, low CBD) and traditional (high THC and CBD) imported hashish varieties can no longer be distinguished by name.

Dutch weed, imported weed and Dutch hash hardly contain any CBD (median for most popular and strongest weed 0.0%, for imported weed 0.1%). The median CBD content of both types of Dutch weed decreased in this measurement from 0.1% in last year's measurement. This is partly explained by the fact that this year the variants sold as "CBD weed" were no longer included in the strongest or most popular Dutch weed category, unlike in previous years. This year, 6 types of cannabis were sold as CBD cannabis. Five of these contained a significant amount of CBD (median 13.2%); one sample contained no CBD, but only THC.

The average price for the most popular type of Dutch weed (€11.70 per gram in 2021, €11.17 per gram in 2022) did not change significantly this year. The same applied to imported cannabis (€3.79 compared to €4.67 in 2021) and the supposedly strongest cannabis strain (€14.21 in 2021, €15.45 in 2022). When looking at the long-term developments, it can be seen that there has been a significant increase for both the most popular and the strongest Dutch weed since 2007 (respectively from around €7 to around €11 and from around €7 to around €14). The price for a gram of imported cannabis has fluctuated between €4 and €6 over the past 10 years and was significantly lower than that of other cannabis products (€3.79 in 2021/2022). The price for a gram of Dutch hash was always higher than for any of the other cannabis products, but not this year, as in the previous measurement (€12.53 compared to €13.80 in the previous measurement; difference with previous measurement not significant). The average price paid for a gram of imported hashish was around €7 at the beginning of this century and has since gradually risen to just over €10 in recent years. However, over the past year the price for a gram of imported hashish dropped significantly (€11.74 in 2021 versus €10.55 in 2022). It is also notable that this year, for the first time, no correlation can be demonstrated between the THC content and the price of either weed or hashish: this underlines the importance of good information provision in the coffee shop.

1 Introduction

Commissioned by VWS, the strength of cannabis products, such as those offered in Dutch coffee shops, has been systematically mapped since 1999 (Pijlman et al., 2005; Niesink et al., 2015). To this end, a selection of cannabis products are purchased anonymously every year in 50 coffee shops across the country. The products are analyzed in a specialized laboratory for THC, CBD and CBN content. This report contains the results of the 23rd annual measurement discussed.

1.1 The cannabis plant

The hemp plant with the genus name *cannabis* belongs to the Cannabaceae (hemp family) family. Also the hop plant (*Humulus lupulus*) belongs to the hemp family. Hemp has been cultivated and refined for thousands of years for its fiber, seed and oil, but also for the psychoactive properties of the plant (Clarke and Merlin, 2013).



Figure I-1Buds of a male (left) and female plant (right) of *Cannabis sativa*. The male plant is much smaller and less branched than the female. Only the female plant is used for its psychoactive effect.

Cannabis is naturally a hermaphroditic, dioecious plant, that is, it has both male and female flowers (Figure I-1), each occurring on separate plants (Paris and Nahas, 1973). For the purpose of hemp fiber production, monoecious varieties are grown in which the male and female inflorescences grow on one plant. In general, the female plant is highly branched and can grow between 3 and 4 meters high. Male plants are usually smaller and less branched. Whether one is dealing with a male or female plant can only be seen when the inflorescences appear

have developed. In the past, male plants could only be distinguished from female plants when they were already fully grown. Nowadays there are feminized seeds for sale, seeds that only produce female plants. In order to produce fertile seeds in nature, the female plant must be fertilized with pollen from the male flower. To facilitate the collection of pollen from the air, the female plant produces a sticky resin on its flower buds (See §1.2). The resin also protects the seeds from heat and insects. Once the female flower is fertilized, resin production decreases.

The amount of the main psychoactive substance Δ^9 -tetrahydrocannabinol (THC) that a cannabis plant produces depends, in addition to genetic factors, on agricultural factors such as light, soil, and the way the plant is harvested. In a warm and dry atmosphere, the cannabis plant produces more THC-containing resins, while in temperate conditions it will produce more fiber. Cannabis products from indoor cultivation will therefore contain more THC than similar products from plants grown outdoors.

The unfertilized female flower in particular contains a lot of THC-containing resins, much more than fertilized female flowers. Once a female flower is fertilized with pollen from the male plant, it stops producing THC-containing resins. By removing male plants in a timely manner, or by growing only female plants, e.g. via cuttings or by using feminized seeds, female plants are prevented from being fertilized. By then harvesting and drying only the flower clusters of unfertilized female flowers, a seedless marijuana variety with higher concentrations of THC is obtained. This form of marijuana is known as *sinsemilla* (*sin* = without; *semilla* = seed).

1.2 The resin glands: trichomes

The surface layer, the epidermis, of mature cannabis plants is covered with hair-shaped glands, the trichomes (Figure I-2). The female flowers in particular contain many of these trichomes. They are actually hair-shaped protuberances with a few gland cells at the top that border a cavity, the excretory space. The secretions of the gland cells are collected in the excretory space. The cavity is separated from the outside world by a layer of wax. THC and the other cannabinoids accumulate in this excretory space. Because cannabinoids do not occur in the glandular cells of the hair glands, it is believed that the cannabinoids from their precursors, the terpenes and phenols, are formed at the edge of these cells and enter directly into the excretory space. Here the cannabinoids attach to the cell walls, the surface of secretory vesicles, to fibrous structures on the surface of the gland cells and to the wax layer. The strong adhesion of THC and the other cannabinoids to these cellular structural components suggests that it is a chemical bond rather than the cannabinoids moving freely in the excretory space.

THC is also found in the cell walls of other cells of the cannabis plant. In principle, all cells of the cannabis plant are capable of producing cannabinoids such as THC. The genes necessary for the production of THC are found in all cells of the cannabis plant, only the cells of the hair glands produce large quantities. Plants that have fewer hair glands due to mutations or certain breeding methods contain considerably fewer cannabinoids. By the way, the

The presence of many glandular hairs does not automatically mean that the plant produces a lot of THC, it may also be that it produces a lot of another cannabinoid, cannabidiol (CBD) (See §1.3).

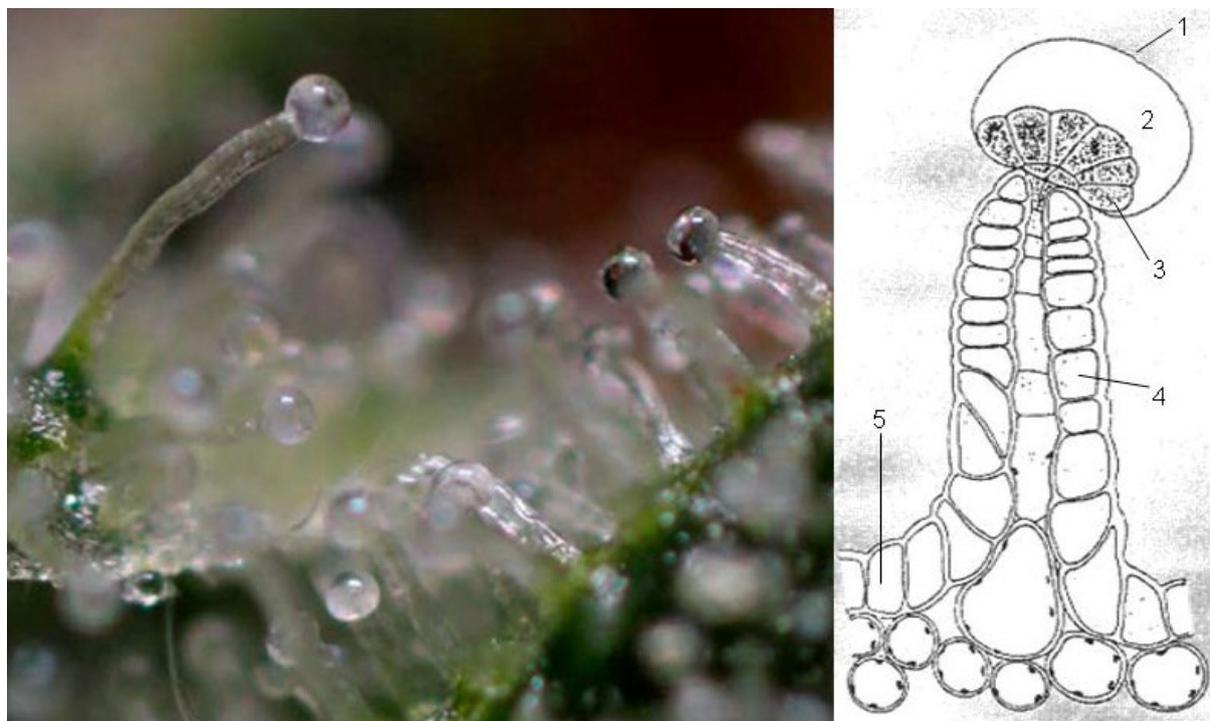


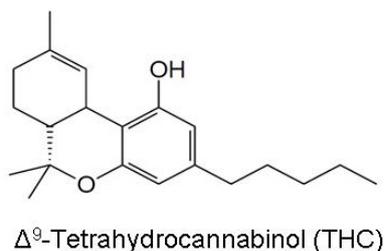
Figure I-2 Microscopic image of the resin glands, the trichomes, of the cannabis plant (Source: www.THCFarmer.com). Right schematic representation of a trichome (Source: Briosi and Tognini, 1894). 1 = wax layer; 2 = excretory space; 3 = gland cells; 4 = neck cells; 5 = epidermal cells.

Traditionally, hash (hashish or Charas) is made by rubbing and shaking the resin containing the plant's cannabinoids and compressing it into a compact mass. Resin glands containing cannabinoids and terpenes may be a form of plant adaptation to the environment. It protects the plant against fungi, insects and animal damage, but also against dehydration by the wind and sun.

1.3 Cannabinoids: Δ^9 -tetrahydrocannabinol, cannabidiol and cannabinol

Meanwhile, from the cannabis plant, *Cannabis sativa*, more than 560 compounds have been isolated (El-Sohly and Slade, 2005; Radwan et al., 2009), of which 126 belong to the cannabinoids (Mehmedic et al., 2010, Aizpurua-Olaizola et al., 2016). Cannabinoids are a group of biologically active compounds that are structurally related. The cannabinoids are classified into three groups: endogenous cannabinoids (endocannabinoids), synthetic cannabinoids and phytocannabinoids. Phytocannabinoids are cannabinoids made by plants. This mainly concerns the cannabis plant, although there are also some other plants that produce cannabinoids (Bauer *et al.* 2008; Gülck and Møller 2020). The most important cannabinoids, i.e. those that occur in the highest concentrations in the cannabis plant, are: Δ^9 -tetrahydrocannabinol (Δ^9 -THC), cannabidiol and cannabinol.

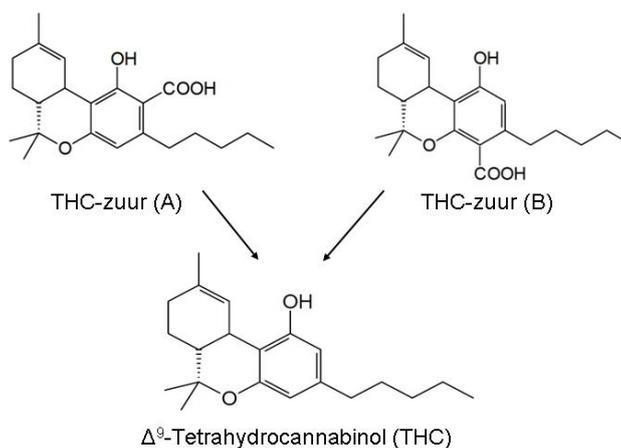
Figure I-3 Structural formula of Δ^9 -tetrahydrocannabinol (THC).



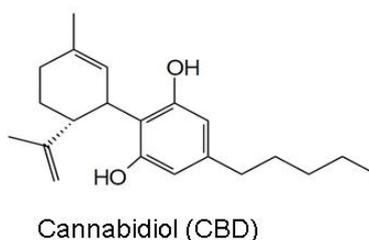
Of the cannabinoids are Δ^9 -tetrahydrocannabinol (Δ^9 -THC) and Δ^8 -tetrahydrocannabinol (Δ^8 -THC) are the only two that can induce all the psychoactive effects of marijuana (Grotenhermen, 1999). Because the quantity Δ^8 -THC in the cannabis plant compared to Δ^9 -tetrahydrocannabinol is negligible, the strength of the psychoactive effects of the cannabis plant is in practice related to the concentration Δ^9 -THC. Although the concentration of THC is an important indication for the user of the quality of cannabis products, it is not the only factor. Compare it to alcohol in red wine; Although the amount of alcohol in red wine is responsible for the “psychoactive” effect of the wine, other substances are responsible for its smell, color and taste. These properties are at least as important for quality.

In the hemp plant Δ^9 -THC is only present to a small extent in free form. Most of the substance is present in the form of acids (THC acids) that spontaneously form when heated, for example by smoking or cooking. Δ^9 -Decarboxylate THC.

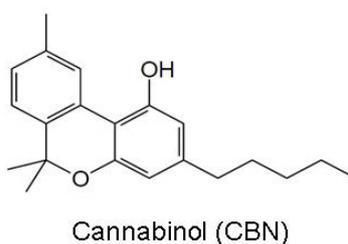
Figure I-4 Conversion of cannabis acids into Δ^9 -tetrahydrocannabinol (Δ^9 -THC).



Because in practice the user is exposed to the total amount Δ^9 -THC becomes the total amount in this THC monitor Δ^9 -THC determined in the purchased cannabis samples. For this purpose, the cannabis is heated during the analysis process in such a way that almost all THC acids are converted into free THC. Although most cannabinoids themselves are not psychoactive, or only to a limited extent, some are able to enhance or inhibit the effects of THC.

Figure I-5 Structural formula of cannabidiol (CBD).

In addition to THC, the hemp plant contains two other cannabinoids that occur in measurable concentrations, *cannabidiol (CBD)* and cannabinol (CBN). Get into nature Δ^9 -THC and CBD are the most common. Cannabidiol is as well Δ^9 -THC present in almost all cannabis varieties. Depending on the variety, CBD can contribute from 0 to 95% of the total cannabinoids in a plant. The hemp used for fiber production generally contains more CBD than Δ^9 -THC. CBD itself is not psychoactive, but in combination with Δ^9 -THC can enhance or weaken certain aspects of a "high". CBD can also reduce some of the pharmacological effects of THC, but the substance has much less affinity for the cannabis receptor than THC (Long et al., 2009; for reviews see Niesink and Van Laar, 2012 and 2016).

Figure I-6 Structural formula of cannabinol (CBN).

Cannabinols is a degradation product of Δ^9 -THC. Δ^9 -THC can be oxidized to CBN. Fresh cannabis products contain very little CBN (Ross and ElSohly, 1997). Cannabinol itself has a (very) slightly psychoactive effect, but this is in no way comparable to the potency of THC (Sampson, 2021). Its concentration in a hemp product does provide information about the original amount Δ^9 -THC.

1.4 The biosynthesis of cannabidiol (CBD) and tetrahydrocannabinol (THC)

Until 1964, it was believed that THC was formed in the cannabis plant by the conversion of CBD. CBD itself would be formed from a monoterpene and olivetol or olivetolic acid and all other cannabinoids would in turn be formed from CBD. In 1964, Gaoni and Mechoulam showed that the substance cannabigerolic acid (CBGA) is the precursor of CBD (Mechoulam and Gaoni, 1965; Gaoni and Mechoulam, 1964). CBG itself is formed in the cannabis plant by the condensation of geranyl phosphate (GPP) with olivetol or olivetolic acid (Figure I-7).

Subsequently, Mechoulam and colleagues concluded that CBD as well as THC and CBN were formed separately from CBG; only the manner in which and the enzyme responsible for the conversions differ (Mechoulam, 1970). Figure 1-7 shows the most important biosynthetic steps of CBD and THC. It is striking that not the free phenols, but the carboxylic acids of CBD and THC are formed in the plant. The carboxyl group (-COOH) is not very stable and under the influence of heat or light it quickly disappears in the form of CO₂, after which the neutral cannabinoids CBD and THC are created. The ratio of the conversion enzymes CBDA synthase and Δ^9 -THC synthase ultimately determines whether a plant produces a lot of THC or a lot of CBD from the available CBGA. This ratio is genetically determined (for review: Hazekamp et al., 2010).

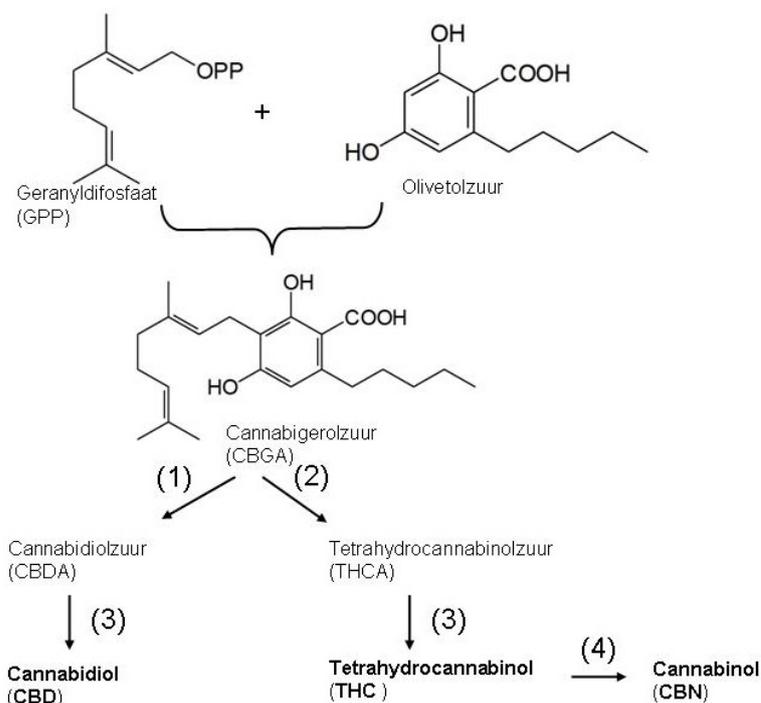


Figure I-7 Biosynthesis of Δ^9 -tetrahydrocannabinol and cannabidiol in the cannabis plant from their common precursor cannabigerolic acid (CBGA). (1) = CBDA synthase; (2) = Δ^9 -THC synthase; (3) = decarboxylation; (4) = oxygenation of THC to CBN.

1.5 Cannabidiol vs Tetrahydrocannabinol

In 1940, Adams and colleagues first described the isolation of a cannabinoid-like structure from the extract of the cannabis plant (Adams et al., 1940). In 1963, Mechoulam and Shvo were able to elucidate the structure of this substance, cannabidiol (Mechoulam and Shvo, 1963). No pharmacological effects of CBD were reported until the early 1970s. It soon became clear that CBD did not cause "cannabis-like" effects, it turned out to be a non-psychoactive substance. Interest in cannabis research only increased again in the early 1990s. This was due to the discovery of specific receptors for the cannabinoids in the nervous system and the subsequent isolation of an endogenous cannabinoid, anandamide. Since then, the number of publications on cannabis has increased noticeably, but only since the turn of the millennium has interest in CBD also grown (Zuardi, 2008). Initially, it was believed that only THC was pharmacologically active because only that substance had the

effects of cannabis in animal models and humans (Mechoulam and Carlini, 1978). The idea that CBD had no pharmacological properties changed with the observation that the activity of cannabis in animal models differed greatly, something that could not be attributed solely to the different amount of THC in the cannabis. This led to the suspicion that other cannabinoids, such as CBD, could influence the effects of THC. Although there was initially the idea that CBD was an inactive cannabinoid, there have now been publications on the anticonvulsant and anti-anxiety properties of CBD. Effects against nausea, antioxidant properties and the possible use of CBD as a medicine for rheumatoid arthritis were also described (for reviews: Niesink and van Laar, 2012 and 2016; Zuardi et al., 2012; Grotenhermen and Müller-Vahl, 2012; Morales et al., 2017). It now appears that CBD is responsible for some of the “positive” effects of cannabis (Fasinu et al., 2016; Niesink and van Laar, 2016; Russo, 2016). For example, CBD could partially counteract the anxiety and panic-inducing effects of cannabis (THC) and cannabis with a high THC content probably poses a greater risk of developing an addiction than cannabis with a high CBD and low THC content (See : Niesink and van Laar, 2013, Spronk and Oomen, 2022). Self-care preparations that contain only CBD are now also widely available at pharmacies and drugstores for a wide variety of conditions. It should be noted that it is not always clear what is in these preparations – sometimes they may even contain THC (Hazekamp 2018; Liebling 2020).

Also with the psychotogenic¹ effects of cannabis, CBD may play a role. There is a relationship between long-term intensive cannabis use, especially in young users (roughly before the age of eighteen), and the later occurrence of schizophrenia or chronic psychoses. But because this association is relatively small, it means that at population level cannabis use only accounts for a small share in the total incidence of schizophrenia or other chronic psychotic disorders. However, the relationship appears to be much greater in special risk groups such as users with an underlying psychiatric illness with or without premorbid symptoms (for reviews: Moore et al., 2007; CAM, 2008; Bossong and Niesink, 2010; van der Steur and Bossong, 2020; Hasan 2019). Cannabis with a high THC content appears to pose a greater risk than cannabis with a low THC concentration. The CBD/THC ratio may also be important: the lower the CBD content, the higher the risk. However, a lot of research is still needed to gain more certainty about this. However, CBD appears to be able to dampen psychotic symptoms (Spronk and Oomen, 2022).

Our annual measurements have shown that Dutch weed is more Δ^9 -tetrahydrocannabinol (THC) than contains the weed from the nineties. It has also been shown that cannabidiol (CBD) hardly occurs in Dutch cannabis, but does occur in foreign hashish. The absence of CBD may seem to play an important role in the development of psychoses. Laboratory studies have shown that pure, synthetic THC causes transient psychosis in 40 to 50 percent of healthy subjects (D'Souza et al, 2009; Sherif et al., 2016). In contrast to THC, CBD appears to have an antipsychotic effect (Bartoli et al., 2021). However, human research in this context is not always consistent, and more research is certainly needed (Batalla and Bossong, 2019; Hindley, 2020, Amminger et al., 2021).

¹Psychotogenic = inducing psychosis.

1.6 Terpenes

As already mentioned, another group of compounds is present in the resin glands of the cannabis plant: terpenes. Terpenes are hydrocarbon compounds that consist of building blocks of 5 carbon atoms (5Cs). The number of these 5Cs and the extent and manner in which they are chemically functionalized determines the further classification. Monoterpenes and sesquiterpenes (with 2 and 3 5C building blocks respectively) are volatile substances and cause the smell and taste of the plant material, but are not psychoactive themselves. The terpenes myrcene, β -caryophyllene and α -humulene are found in virtually every variety of cannabis (see Figure I-8). However, more than 150 different terpenes have now been identified in cannabis, and the precise composition and proportions vary widely from variety to variety. When the cannabis is poorly controlled (*harrow*, under illegal) conditions, the amount of terpenes (and cannabinoids) can also vary greatly from plant to plant (Andre 2016; Booth 2019; Krill 2020).

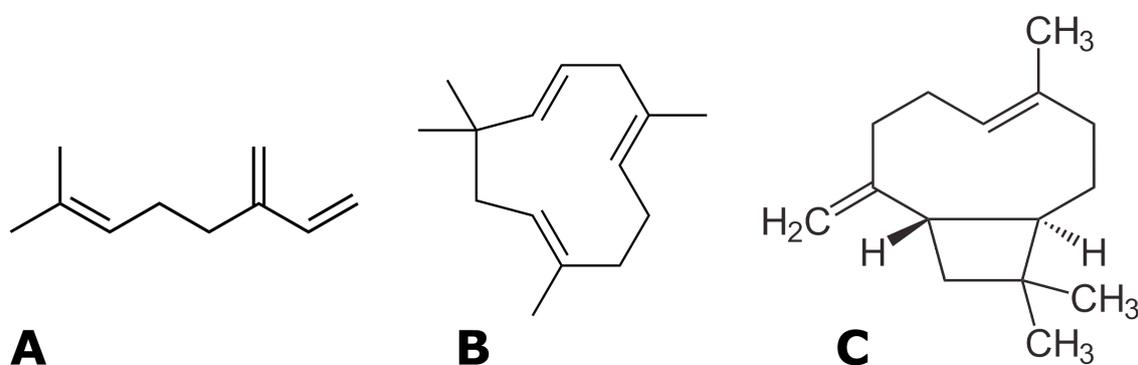


Figure I-8 Structural formulas of the terpenes myrcene (A), β -caryophyllene (B) and α -humulene (C), which is found in virtually every variety of cannabis.

Various terpenes are known to have pharmacological effects at the cellular level. Although the concentrations of (some) terpenes in cannabis are high enough that this can also be seen in humans, there is no solid scientific evidence for this to date (Booth, 2019). One of the hypotheses, which will be investigated in the near future in a large experiment by the UCLA Cannabis Research Initiative (led by Dr. Ziva Cooper), is that some terpenes in cannabis (particularly myrcene and/or β -caryophyllene) work synergistically with opiates, which means that less heavy and highly addictive painkillers are needed when combined with cannabis (terpenes). In any case, the subject of terpenes in cannabis still needs a lot of study.

Recently, research has been conducted into the possible subjective effects of different cannabis varieties (de la Fuente *et al*, 2020). On the website <https://leafly.com>, cannabis users (medical and recreational) can share their experiences with certain cannabis variants. This concerns self-reporting and the question is therefore whether these people actually used these variants. The website is mainly aimed at users in the US, where (medical) cannabis is currently legalized in some states and the origin of the purchased product is often known. The subjective information that users gave to the various variants was clustered, after which this data was linked to the chemical profiles of these species. A database from PSI Labs was used for this (<https://psilabs.org/>). This laboratory performs for the state

Michigan chemical analyzes of both medicinal and recreational cannabis: in more than 1600 samples they measure the presence of 14 cannabinoids and 33 terpenes. In de la Fuente's paper *et al.* are using *machine learning* links have been demonstrated between subjective effects and odor and taste profiles. For example, the "Blueberry" variants are said to produce a relaxing effect and "Lemon" or "Tropical" variants have a more uplifting effect. Variants such as "Cheese" and "Lavendar" are said to have a more anti-anxiety effect. These odors are caused by volatile terpenes, and the article links the chemical composition (terpenes) of the different samples to the odor profiles - even though there is a lot of variability in the chemical analysis data. Much more research is needed to really say something about the effects of these terpenes: for example, do the terpenes themselves also have psychoactive effects or is it an interaction or synergy with cannabinoids? In any case, whether a so-called "entourage effect" actually exists is still the subject of heated debate (Finlay et al., 2020, LaVigne et al., 2021).

Nevertheless, cannabis varieties sold in coffee shops are increasingly described using an overall picture of cannabinoids and terpenes, instead of or in addition to the description Indica or Sativa. With changes in the legal status of cannabis in different parts of the world, large-scale, controlled cultivation of cannabis varieties with known genetic makeup is becoming increasingly common. This has led to the emergence of a new discipline within the cannabis world: "interpening". An attempt is made based on the smell (*i.e.* caused by volatile terpenes) and the appearance of cannabis to estimate the psychotropic effects. In a way this is similar to the work of a sommelier. If this is possible, it will only be effective with cannabis grown under standardized conditions, and by people who are experienced in this. Non-specialist cannabis consumers have previously been shown to be unable to effectively estimate the effects or strength of a cannabis product based on its smell, taste and/or appearance (Gilbert and DiVerdi 2018).

1.7 Hash

When the first coffee shops opened in the 1970s, they sold a wide range of hashish varieties from all over the world. The most recent estimate is that hashish now accounts for 20% of sales. With the arrival of Dutch weed, the share of hashish in sales decreased. The range of hash varieties in the coffee shop also became less diverse. During our research over the past 20 years, we saw that Dutch coffee shops mainly sold hashish varieties from Morocco. In addition to a high THC content, these strains also contain a significant amount of CBD. A much smaller part of the hashish sales consisted of hashish from other parts of the world (including Afghanistan, Nepal, Lebanon, India). Some of these strains contain less THC and more CBD. In addition, hashish varieties were made in the Netherlands. Roughly speaking, there are two types: skuff (hash from pressed Dutch weed powder) and is-o-lator (hash made from Dutch weed using an extraction process). The latter strain in particular can be very strong (THC percentages of over 60% have been measured), but the price in the coffee shop is correspondingly: these strains can cost up to €50 to €60 per gram. Since 2011, a new type of hashish has been made in Morocco. This is hash that is made in Morocco, but instead of the traditional kief, sinsemilla, Dutch cannabis-like varieties with less CBD, are used (Stambouli et al, 2016). These types of hash, which also contain less CBD than traditional types, are sold as "blocks" in Dutch coffee shops. In recent years, more and more types of this hashish have been produced

offered in more and more coffee shops. In some coffee shops, such strains are also the most popular hash, indicating an increase in use.

1.8 Weed

Two different types of cannabis were sold in coffee shops during the sampling period of this monitor (winter 2021/2022). One type is imported cannabis. This species comes from abroad, where it is grown outdoors. Because the plant is grown outdoors, it is often fertilized by male plants and cannabis products from this species therefore contain seeds. Imported cannabis is also often dried and compressed for transport. These types of cannabis products are often sold as "Thai" or "Jamaica". The strain has a low THC content and looks very different from the usually green and fresher-looking Dutch weed varieties.

The other type of cannabis that was sold in coffee shops during the sampling is nederwiet, or sinsemilla: a species that is usually grown indoors under optimal conditions and is not fertilized. After the first species, many crosses have been made over the past 20 years with other species, often from other continents. In this way, all kinds of properties of different varieties are combined (breeding). Well-known varieties are "Skunk", the white cannabis varieties ("White Widow", "Snow White"), "Haze", "Cheese", "Kush" and in recent years varieties named after all kinds of fruit and tropical associations.

There has been a debate going on for some time about the origin of Dutch cannabis sold in Dutch coffee shops. For years, this has not only come from the Netherlands, but has also been imported from other countries in Europe: for example just across the border from Belgium, but also from Poland. This weed could therefore be called "eurowiet" instead of Dutch weed. Since there is no hard evidence for this, and much of the breeding took place in the Netherlands, this report refers to Dutch weed.

In recent years, a new type of cannabis has also been sold in coffee shops (particularly in Amsterdam): cannabis that has in any case been bred in the United States of America. Some of this weed sold in coffee shops in the Netherlands would actually come directly from American "dispensaries", but another part might be rejected weed from the US. It also happens that it concerns cannabis grown in the Netherlands (or other countries in Europe) from seed from the US. The American varieties would not differ so much in THC or CBD content, but mainly in taste and smell. Some users would also like that the species have been analyzed in a laboratory (Green, 2018; Zandstra, 2020).

For several years now, weed has also been sold in coffee shops under the name "CBD weed". This weed is said to contain significant amounts of CBD and only low amounts of THC. In recent years it has been seen that cannabis grown outdoors or CBD cannabis is often the not so strong variants sold in coffee shops, and increasingly less often the imported cannabis from abroad (for example Thai and Jamaica).

1.9 Cannabis contaminated with synthetic cannabinoids

Although not the subject of this THC monitor, the previously virtually unprecedented phenomenon of cannabis contaminated with synthetic cannabinoids deserves some attention. Synthetic cannabinoids, or SCRA (for *synthetic cannabinoid receptor*

agonists), are substances that do not occur naturally in the cannabis plant, but have subjective effects similar to those of THC. However, SCRAAs are generally much more potent (up to 1000x the potency of THC), and interact more strongly with the cannabinoid receptors in the human brain. As a result, they generally have a toxicological profile that is “more dangerous” than that of THC (Banister 2018, EMCDDA 2017). One of these SCRAAs is MDMB-4en-PINACA, which was first found in powder form on the European drug market by the German police in 2017 (De Morais 2020). However, as of mid-2020, this SCRAA has also been found in several European countries on cannabis products with low amounts of THC (so-called CBD weed or industrial hemp), which were sold as regular cannabis. Given the much stronger effect of SCRAAs compared to cannabis, consumption led to negative side effects in several cases and in at least one case in Germany to hospital treatment.

Cannabis (hash and weed) treated with MDMB-4 and PINACA was also found in the Netherlands. These cannabis samples were submitted to the Drug Information & Monitoring System (DIMS) after (experienced) cannabis consumers experienced serious and unexpected side effects. A total of 45 suspicious samples were submitted in the Netherlands, 18 of which turned out to be contaminated. Of this, 50% was purchased from coffee shops. Given the situation, it was decided in consultation with the Ministry of Health, Welfare and Sport to initiate a Red Alert for contaminated cannabis - this was the first time in the history of the DIMS (Trimbos, 2020). No serious health incidents have been reported in the Netherlands following the use of contaminated cannabis. After no more suspicious samples were submitted for several months, the Red Alert was scaled down in April 2021.

This (European) phenomenon was described in a scientific article that was published in 2022 (Oomen et al., 2022). The role of drug-checking services such as the DIMS is further discussed. In the case of contaminated cannabis in the Netherlands, this is extra interesting, as the DIMS does not normally analyze cannabis. Fortunately, this option does exist in the event that a sample has been used with unexpected, unpleasant side effects. Since the scaling down of the Red Alert in April 2021 until the time of writing (July 2022), 17 more such suspicious cannabis samples have been submitted. Of these, 7 had been processed with a synthetic cannabinoid, but in 3 cases this was not MDMB-4en-PINACA, but the related substance ADB-BUTINACA.

1.10 Cannabis and the COVID-19 pandemic

In the Netherlands, research into cannabis use during the first lockdown was conducted in the first months of the pandemic (Vercoulen et al., 2020). This research has now also been published in a scientific publication (van Laar et al., 2020). The results of this study indicate that respondents started smoking more and more often during the first lockdown. This is in line with studies conducted in other countries (EMCDDA, 2020, GDS, 2020, Pocuca et al, 2022). This phenomenon does not necessarily have to result in persistent problematic use, but is something to keep an eye on in the future. Furthermore, in the Netherlands the vast majority of cannabis consumers smoke cannabis (with tobacco), a known contributing factor to a poor outcome of an infection with SARS-CoV-2.

2 Design and implementation of the research

The central question of this research is: "What is the THC content in hashish and weed sold in Dutch coffee shops?"

Sub-questions are:

- What are the THC levels of cannabis products grown in the Netherlands (nederwiet) and are they significantly different from those imported from abroad?
- What changes have occurred in the past year compared to previous years?
- How high are the CBD and CBN concentrations in Dutch weed and Dutch hash, and how do they differ from those of imported weed and hash?

An answer to the first sub-question was also obtained in previous studies (Niesink et al., 2000 to 2008, 2013; Rigter et al., 2009; Rigter and Niesink, 2010 to 2012, 2014 to 2018, Rigter and Bossong, 2019; Rigter and Oomen, 2020 to 2021, Pijlman et al., 2005; The second sub-question can be answered by comparing the THC levels found with research previously conducted in the Netherlands and now also abroad and by comparing the results of successive years. The CBD and CBN analyzes provide an answer to the last question.

2.1 Sampling

This study includes 50 coffee shops from the total number of Dutch coffee shops *at random* selected. At the time of selection, the updated Bureau Intraval list used for this purpose contained the names and addresses of 565 (March 2021) coffee shops tolerated by local authorities in the Netherlands (R. Mennes, R. Pieper, I. Schoonbeek, B. Bieleman, 2020). The sampling was carried out by the Intraval agency using the SPSS routine Sample.

Each coffee shop was visited by two employees. This was done because according to AHOJ-G criteria, no more than 5 grams of cannabis product may be sold per visitor to a coffee shop, regardless of strength and regardless of strain, per day. The employees were provided with proof of identity, a copy of the exemption from the Opium Act for this research, a checklist of samples for the opium leave and a letter requesting cooperation for the research. The manager/operator of the coffee shop was first asked about the "menu". They were then asked which quality of Dutch weed was the most popular and, in this case, the most sold. They were also asked about the strain of Dutch weed that was considered the "strongest". If present, one portion of the relevant qualities was taken

purchased². A standard portion was asked for per sample³. 1 portion of Dutch hash was also purchased, and if this was not available, 1 portion of hash of the most popular quality of imported hash was purchased. 1 portion of imported cannabis was also purchased. Not every coffee shop sells imported weed and Dutch hash. In cases where a certain strain was not in the range, an additional sample of another product was purchased (for example, a strain of cannabis with an assumed high CBD content).

In principle, 4 cannabis samples were purchased per selected coffee shop, consisting of 1 usage unit of the most sold Dutch weed, 1 usage unit of weed of foreign origin, 1 usage unit of hashish and 1 usage unit of the strongest quality Dutch weed. After the transaction was completed and the samples had been paid for, the manager was informed that the samples were intended for scientific research in the context of public health. If necessary, a letter requesting cooperation was provided. The manager was then asked if he would be willing to answer some questions about the purchased samples. If the answer was affirmative, the following questions were asked:

- What is the name of the cannabis samples just purchased. Are these from the Netherlands or abroad?
- Do you know anything more about the cultivation of these monsters? Were the plants from which these hashish or weed samples come grown outdoors or indoors? Does it concern hydroponics? Are the plants grown organically?⁴
- Do you have any comments or questions?

2.2 Chemical analysis

Since 2010, the analyzes of the cannabis samples have been carried out by the same laboratory in Limburg. The cannabis and hashish samples were analyzed using a gas chromatograph coupled to a flame ionization detector (GC-FID). To analyze the cannabis samples, the coarse parts such as twigs were first removed⁵ after which the samples were ground using a mortar and pestle. For analysis, approximately 25 milligrams of freshly ground material was weighed and ultrasonically extracted with an organic internal standard solution. After extraction, the extracts were centrifuged; the supernatant clear liquid was analyzed by GC-FID.

The levels Δ^9 -THC, CBD and CBN in the samples were determined using an internal standard method. Checking of the internal calibration factors was performed using three calibration standards that were analyzed in triplicate before and after measuring each sample set. Every tenth sample was analyzed in duplicate, the remaining samples in single samples. The coefficient of variation (CV%) of the results of the duplicate measurements is approximately 4%.

²In contrast to the studies in the early years, no duplicates were purchased in the later studies.

³Many coffee shops have pre-packed user units ready. Such a user unit usually consists of a certain quantity for a rounded amount of money, for example a portion of 5 or 10 euros.

⁴Organic means that the plants have been grown without the use of chemical pesticides.

⁵Marijuana users also first remove the woody parts and seeds.

In addition, 3 different reference cannabis samples, from the Medicinal Cannabis Office, were analyzed in triplicate as a control. The results (Δ_9 -THC) correspond well (difference less than 15%) with the results as reported by the Medicinal Cannabis Bureau. Only the THC content of the Bedrobinol was measured to be 16.7% lower than indicated by the BMC. The explanation may be that the BMC values are generalized: the data for a specific batch is not available. In addition, the Trimbos Institute also adds various samples from the BMC for the laboratory “blind” to each determination. The analysis results of these blindly measured samples are also used to determine the quality of the analyses. The values found here deviated more than with the “non-blind” control samples: deviations of around 20% were found here. This is most likely a different, perhaps older batch, as the CBN levels were also quite high.

2.3 Processing of the data

The statistical analyzes were performed using R (RStudio 2022.02.3+492) for Windows. Tests were two-sided with $\alpha = 0.05$, unless otherwise stated. For all cannabis samples together and for the weed and hashish samples and for each product separately (Dutch weed, foreign weed, Dutch hash, strongest weed and foreign hash), averages (\pm sd) have been calculated for all parameters studied.

Previously, the analysis of the results obtained in the context of the THC monitor used statistical tests that assumed a normal distribution of the different variables being compared. This is with the exception of the levels of CBD and CBN in the purchased cannabis, as it was already known that these are not normally distributed (Niesink et al., 2015). The parametric tests used in the past to compare the parameters THC content, CBD/THC, price per gram and THC per euro were T-tests, or in the case of multiple comparisons, an ANOVA with post-hoc SNK. The nonparametric tests used were χ^2 tests in the case of a comparison between two groups, or a Kruskal-Wallis test in the case of multiple comparisons.

When analyzing the data for the THC monitor 2021/2022, a new look was taken at the distribution of the variables examined for this research. To this end, distribution and QQ plots were created based on all samples collected as part of the THC monitor. These are shown below (Figure II-1 and II-2).

⁶Cannabis here means Dutch weed, imported weed, Dutch hash and imported hash; When talking about weed, we mean Dutch weed and imported weed and when we talk about hash, we mean Dutch hash and imported hash.

Figure II-1 Distribution plots for the different variables used in the different editions (2000-2022) of the THC monitor have been measured.

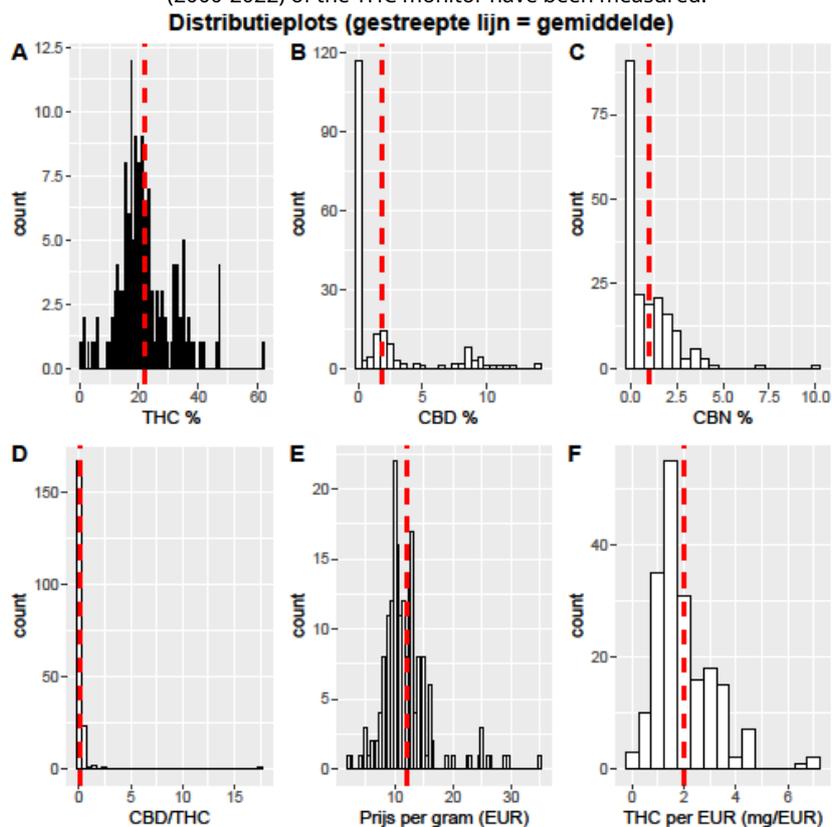
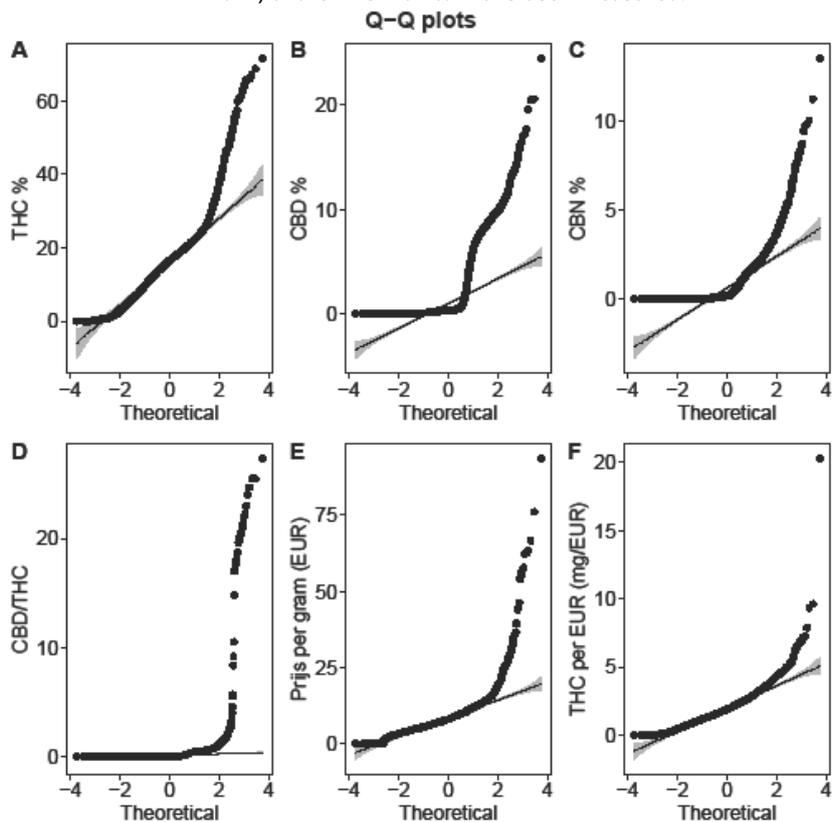


Figure II-2 QQ plots for the different variables used in the different editions (2000-2022) of the THC monitor have been measured.



This shows that not only are the levels of CBN and CBD not normally distributed, but that this is the case for all variables. Therefore, in consultation with a data

analysis expert from the Research Support of the Trimbos Institute decided to use only non-parametric tests. Comparisons between two groups are now done with a Mann-Whitney U test. Comparisons between more than two groups are done using Kruskal-Wallis tests with a post-hoc Wilcoxon's test with Bonferroni correction. This concerns, for example, the comparisons between the different years of the THC monitor within the different categories. A graphical representation of this analysis can be found in the appendix as cross-tabulation. Please note: the category "strongest Dutch weed" has been collected since 2001 – so there is one year less to compare with than the other categories.

Due to the relatively small sample size, where different varieties are always purchased, large fluctuations can occur in the annual averages of the THC content of a particular product. In order to trace lasting trends, the moving averages have also been calculated over periods of 3 years. These are plotted for the price, THC and CBD levels and the CBD/THC ratio of the different products. It is important for the reader to realize here that this moving average is calculated over the year, together with the two previous years. The moving average in 2015 is therefore calculated based on data from 2015, 2014 and 2013. As a result, the moving averages of the first two years (2000 and 2001) are based on less than three years.

3 Results

For this research, 50 coffee shops were visited throughout the country. Figure III-1 provides an overview of the distribution of these coffee shops across the various provinces.

Figure III-1 Distribution of the fifty coffee shops visited in the context of the research.



There were 2 coffee shops closed at the time of our visit, but an alternative was found. Table III-1 provides an overview of the cannabis samples purchased.

Table III-1 Overview of the items purchased in the context of the research cannabis samples.

<i>Product</i>	<i>Samples purchased as part of the research</i>
Strongest (Dutch) weed	49
Dutch weed (most popular)	61
Nederhash	19
Imported cannabis	4
Imported hash	62
Total	195

All samples desired according to the protocol could be purchased in 4 coffee shops (i.e. 1 Dutch cannabis sample of the strongest and 1 of the most popular species, 1 sample of foreign weed and 1 sample of (Dutch) hash). There was no foreign cannabis for sale in 46 coffee shops at the time of sampling. Instead, an extra hashish sample was purchased in 31 coffee shops and an extra Dutch weed sample was purchased in 15 other coffee shops. Five of the additional cannabis samples were so-called CBD cannabis, which is said to contain little to no THC and significant amounts of CBD. CBD weed was also purchased as a fifth sample in one coffee shop. Because this is a completely different product than normal Dutch weed, we have not included these samples in the most popular or strongest Dutch weed category, but we report on them separately.

In recent years, a new type of hash has been sold in coffee shops. When the coffee shops emerged, hash from all over the world was sold, followed later by hash from Morocco and Dutch hash (skuff, Isolator and Bubblehash). The traditional hash from Morocco always had a significant THC content, but also contained a lot of CBD (about half the amount of THC). The modern hashish strain probably comes from plants derived from sinsemilla genetics (nederwiet-like species), and is grown in Morocco (and Spain) and processed into hashish there (or in the Netherlands). This modern hash contains very high amounts of THC (as much as 30 to 40%), but virtually no CBD (less than 2%). There are several stories about these species. Sometimes they are sold as modern Moroccan hash, but sometimes also as traditional hash (for example under the name "Polm"), but often the hash is also sold as Dutch hash. Of the 81 hashish samples purchased this year, based on information obtained from coffee shop employees and the names and information on the menus, 41 samples were classified as the traditional type and 19 as the new type.

3.1 Weights and purchase prices

Weights and purchase prices: measurement 2022

On average, a gram of cannabis, regardless of type, cost €12.03 (n=195; SD=4.54). The average purchase price for a gram of hashish was €11.01 (n = 81; SD = 3.56) and for a gram of weed it was €12.76 (n = 114; SD = 5.01).

Table III-2 shows how the average prices of the various products differ [H(4)=52.07; p < 0.001]. The price of imported cannabis is significantly lower than that of Dutch cannabis. The price of a gram of the "strongest" weed (€15.45) is higher than that of the most "popular" weed (€11.17) and imported hashish (€10.55). The price of a gram of Dutch hash was on average €12.53 per gram.

Table III-2Weights and prices of the purchased samples per cannabis product.
Shown are means (\pm sd); n=number of observations.

<i>Product</i>	<i>(n)</i>	<i>Weight per sample (mg)</i>	<i>(n)</i>	<i>Purchase price per gram sample (€/gram)</i>	<i>Highest price per gram sample (€/gram)</i>
Strongest (Dutch) weed	49	1016.3 \pm 174.8	49	€15.45 \pm €5.98	€34.93
Dutch weed (most popular)	61	982.6 \pm 161.6	61	€11.17 \pm €2.36	€16.73
Nederhash	19	988.3 \pm 198.8	19	€12.53 \pm €5.14	€25.77
Imported cannabis	4	1250.0 \pm 250.0	4	€3.79 \pm €1.07	€6.66
Imported hash	62	1021.7 \pm 225.0	62	€10.55 \pm €2.81	€20.00

Although the purchase always assumed that a user unit was 1 gram, unless stated otherwise, 18 times (=9%) less than the “promised” quantity was given and 9 times (=5%) more than the promised quantity. In the remaining 168 cases (=86%), the intended quantity differed by less than 10% from what was actually received.

Of the 129 cannabis products that came from plants grown in the Netherlands (Nederhash, Nederwiet and strongest weed), 41% were grown indoors and 2% outdoors. This is not known for the other samples. According to the seller, five percent of the plants grown in the Netherlands were grown in open ground. However, for most samples this was not known to the seller. 8% of samples grown in the Netherlands were said to come from organically grown plants.

Of the imported cannabis products, 45% of the cases were said to be plants grown outdoors, 7% were stated to be plants grown indoors and this was unknown for the rest of the samples.

The price that had to be paid for one gram of Dutch weed (most popular) in Amsterdam (€11.84) did not differ significantly from that in the rest of the country (€10.93). The price of the supposedly strongest weed was more expensive in Amsterdam (€18.79 in Amsterdam; €14.25 in the rest of the country), but this difference was not statistically significant. The price for Dutch hash and imported hash in Amsterdam was not significantly higher than in the rest of the country (respectively €10.74 in Amsterdam; €15.00 in the rest of the country and €10.80 in Amsterdam; €10.48 in the rest of the country). Imported cannabis could not be purchased in Amsterdam, so a comparison was not possible. Table III-3 provides an overview of prices in Amsterdam compared to the rest of the country.

Table III-3 Comparison of the prices of cannabis products (per gram) in Amsterdam with those in the rest of the country. Shown are means \pm sd

<i>Product</i>	<i>(n)</i>	<i>Amsterdam</i>		<i>(n)</i>	<i>Other</i>	
		<i>purchase price</i>			<i>purchase price</i>	
		<i>(€/gram)</i>			<i>(€/gram)</i>	
Strongest (Dutch) weed	13	€18.79	\pm €7.67	36	€14.25	\pm €4.65
Dutch weed (most popular)	16	€11.84	\pm €3.01	45	€10.93	\pm €2.07
Nederhash	11	€10.74	\pm €2.51	8	€15.00	\pm €6.85
Imported cannabis	0	AFTER	\pm AFTER	4	€3.79	\pm €2.15
Imported hash	14	€10.80	\pm €2.77	48	€10.48	\pm €2.86

n = number of observations.

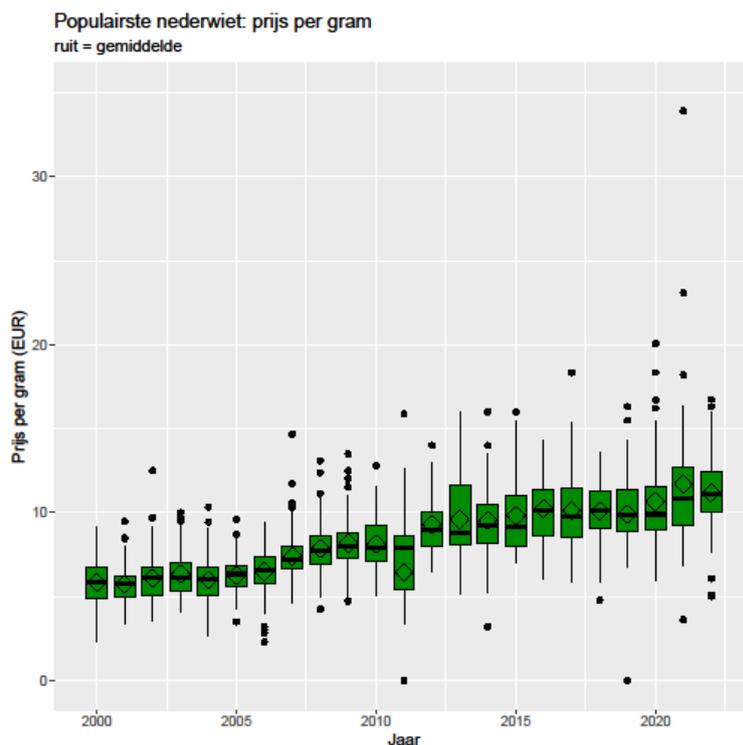
On average, the modern type of hash had to pay slightly less per gram than for the traditional type (€10.77 compared to €11.03), but this difference was not significant. The decrease in price for both the traditional and modern varieties in the past year is also not significant (€11.57 and €11.92 respectively in 2021).

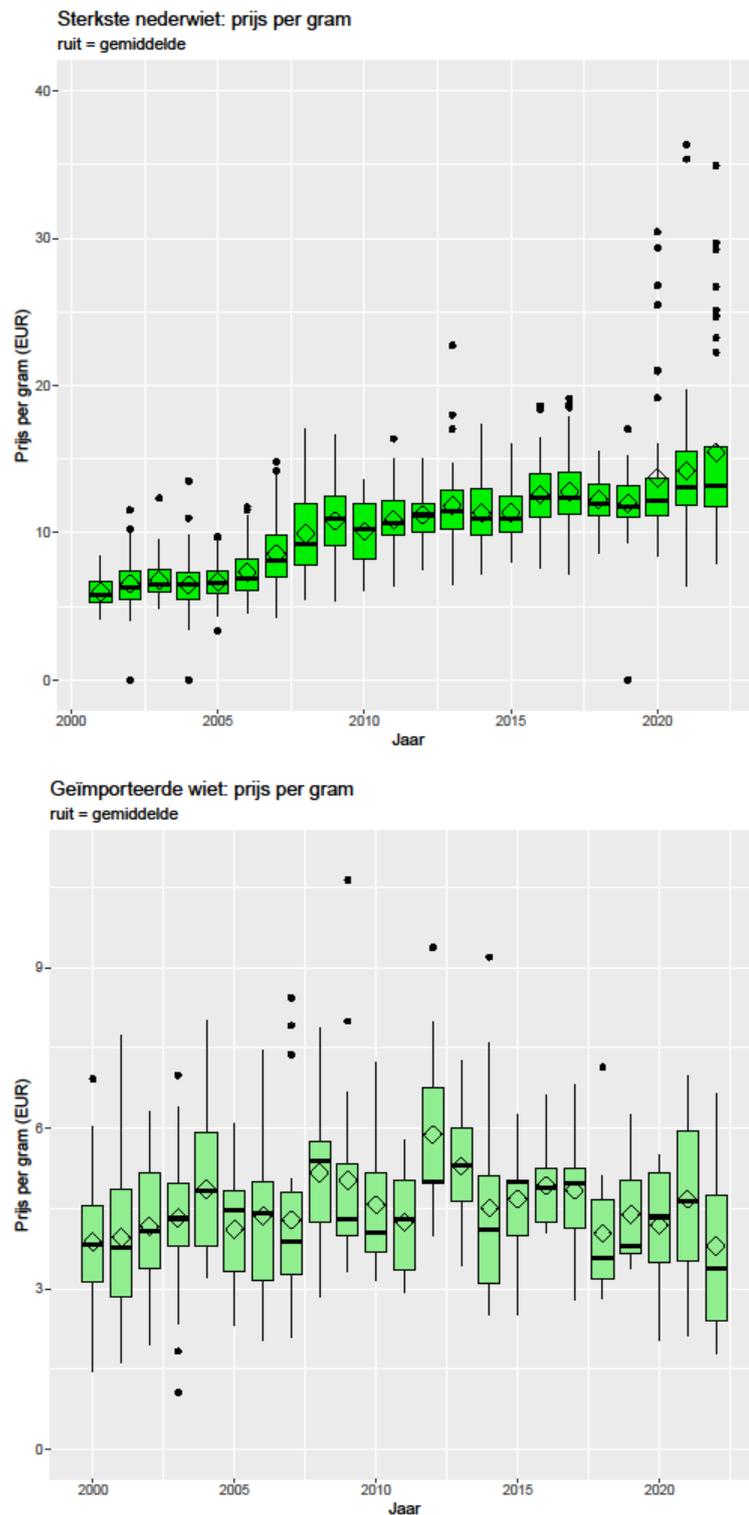
This year, 6 CBD cannabis samples were purchased, for which an average of €7.74 was paid.

Purchase prices: comparison with previous samples

See Appendix A for a graphical overview of the differences between the years (cross tables). Table III-4 and Figures III-2 and III-3 show the prices (per gram in euros) paid for the various cannabis products in recent years. Before 2007, there were no (systematic) price increases for either the most popular or strongest cannabis variants. Since 2007, there has been a gradual increase in the price for one gram of Dutch weed [$H(22)=1060.236$; $p < 0.001$], with significant increases in 2007 and 2012. In a direct comparison, the price for a gram of Dutch weed in 2022 (€11.17) does not differ significantly from that in 2021 (€11.70). In a direct comparison, the price of a gram of the supposedly strongest weed in 2022 (€15.45) was not significantly different than that in 2021 (€14.21). A significant price increase was also observed for the strongest Dutch cannabis in 2007, just as for the most popular Dutch cannabis. The price for a gram of imported cannabis has fluctuated between (approximately) €4 and €6 per gram over the past 10 years and was an average of €3.79 in 2022. No significant changes were found here over the years.

Figure III-2 a, b and c Box plots of the price of Dutch weed (a), strongest weed (b) and imported weed (c) over the past years. Shown are the median values (thick black line), mean (diamond), interquartile range (green part) and outliers per measurement moment.

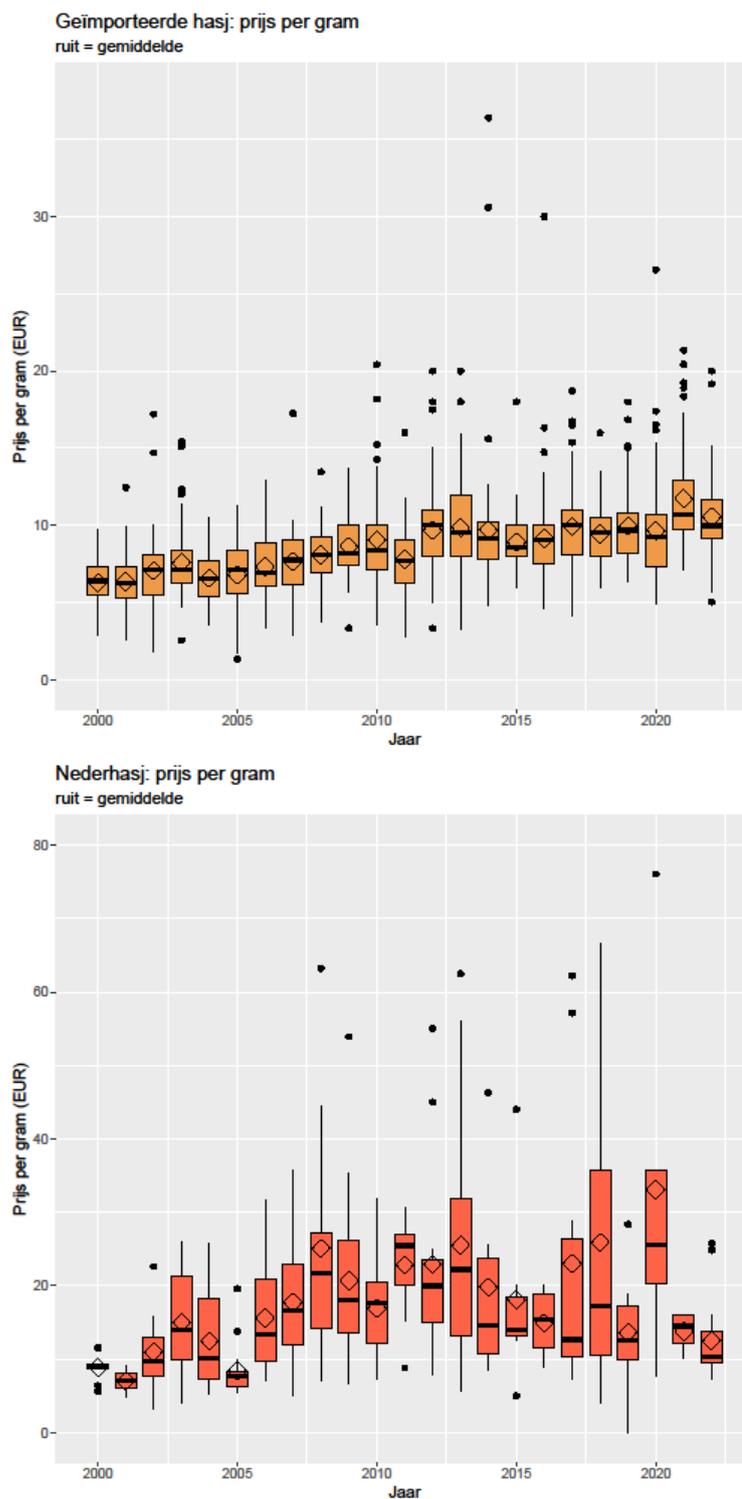




There has also been a gradual price increase for imported hashish, from €6.29 per gram in 2000 to €11.74 last year [$H(22)=389.336$; $p < 0.001$]. Over the past year, the average price for a gram of imported hash has fallen by more than one euro (€11.74 in 2021 versus €10.55 in 2022, $p < 0.05$). Figure III-3 shows that the average price for Dutch hash has fluctuated sharply over time, often involving a limited number of samples. The average price for a gram of Dutch hash in 2022 did not differ significantly from that of 2021 (€12.53 vs €13.80). It was striking

the difference in the number of samples of Dutch hash that could be purchased in 2022 compared to 2021: 19 and 4 respectively. There was a significant increase in the price of imported hash in 2020 compared to the year before, for Dutch hash this was in 2006.

Figure III-3 a and b Box plots of the price of imported hash (a) and Dutch hash (b) over the past years. Shown are the median values (thick black line), mean (diamond), interquartile range (red part) and outliers per measurement moment.

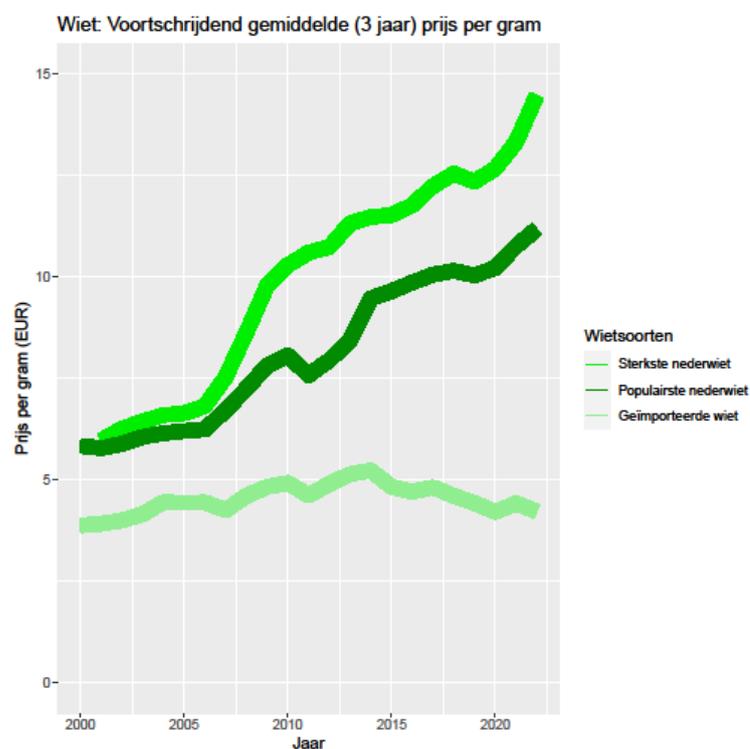


Long-term trends

In Figure III-4 a (weed) and b (hashish), moving averages (taken over 3 years) of the price per gram of the various categories are plotted. At the beginning of this century, people paid about the same for a gram of the strongest and most popular Dutch weed (around €7) and it rose slightly in the first years, but since 2007 there has been a stronger increase. For imported cannabis, the price rises slightly from 4 to 5 euros in the first 10 years and then returns to around 4 euros.

For Dutch hash it can be seen that the price per gram has fluctuated enormously over the years. The average price paid for a gram of imported hashish was around €7 at the beginning of this century and has since gradually risen to just over €10 in recent years.

Figure III-4 a and b Development of the trends for the average price of the various cannabis products.



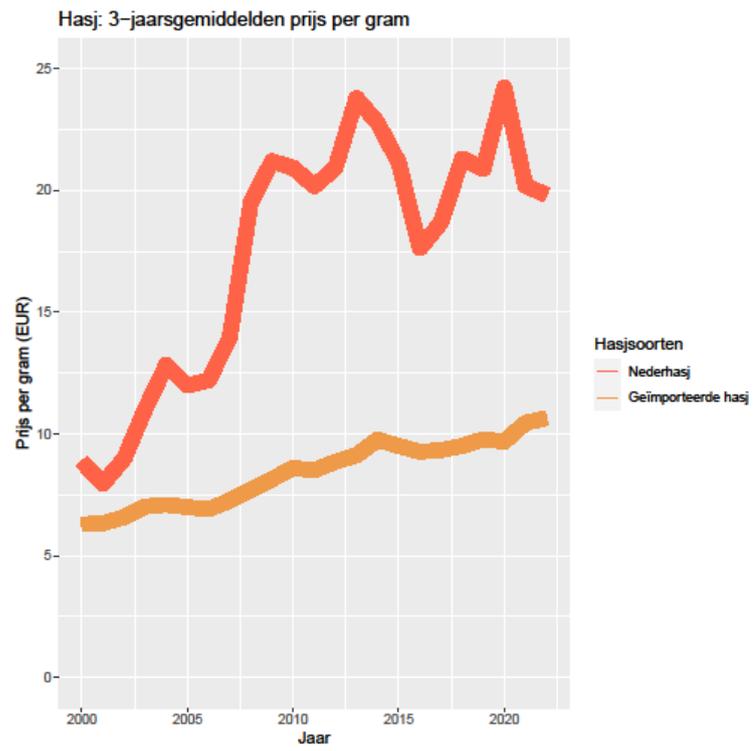


Table III-4 Average price of various cannabis products in recent years (2017 – 2022). Shown are means \pm standard deviation and the number of observations in brackets.

	2017*	2018	2019	2020	2021	2022
Dutch weed	10.11 \pm 2.31 (63)	10.09 \pm 1.76 (60)	9.90 \pm 2.77 (55)	10.65 \pm 2.81 (52)	11.70 \pm 4.11 (64)	11.17 \pm 2.36 (61)
Imported cannabis	4.84 \pm 1.28 (10)	4.04 \pm 1.34 (10)	4.39 \pm 1.10 (9)	4.19 \pm 1.16 (10)	4.67 \pm 1.70 (8)	3.79 \pm 2.15 (4)
Nederhash	23.0 \pm 22.02 (21)	25.92 \pm 21.62 (10)	13.64 \pm 8.79 (7)	33.10 \pm 26.05 (5)	13.80 \pm 2.90 (4)	12.53 \pm 5.14 (19)
Imported hash	9.93 \pm 2.79 (56)	9.43 \pm 1.94 (60)	9.97 \pm 2.36 (76)	9.65 \pm 3.35 (81)	11.74 \pm 3.13 (71)	10.55 \pm 2.82 (62)
Strongest weed	12.77 \pm 2.66 (50)	12.26 \pm 1.56 (46)	11.99 \pm 2.46 (49)	13.73 \pm 5.04 (49)	14.21 \pm 4.98 (53)	15.45 \pm 5.88 (49)

*) 2017 means that the samples were purchased in the winter of 2016/2017.

3.2 THC concentrations in cannabis products

THC concentrations: measurement 2022

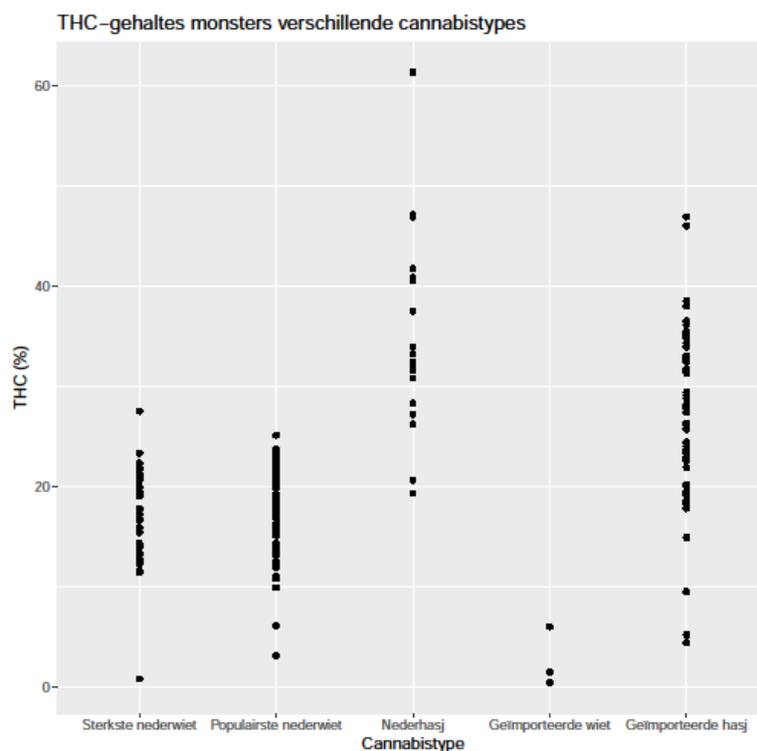
Table III-5 provides an overview of the average THC concentrations in the various cannabis products. This table also shows the lowest and highest THC values found per cannabis product. Figure III-5 shows the individual THC levels per product graphically.

Table III-5 Average, lowest and highest THC concentrations in the different cannabis products.

Product	(n)	Average THC concentration (%)	Median	Lowest THC concentration (%)	Highest THC concentration (%)
Strongest (Dutch) weed	49	17.5 ± 4.3	17.7	0.8	27.5
Dutch weed (most popular)	61	17.2 ± 4.3	17.4	3.1	25.1
Nederhash	19	35.7 ± 10.3	33.2	19.3	61.3
Imported cannabis	4	2.4 ± 2.5	1.5	0.4	6.0
Imported hash	62	26.8 ± 9.4	20.0	0.4	61.3

Shown are means ± sd, median and lowest and highest measured value within a given group; n = number of observations.

Figure III-5 THC concentrations in the various cannabis samples.



The concentration of THC in cannabis (Dutch weed, strongest weed and imported weed) was on average 16.8% (SEM=0.47; n=114), and in hash (imported hash and Dutch hash together) 28.9% (SEM=1.07; n=81).

The percentage of THC was not the same in the different cannabis products [$H(4)=94.890$; $p<0.001$]. The Dutch cannabis samples (most popular Dutch cannabis) contained on average more THC ($17.2\pm 0.5\%$, $n=61$) than the imported cannabis samples ($2.4\pm 1.2\%$, $n=4$; $p<0.05$). The average THC content of the supposedly strongest cannabis samples ($17.5\pm 0.6\%$, $n=49$) does not differ from that of the most popular Dutch cannabis variant ($17.2\pm 0.5\%$, $n=61$). The imported hash ($26.8\pm 1.1\%$, $n=62$) had a higher average THC content than the most popular Dutch cannabis variety ($17.2\pm 0.6\%$, $n=61$; $p<0.001$).

The highest THC content in Dutch weed was 25.1%. The highest content in the strongest sold variant was 27.5% and for the imported weed the maximum content was 6.0%.

This year, 6 cannabis samples were purchased that, according to the coffee shop, were CBD cannabis (samples high in CBD and low in THC). Of these, 5 samples indeed contained less than 1% THC, but one sample contained 9.2% THC and no CBD.

19 samples of hash from cannabis grown in the Netherlands (nederhash) were purchased, containing an average of $35.7\pm 10.3\%$. The highest measured concentration of THC in Dutch hash was 61.3%; in the imported hashish samples this was 46.9% and the average concentration was $26.8\pm 8.5\%$.

If we compare traditional hash from Morocco with “new” hash from Morocco, we see that the new variant does not contain significantly more THC (30.6%) than the traditional variant (28.2%). The traditional Moroccan hashish has a significantly higher THC content this year than last year (28.2% versus 22.0%, $p<0.05$).

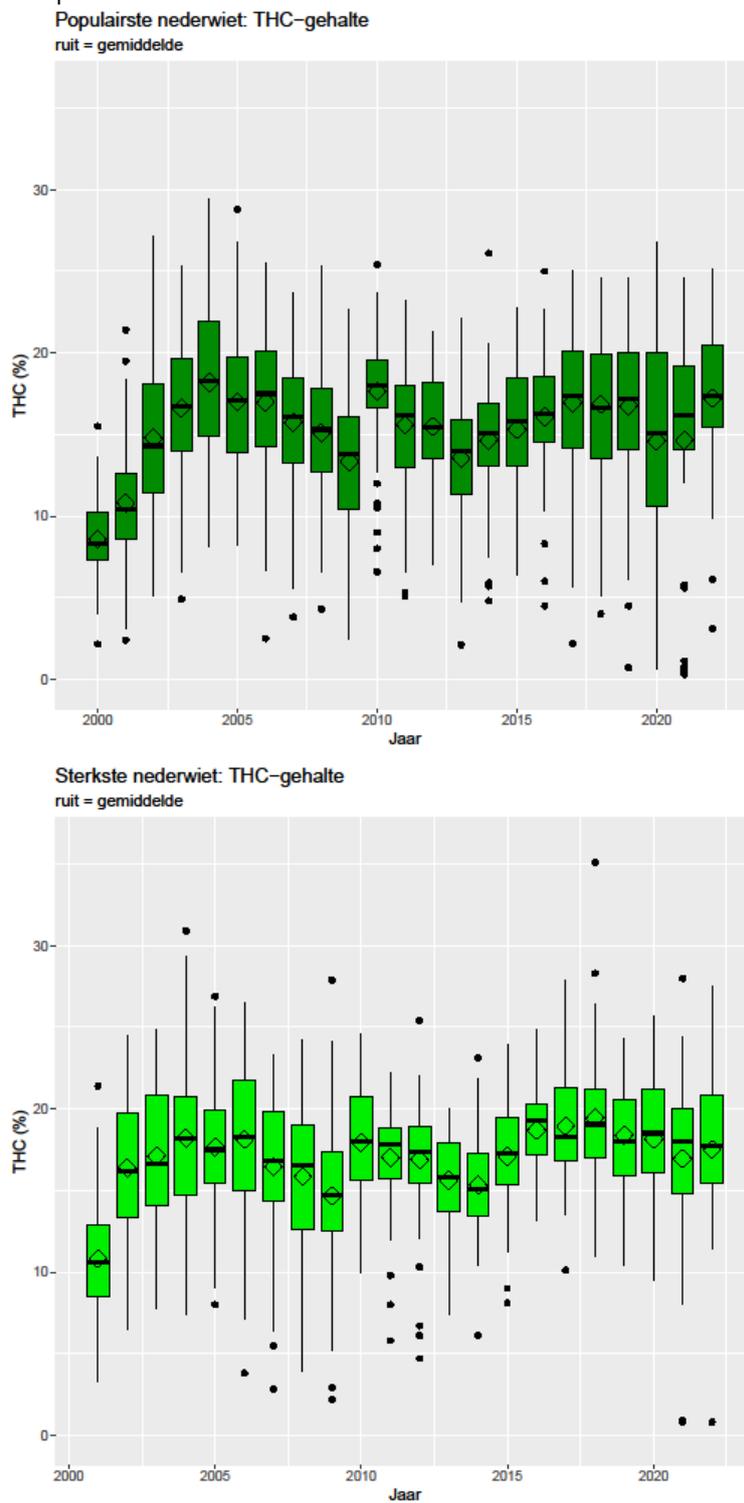
THC concentrations: comparison with previous samples

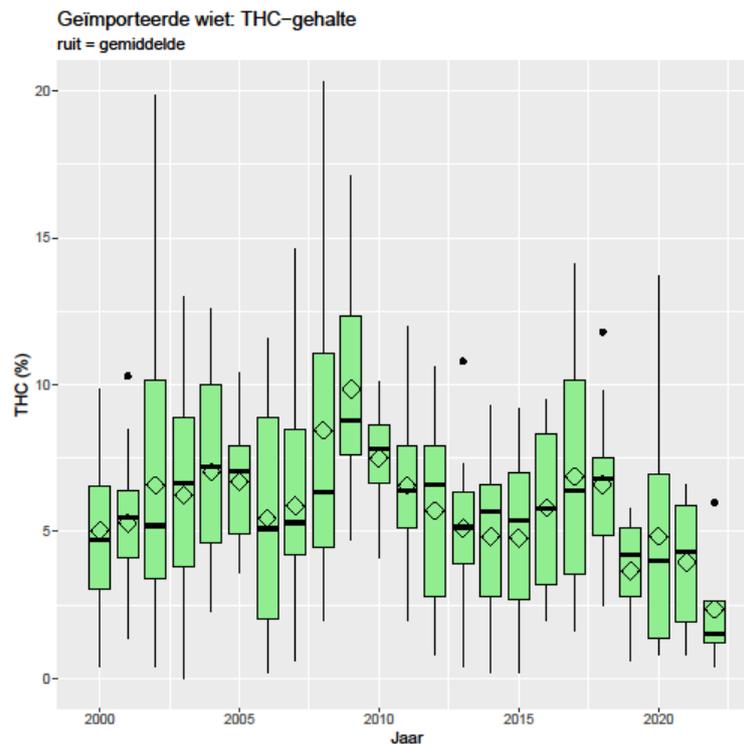
See Appendix B for a graphical overview of the differences between the years (cross tables). The THC concentration in Dutch weed initially increased up to and including the 2004 measurement, then decreased and subsequently stabilized [$H(22)=369.576$; $p<0.001$]; the THC levels in the cannabis varieties purchased as the “strongest” cannabis show the same picture [$H(21)=232.101$; $p<0.001$].

Of all cannabis types, the average THC content in imported cannabis was the most stable until 2007. There was a slight increase in 2008 and 2009, but since then the THC content in this cannabis variant has fallen slightly again [$H(22)=53.531$; $p<0.001$] (Figure III-6 and Table III-6).

The average THC content in Dutch weed (the most popular variant) has increased over the past year (14.6% in 2021 and 17.2% in 2022). In a direct comparison this difference is significant ($p < 0.05$). The average THC content in Dutch cannabis samples that were purchased as strongest remained the same over the past year (17.0% in 2021, 17.5% in 2022; ns). We also see this picture for imported cannabis (4.0% in 2021, 2.4% in 2022; ns).

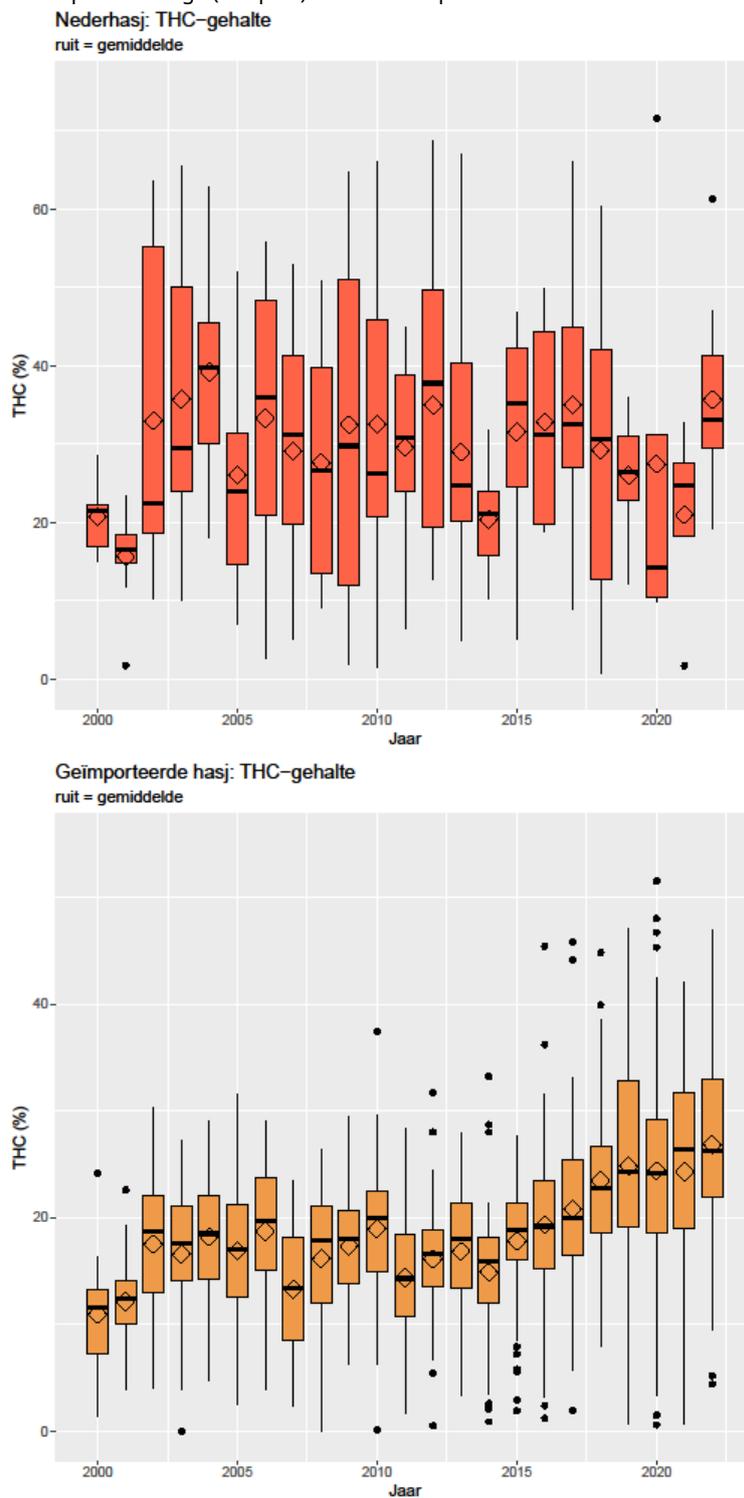
Figure III-6 a, b and c Box plots of the price of Dutch weed (a), strongest weed (b) and imported weed (c) over the past years. Shown are the median values (thick black line), mean (diamond), interquartile range (green part) and outliers per measurement moment.





In a direct comparison, the THC content of Dutch hash is higher in 2022 than in 2021 (35.7% vs 21.0%, $p < 0.05$). In a comparison of all years of the THC monitor with each other, no significant differences were found [$H(22) = 33.785$, ns]. The highest average concentration of THC in Dutch hash was measured in 2004 ($39.2 \pm 14.3\%$; $n=12$) and the lowest average concentration in 2001 ($16.0 \pm 6.5\%$; $n=18$). There are strong fluctuations in the average THC content of imported hashish [$H(22) = 350.853$; $p < 0.001$] (Figure III-7 and Table III-6). In 2002 there was an increase compared to 2001, in 2007 compared to 2006. In a direct comparison, the average THC content of hashish imported from abroad remained stable (24.3% 2021 versus 26.8% in 2022, ns).

Figure III-7 a and b Box plots of the price of domestic hash (a) and import hash (b) over the past year years. Shown are the median values (thick black line), mean (diamond), interquartile range (red part) and outliers per measurement moment.

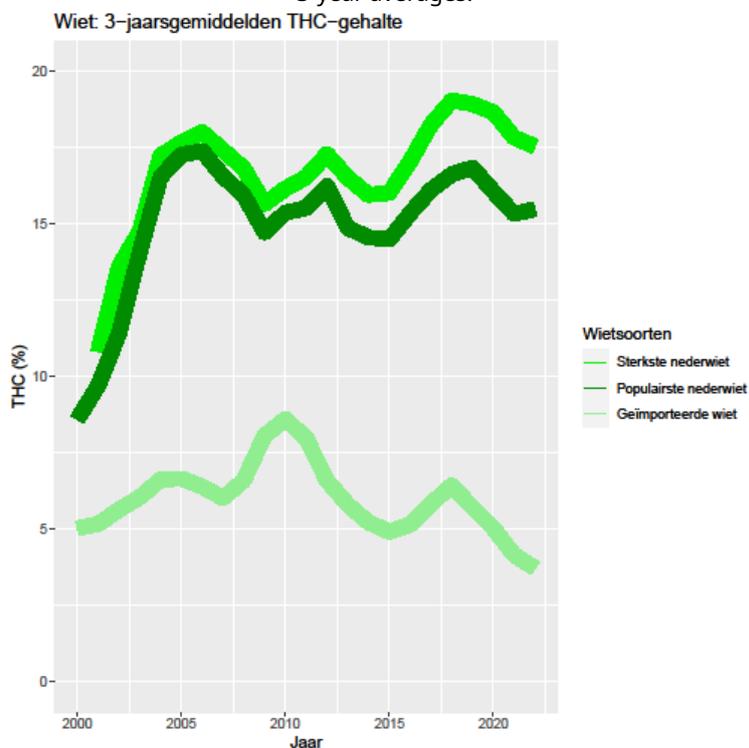


Long-term trends

Figure III-8 a (weed) and b (hashish) shows the trends for the different types. For cannabis, it can be seen that the average THC content of both Dutch cannabis varieties increased considerably in the first years of the research and has fluctuated continuously between 15 and 15% since 2005.

and 18% THC. For imported weed, the average is fairly constant between 4 and 7% THC.

Figure III-8 a THC concentrations in Dutch weed (most popular variant), strongest weed and imported weed in the different samples. Shown are the progressing ones
3-year averages.



Just like for Dutch weed, the average THC content of Dutch hash showed an increase in the first years of the research, after which the content then stabilized between 25 and 35%. In the case of imported hashish, we see an increase in the average in the first years, followed by a stabilization, but in the last 8 to 10 years a clear increase has been observed again.

Figure III-8 b THC concentrations in Dutch hash and imported hash in the various samples. Shown are the moving 3-year averages.

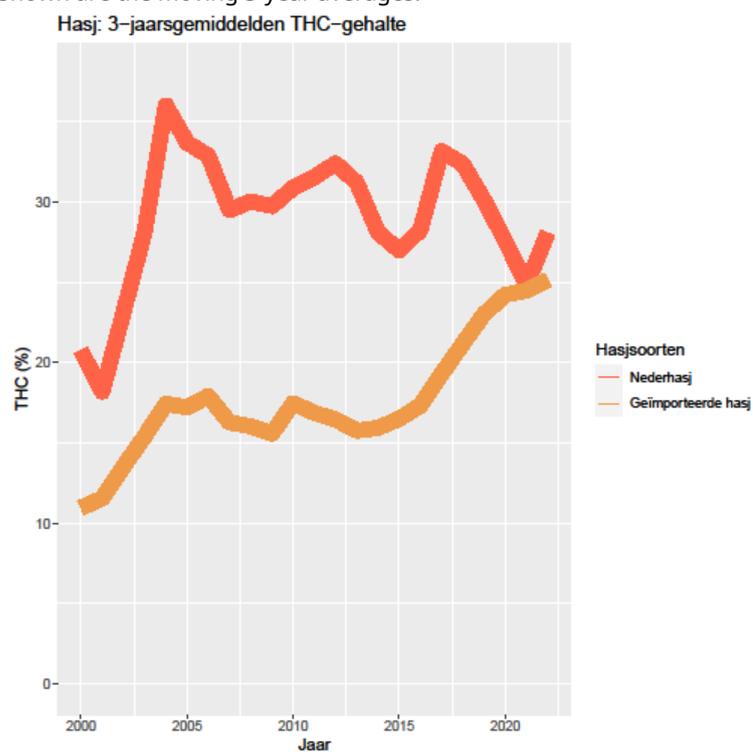


Table III-6 Average THC levels of the various cannabis products in recent years (2017 – 2022). Shown are means \pm standard deviation and the number of observations in brackets.

	2017*	2018	2019	2020	2021	2022
Dutch weed	16.9 \pm 4.7 (63)	16.8 \pm 6.8 (60)	16.7 \pm 5.0 (55)	14.6 \pm 6.7 (52)	14.6 \pm 6.6 (64)	17.2 \pm 5.3 (61)
Imported cannabis	6.9 \pm 4.2 (10)	6.6 \pm 2.7 (10)	3.7 \pm 2.0 (9)	4.8 \pm 4.2 (10)	4.0 \pm 2.2 (8)	2.4 \pm 2.5 (4)
Nederhash	35.1 \pm 13.7 (21)	29.2 \pm 18.6 (10)	26.0 \pm 7.9 (7)	27.5 \pm 26.1 (5)	21.0 \pm 13.4 (4)	35.7 \pm 10.3 (19)
Imported hash	20.8 \pm 8.1 (56)	23.5 \pm 7.3 (60)	24.8 \pm 10.0 (76)	24.4 \pm 11.1 (81)	24.3 \pm 9.6 (71)	26.8 \pm 8.5 (62)
Strongest weed	18.9 \pm 3.6 (50)	19.5 \pm 4.4 (46)	18.4 \pm 3.3 (49)	18.1 \pm 3.9 (49)	17.0 \pm 5.0 (53)	17.4 \pm 4.3 (49)

*) 2017 means that the samples were purchased in the winter of 2016/2017.

3.3 CBD and CBN concentrations in cannabis products

CBD and CBN concentrations: measurement 2022

Table III-7 provides an overview of the measured concentrations of cannabidiol (CBD) and cannabinol (CBN) in the various cannabis products. The table also includes the median value for the CBN/THC concentration ratio for the various cannabis products. This value is an indication of the 'freshness' of a particular sample; the lower this value, the fresher the product (Ross and ElSohly, 1997).

Table III-7 Percentages of cannabidiol (CBD) and cannabinol (CBN) in the analyzed cannabis products.

Product	CBD			CBN			CBN/THC x100	
	n	average ±SD	median	lowest - highest value	average ±SD	median		lowest - highest value
Strongest (Dutch) weed	49	0.3 ± 2.0	0.0	(0.0 - 13.9)	0.2 ± 0.1	0.2	(0.0 - 0.7)	1
Dutch weed (most popular)	61	0.0 ± 0.0	0.0	(0.0 - 0.0)	0.2 ± 0.0	0.2	(0.0 - 0.4)	1
Nederhash	19	1.5 ± 1.0	1.7	(0.0 - 3.0)	1.6 ± 0.7	1.5	(0.6 - 3.2)	5
Imported cannabis	4	0.1 ± 0.1	0.1	(0.0 - 0.2)	2.0 ± 1.3	1.8	(0.5 - 3.7)	28
Imported hash	62	5.1 ± 3.8	3.2	(0.2 - 13.9)	2.2 ± 1.5	1.9	(0.0 - 9.8)	12

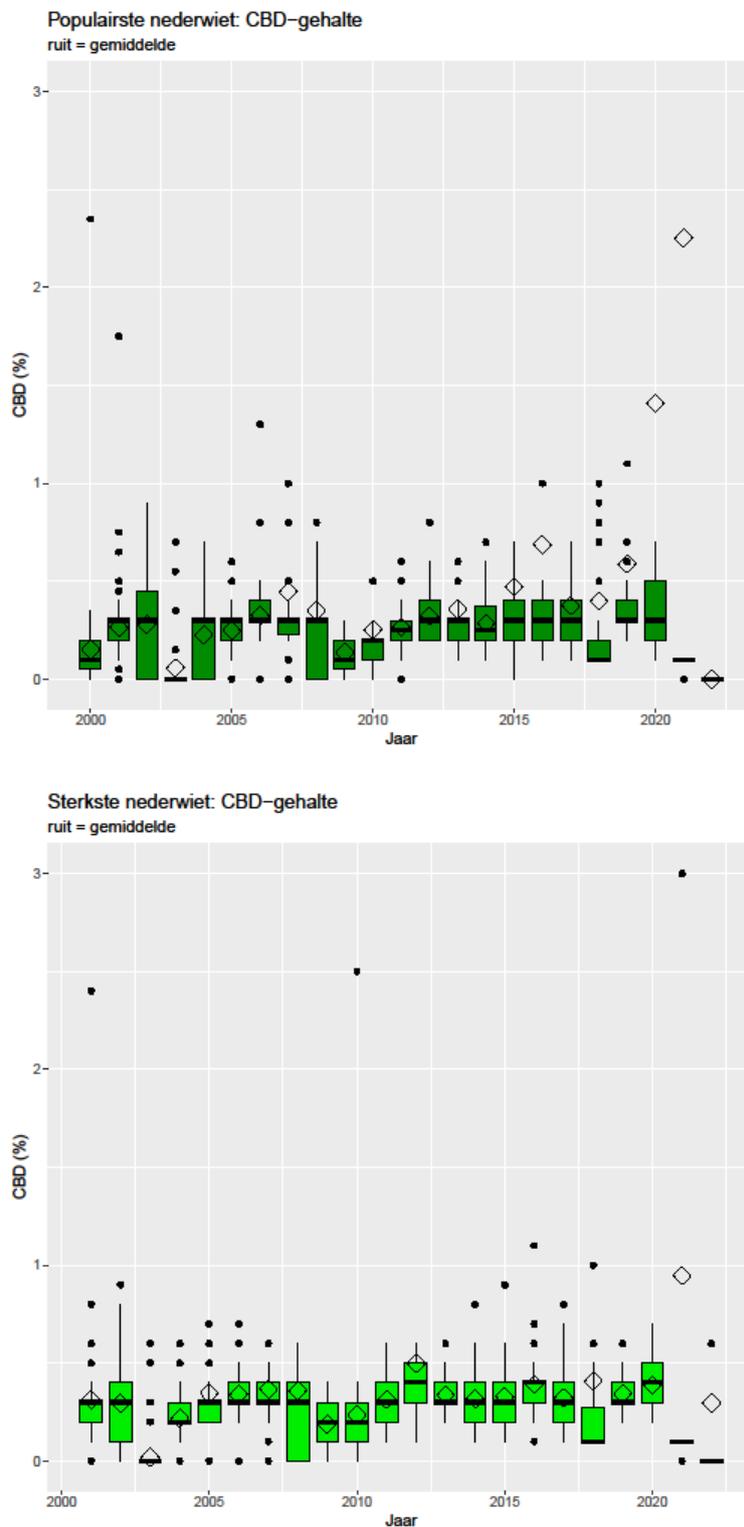
The lowest and highest values are always shown in brackets; n = number of observations.

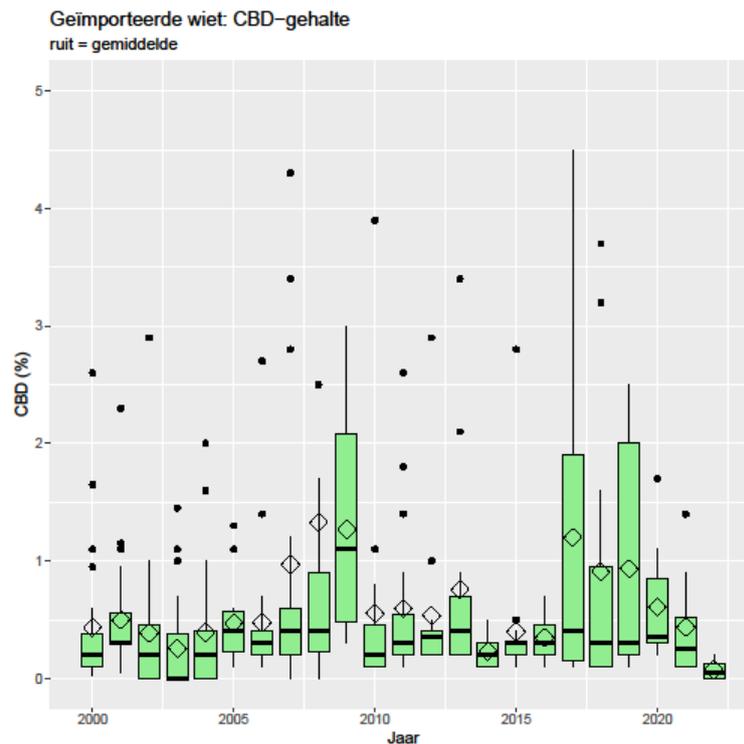
Both the percentages of cannabidiol and cannabinol differed per cannabis product (CBD [H(4)=168.011; p<0.001]; CBN [H(4)=146.833; p<0.001]). The CBD content is highest in imported hashish and much lower in the cannabis varieties. Dutch weed (strongest and most popular variant) contains the least CBN, while imported weed and the various hash types contain the most CBN. The CBN/THC concentration ratio differs between the various cannabis products [H(4)=137.196; p<0.001] and was highest in imported cannabis, followed by both types of hashish.

CBD concentrations: comparison with previous samples

See Appendix C for a graphical overview of the differences between the years (cross tables). The CBD content in the most popular Dutch weed varies over the years [H(22)= 643.807; p<0.001]. There were significant changes in 2001, 2003, 2004, 2009, 2011, 2018, 2019, 2021 and 2022. Over the past year, the median CBD value decreased from 0.1% in 2021 to 0.0% in 2022 (p<0.001). For the strongest weed we see the same pattern with many significant differences over the years [H(21)=535.203; p<0.001]. The median CBD content in the strongest Dutch weed also decreased from 0.1% in 2021 to 0.0% in 2022 (p<0.001). For imported cannabis there is also a significant difference over the years [H(22)= 62.679; p<0.001]. However, there are much fewer changes between the years - last year the CBD content did not differ significantly from 2021. For median CBD and CBN contents in weed and hash over the years, see Tables III-8 and III-9 respectively. . In addition to all regular samples, 6 so-called CBD cannabis varieties were purchased this year, these contain between 0 and 17.3% CBD with a median value of 13.2% CBD.

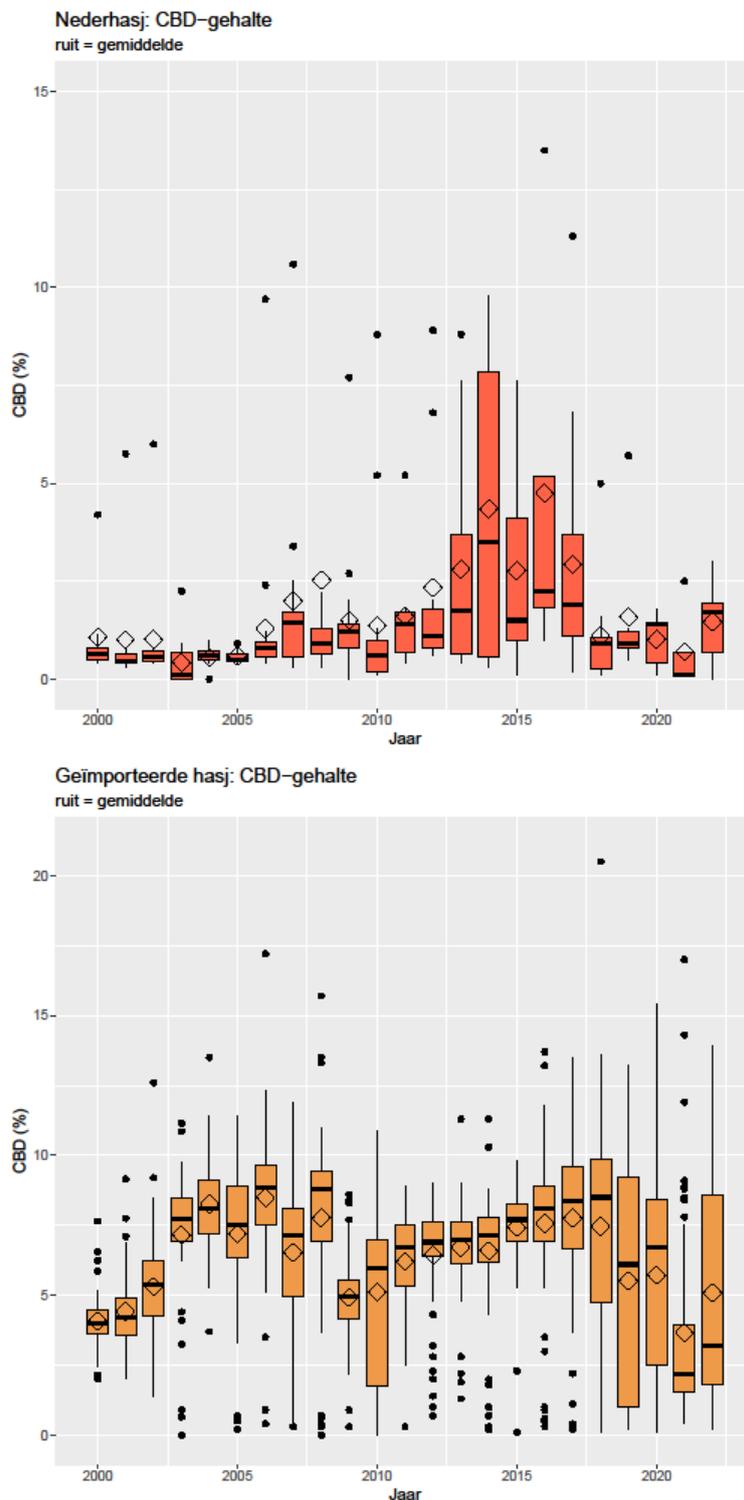
Figure III-9 a, b and c Box plots of the CBD value of Dutch weed (a), strongest weed (b) and imported weed (c) over the past years. Shown are the median values (thick black line), mean (diamond), interquartile range (green part) and outliers per measurement moment.





The average CBD content in imported hash varies over the years [$H(22)=299.382$; $p<0.001$]. In 2003 and 2009 there were significant changes compared to the previous year. The CBD content was higher last year than the year before (2.2% in 2021 compared to 3.2% in 2022). In a direct comparison, this difference was significant ($p<0.05$). Within the imported hashish, the traditional Moroccan hashish contained 4.4% CBD last year and the new variant 2.3% CBD. This year the traditional variant contained 4.6% and the new hashish from Morocco contained 3.4% CBD (both not significantly different from each other and compared to last year). The CBD content for Dutch hash also varies over the years [$H(22)=68.285$; $p<0.001$]. However, the post-hoc Wilcoxon's tests with Bonferroni correction cannot identify these differences between years (see Figure III-10).

Figure III-10 a and b Box plots of the CBD value of domestic hash (a) and imported hash (b) over recent years. Shown are the median values (thick black line), mean (diamond), interquartile range (red part) and outliers per measurement moment.



Long-term trends

Figure III-11 a (weed) and b (hash) shows the CBD trends for the different types. For all types of weed, the CBD content is constantly between 0.1 and 0.3%. In Dutch hash

It can be seen that after an increase in the content between 2005 and 2016 from 0.5 to 2.5%, a decrease can be seen and the content is now around 1% again. Imported hashish increased sharply in median CBD content to above 7.5% at the beginning of the century, but in recent years this has fallen sharply again to below 5%.

Figure III-11 a and b CBD concentrations in Dutch hash and imported hash (a) and the most popular Dutch weed, strongest Dutch weed and imported weed (b) in the different samples. Shown are the 3-year moving averages of the median CBD levels.

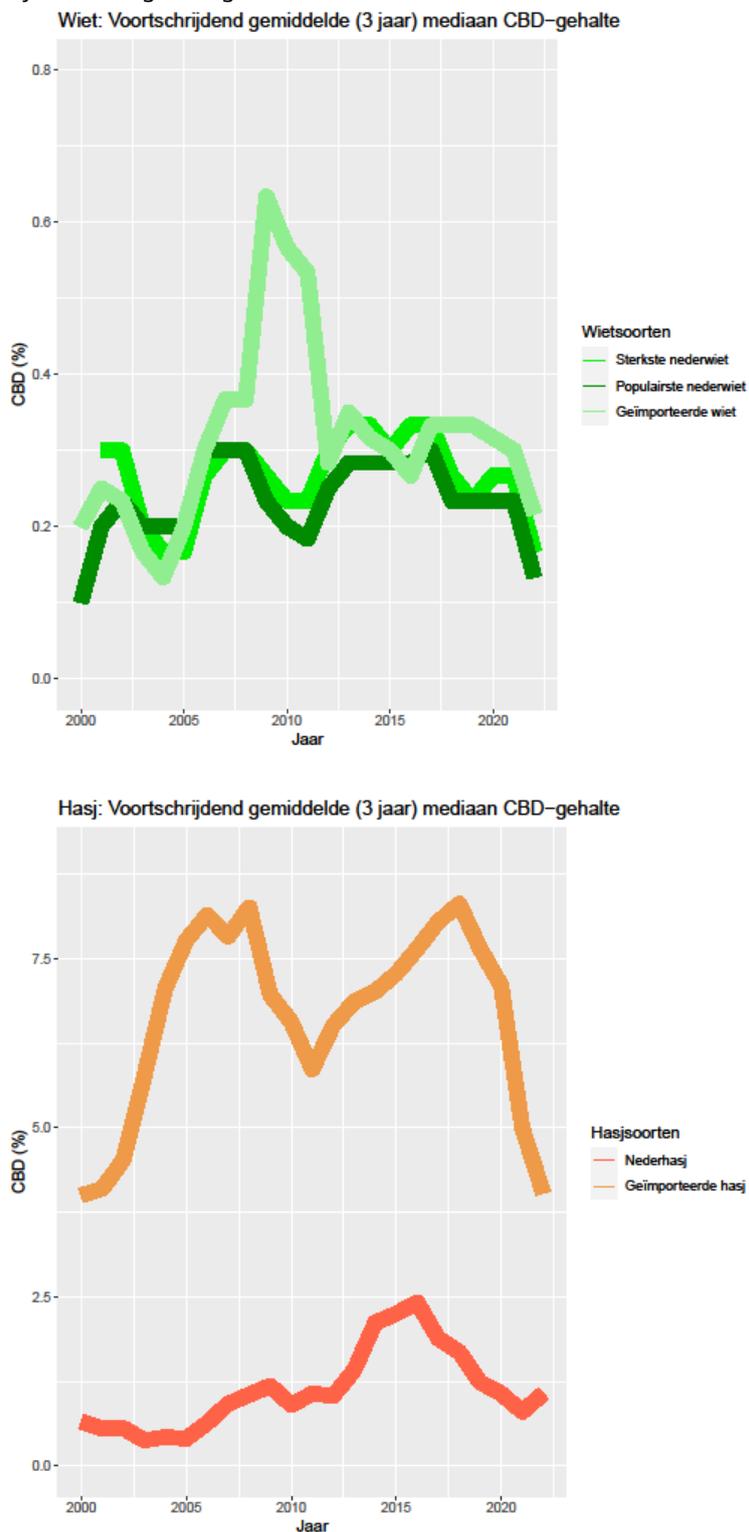


Table III-8 CBD contents of the various cannabis products in recent years (2017-2022). Shown are the median values and the lowest and highest values, with the number of observations in brackets.

	2017*			2018			2019			2020			2021			2022		
Dutch weed	0.3	0.1-5.9	(63)	0.1	0.1-9.8	(63)	0.3	0.2-14.1	(55)	0.3	0.1-19.6	(52)	0.1	0.1-24.5	(64)	0.0	0.0-0.0	(61)
Imported cannabis	0.4	0.1-4.5	(10)	0.3	0.1-3.7	(11)	0.3	0.1-2.5	(9)	0.4	0.2-1.7	(10)	0.3	0.1-1.4	(8)	0.1	0.0-0.2	(4)
Nederhash	1.9	0.2-11.3	(21)	0.9	0.1-5.0	(11)	0.9	0.5-5.7	(7)	1.4	0.1-1.8	(5)	0.1	0.1-2.5	(4)	1.7	0.0-3.0	(19)
Imported hash	8.4	0.2-13.5	(56)	8.5	0.1-20.5	(67)	6.1	0.2-13.2	(76)	6.7	0.1-15.4	(81)	2.2	0.4-17.0	(81)	3.2	0.2-13.9	(62)
Strongest weed	0.3	0.1-0.8	(50)	0.1	0.1-9.7	(50)	0.3	0.2-0.6	(49)	0.4	0.2-0.7	(49)	0.1	0.1-17.7	(53)	0.0	0.0-13.9	(49)

*) 2017 means that the samples were purchased in the winter of 2016/2017.

Table III-9 CBN levels of the various cannabis products in recent years (2017-2022). Shown are the median values and the lowest and highest values, with the number of observations in brackets.

	2017			2018			2019			2020			2021					
Dutch weed	0.1	0.0-0.5	(63)	0.2	0.1-1.2	(63)	0.1	0.0-0.9	(55)	0.1	0.1-0.4	(52)	0.1	0.1-1.0	(64)	0.2	0.0-0.4	(61)
Imported cannabis	0.7	0.4-1.9	(10)	1.0	0.6-2.9	(11)	1.6	0.3-2.6	(9)	1.8	0.6-2.7	(10)	1.1	0.4-2.9	(8)	1.8	0.5-3.7	(4)
Nederhash	1.7	0.4-8.7	(21)	1.4	0.2-4.0	(11)	2.5	0.5-8.6	(7)	1.8	0.7-2.8	(5)	1,2	0.6-1.9	(4)	1.5	0.6-3.2	(19)
Imported hash	1.9	0.1-5.9	(56)	2.4	0.1-8.2	(67)	1.7	0.4-7.8	(76)	1.8	0.7-8.3	(81)	1.7	0.1-13.5	(71)	1.9	0.0-9.8	(62)
Strongest weed	0.1	0.1-0.4	(50)	0.2	0.1-7.5	(50)	0.1	0.1-1.1	(49)	0.1	0.1-0.6	(49)	0.1	0.1-0.6	(53)	0.2	0.0-0.7	(49)

3.4 Ratio of CBD and THC concentrations

Ratio of CBD and THC concentrations: 2022 measurement

Table III-10 shows the CBD/THC concentration ratios for the various cannabis products as measured in 2022. The CBD/THC concentration ratio differs significantly between the cannabis products [$H(4)=164.086$; $p<0.001$], with the highest median ratio seen in imported hash.

Table III-10 Average, lowest and highest CBD/THC ratio in the different cannabis products as measured in 2022.

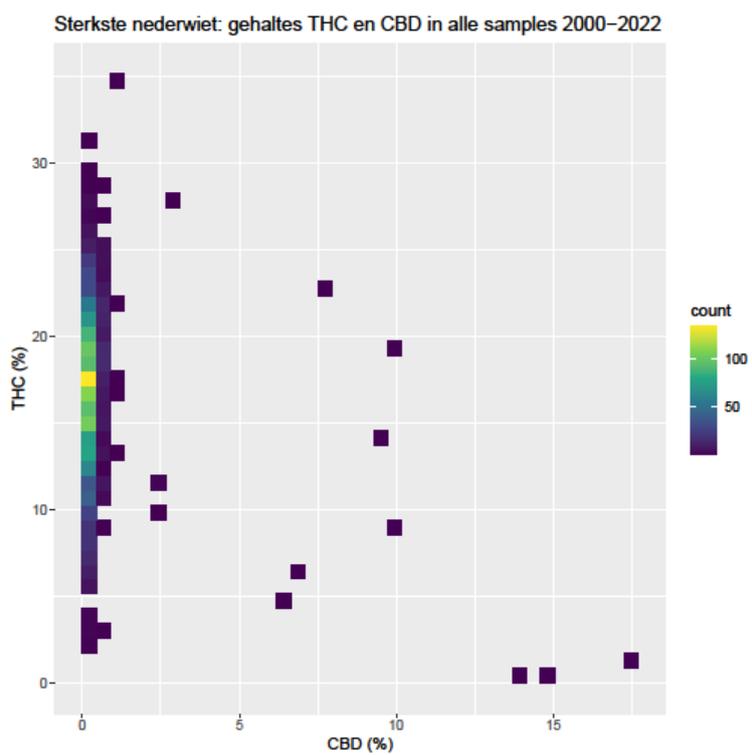
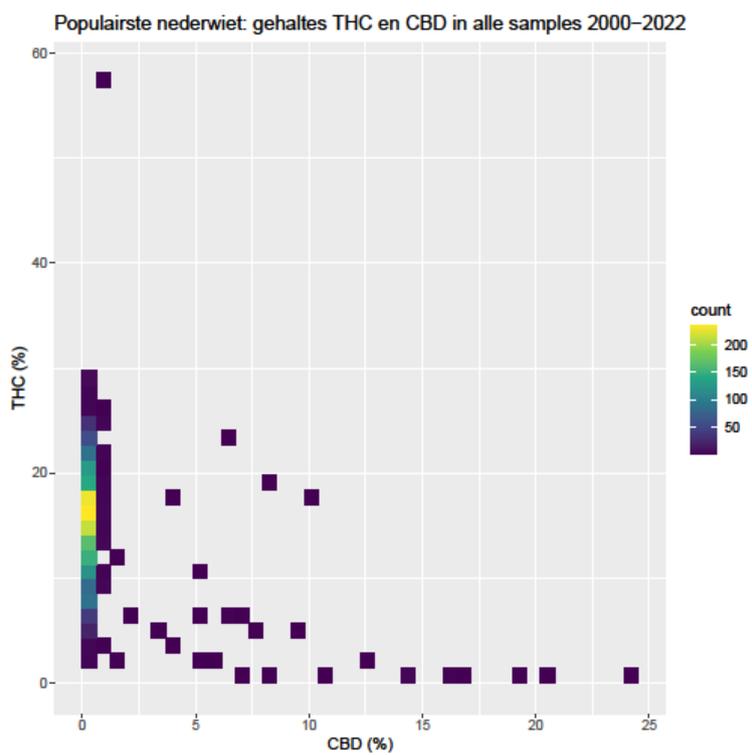
<i>Product</i>	<i>(n)</i>	<i>Average CBD/THC ratio</i>	<i>Median</i>	<i>Lowest CBD/THC ratio</i>	<i>Highest CBD/THC ratio</i>
Strongest (Dutch) weed	49	0.36 ± 2.48	0.00	0.00	17.38
Dutch weed (most popular)	61	0.00 ± 0.00	0.00	0.00	0.0
Nederhash	19	0.04 ± 0.05	0.05	0.00	0.11
Imported cannabis	4	0.14 ± 0.24	0.03	0.00	0.50
Imported hash	62	0.29 ± 0.43	0.12	0.00	2.64

Shown are means ± sd, median and lowest and highest measured value within a given group; n = number of observations.

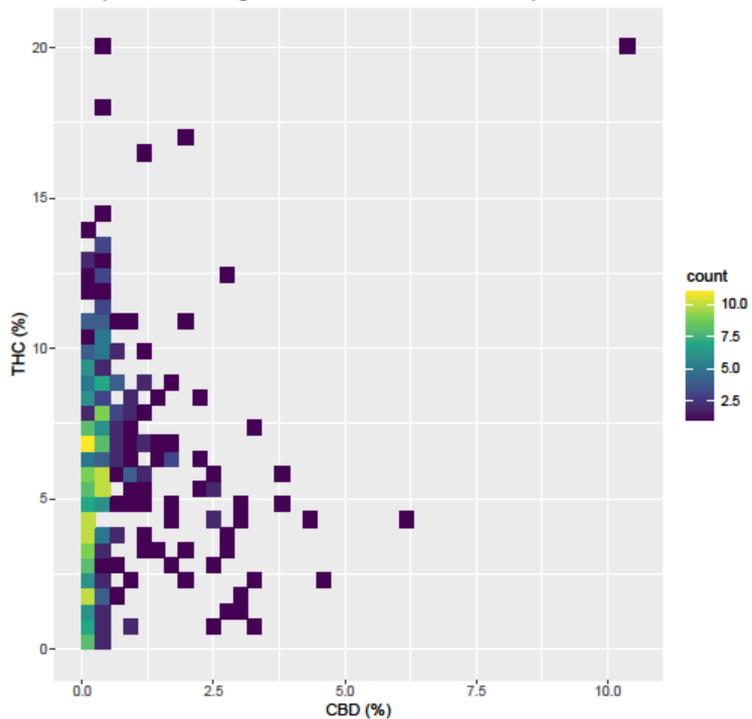
Ratio of CBD and THC concentrations: comparison with previous samples

See Appendix D for a graphical overview of the differences between the years (cross tables). Figure III-12 shows the percentages of THC and CBD of all cannabis samples analyzed in the past 22 years (since 2000) in a clustered form. The figure shows that Dutch weed (the most popular strain and strongest strain) almost always contains high concentrations of THC and hardly any CBD. Only 1.9% of the most popular and 1.1% of the strongest Dutch cannabis has a CBD of $\geq 1\%$. Of the Dutch hashish samples, 43.6% of the samples have had $\geq 1\%$ CBD in the past 10 years. Of the imported cannabis, 17.1% of the samples contain 1% CBD or more. Of the imported hashish, 93.3% of the samples contain 1% CBD or more. However, Figure III-12e shows that clustering occurs in two groups: one with a lot of CBD, and one with less CBD.

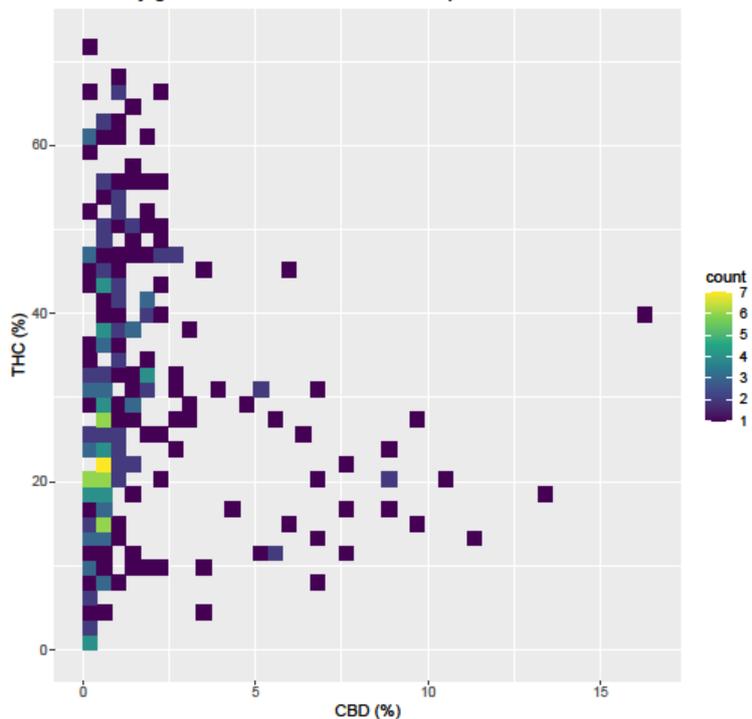
Figure III-12a, b, c, d and e Percentage of THC and CBD in a) most popular Dutch weed, b) strongest Dutch weed, c) imported weed, d) Dutch hash, and e) imported hash from Dutch coffee shops purchased during all years of the THC monitor (2000 – 2022). The color corresponds to the number of samples that fall into a certain cluster.



Geïmporteerde wiet: gehaltenes THC en CBD in alle samples 2000–2022



Nederhasj: gehaltenes THC en CBD in alle samples 2000–2022



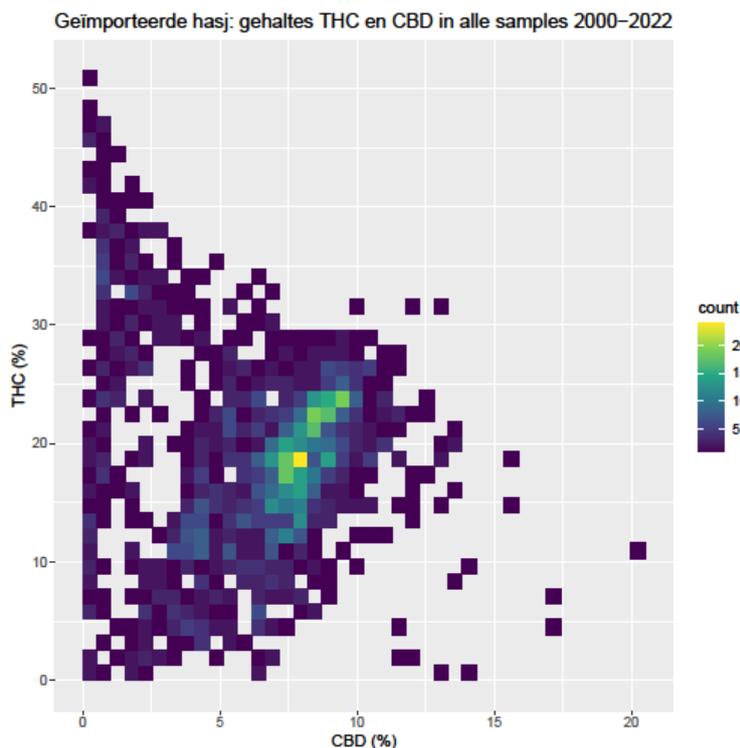
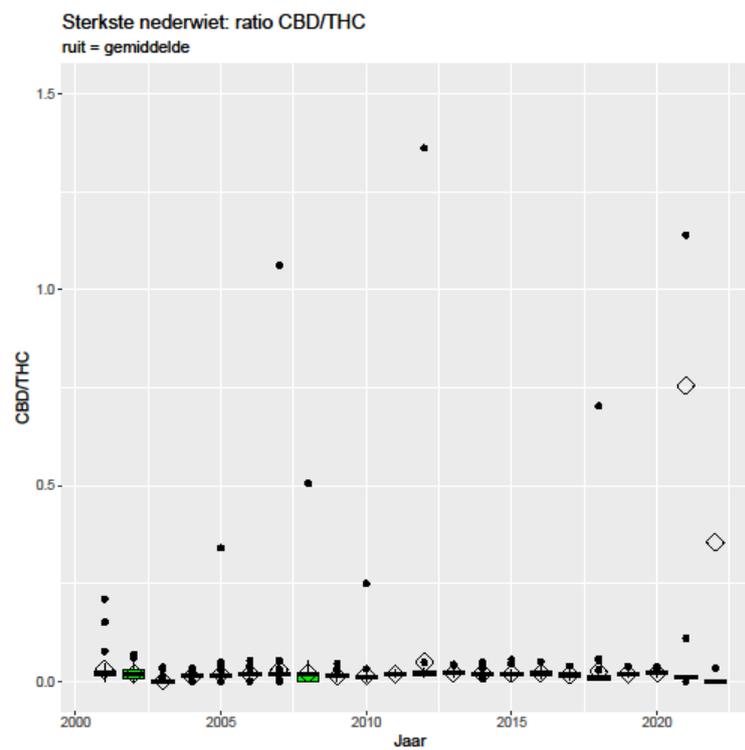
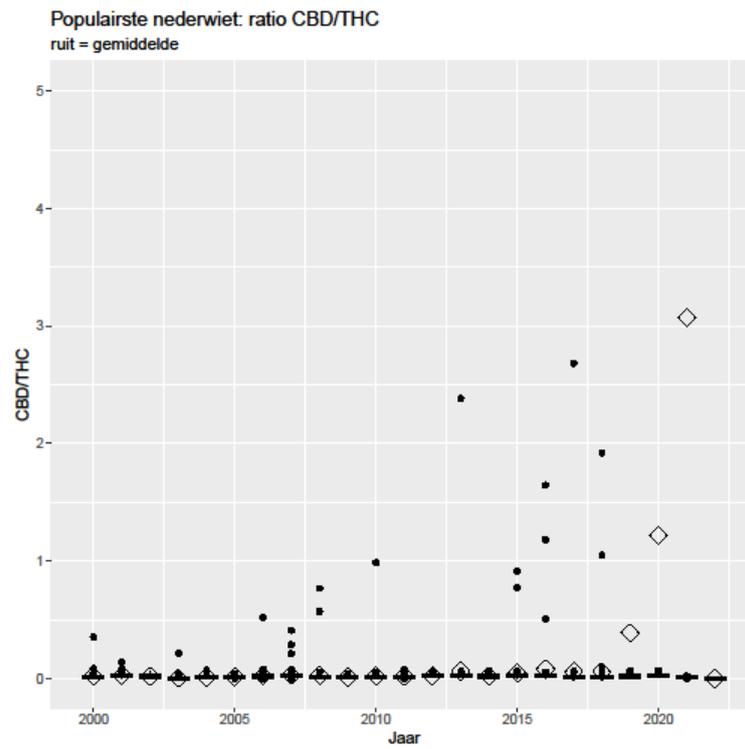


Figure III-13 and 14 show the CBD/THC ratios of all cannabis varieties analyzed during the various THC monitor vintages. In a direct comparison, it is striking that the CBD/THC ratios of the strongest and most popular Dutch weed fell significantly this year, from 0.76 and 3.07 respectively in 2021 to 0.36 and 0.00 ($p < 0.001$ and $p < 0.001$) in 2022. The CBD/THC ratio of the other cannabis products did not differ significantly this year compared to last year.

When comparing over the years (see cross-tables in the annex), it is striking that the CBD/THC ratios of Dutch hash and imported weed do not or hardly change. The CBD/THC ratios of imported hashish increased significantly in 2003 and 2011 compared to the previous year. Significant differences are more often seen for the most popular Dutch cannabis: in 2001, 2003, 2004, 2009, 2011, 2018, 2019 and 2021 the CBD/THC ratio was significantly different from the measurement of the previous year - in addition to the already reported decline in 2022. For the strongest Dutch weed, differences were seen in 2003, 2004, 2011, 2019 and 2021 compared to the previous year - this in addition to the already reported decrease in 2022.

Figure II-15 a and b shows the multi-year trend analyzes (moving averages) of the median CBD/THC ratios. It is striking that it can be seen here that the CBD/THC ratios in the Dutch cannabis varieties appear to be quite stable, while the ratios of the hash varieties and imported cannabis fluctuate more.

Figure III-13 a, b and c Boxplots of the CBD/THC ratios of the most popular Dutch weed (a), strongest Dutch weed (b), and imported weed (c) over the past years. Shown are the median values (thick black line), mean (diamond), interquartile range (green part) and outliers per measurement moment.



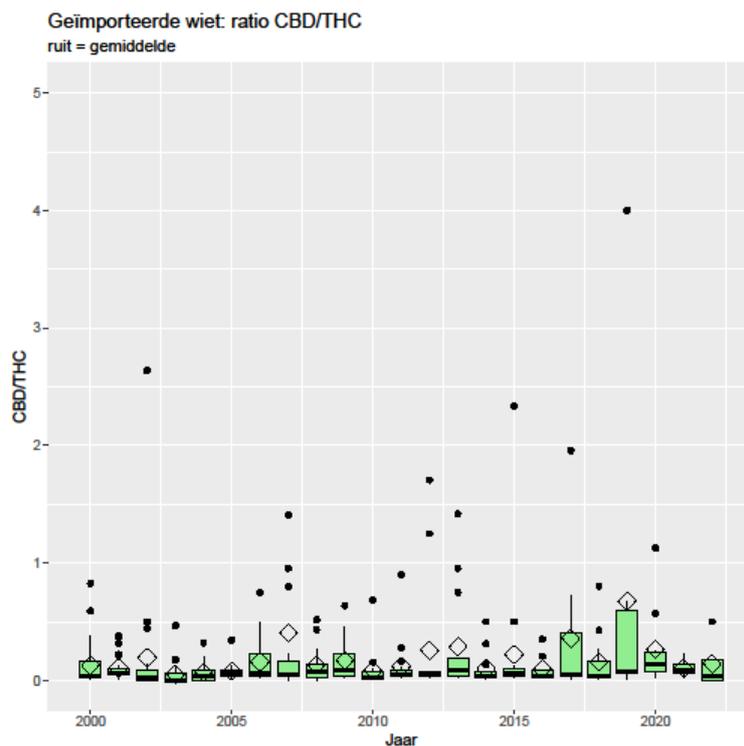
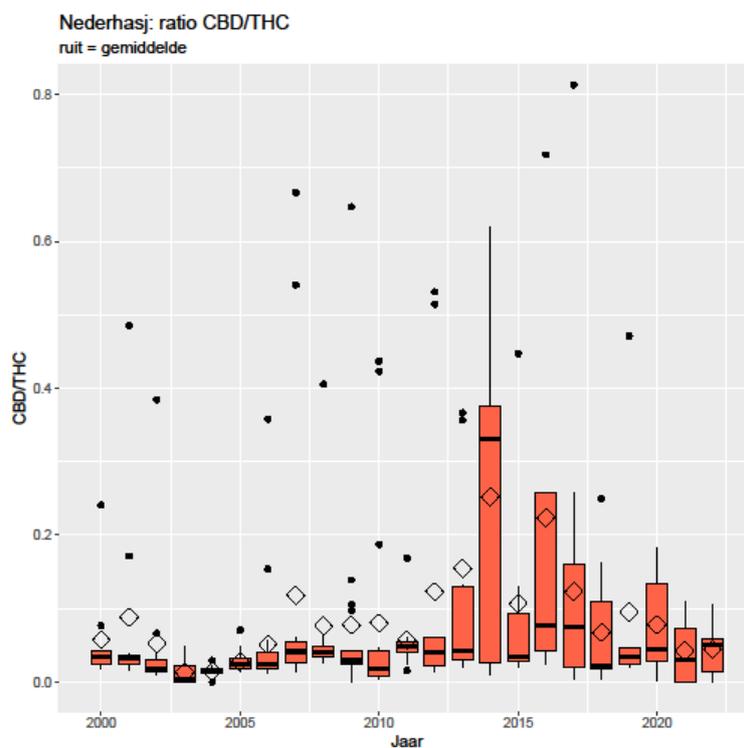


Figure III-14 a and b Box plots of the CBD/THC ratios of Dutch hashish (a) and imported hashish (b) over the past years. Shown are the median values (thick black line), mean (diamond), interquartile range (red part) and outliers per measurement moment.



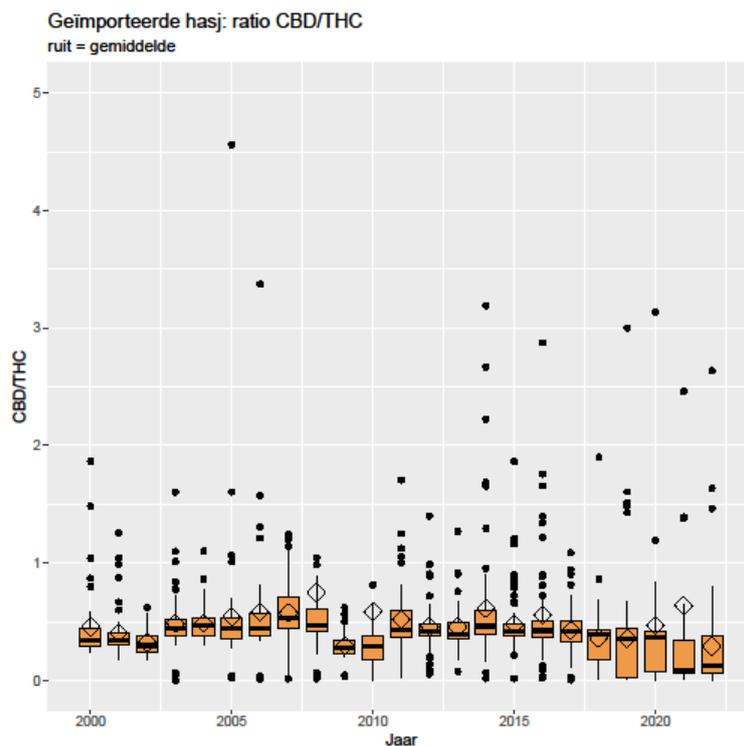
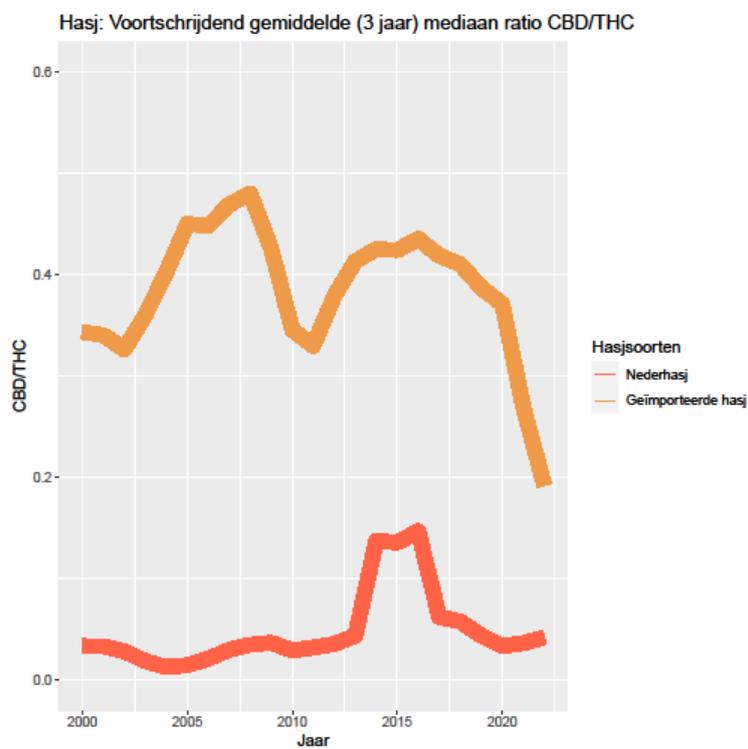
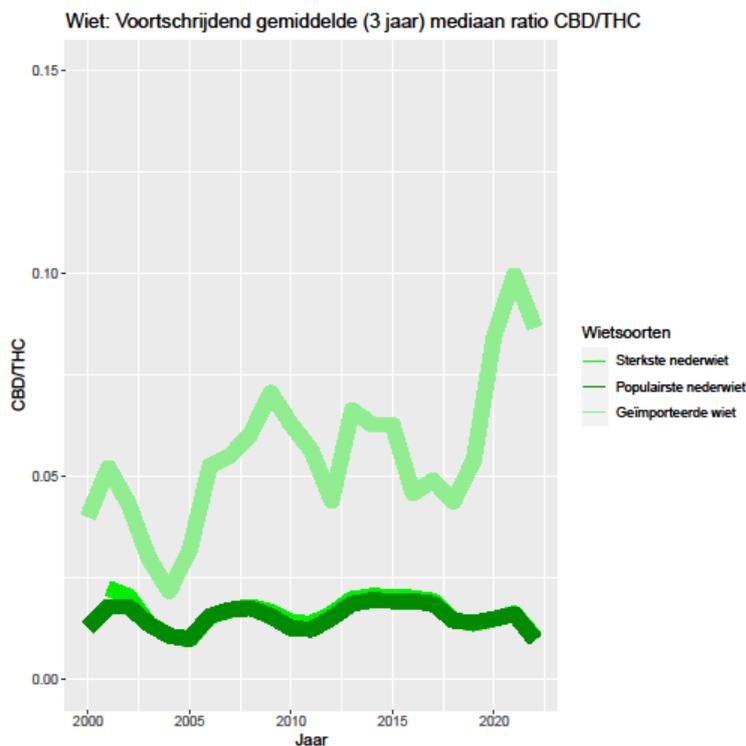


Figure III-15 a and b CBD/THC ratios in Dutch hash and imported hash (a) and the most popular Dutch weed, strongest Dutch weed and imported weed (b) in the different samples. Shown are the 3-year moving averages.





3.5 Correlations between price and strength

Correlation price and strength: measurement 2022

Figures III-16 and III-17 graphically show the relationship between the price and the THC content per cannabis or hashish sample. The calculation is based on the actual amount paid per gram of cannabis sample.

In general, a cannabis product (weed or hashish) for which a higher price was paid does not necessarily have a higher THC content ($r=0.000$; ns). This absence of a correlation also applies to cannabis, i.e. both the “most popular” and “strongest” cannabis strain and imported cannabis together ($r =0.01$; ns), and for hash (local hash and imported hash together, $r=0.02$; ns).

Figure III-16 Purchase value of one gram of weed (nederwiet, strongest weed and imported cannabis) compared to the THC content (n=114).

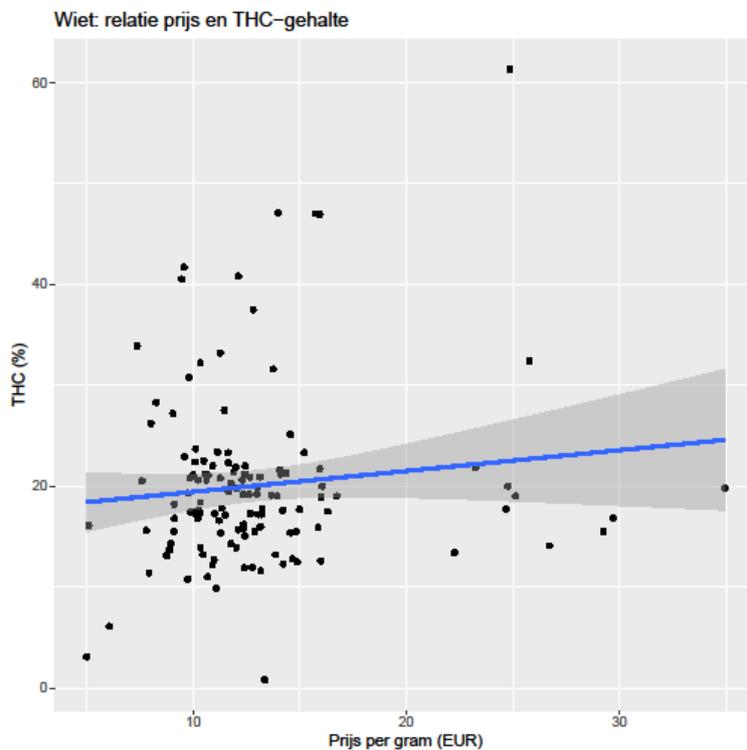
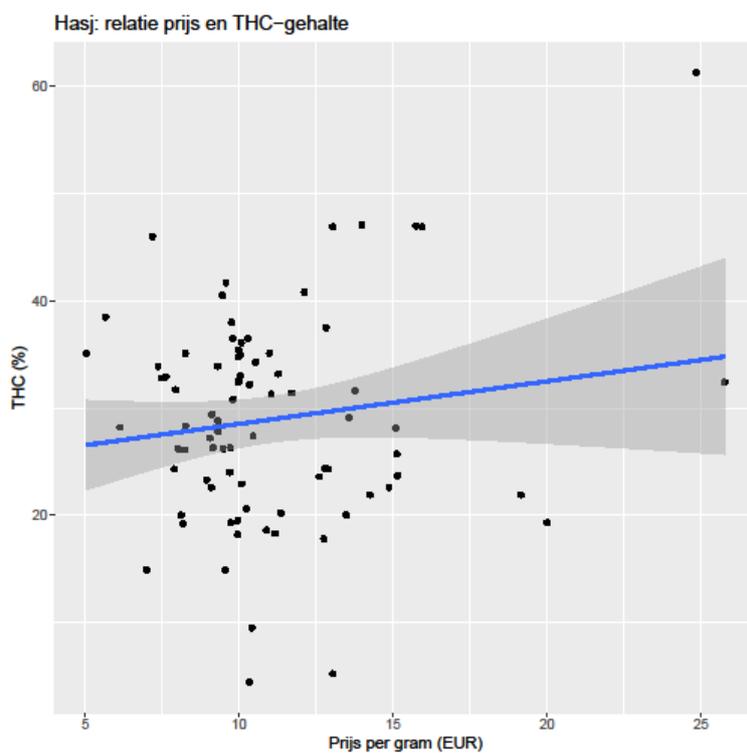


Figure III-17 Purchase value of one gram of hash (Dutch and imported hash) compared to the THC content (n=81).



The value of the various cannabis products can be expressed in the amount of THC that someone receives per euro (THC/euro). The THC/euro value differs between the different products [$H(4)=86.479$; $p<0.001$] and is lowest for foreign weed (7.8 ± 10.2 mg) and highest for Dutch hash (30.4 ± 8.3 mg) (Table III-11). When purchasing the new types of hash from Morocco, people received on average the same amount of THC per euro (30.6 mg) as with traditional Moroccan hash (27.4 mg). For the most popular weed (15.8 vs 13.2 mg THC/EUR), the imported hash (27.8 vs 22.0 mg THC/EUR) and the Dutch hash (30.4 vs 14.1 mg THC/EUR) a consumer received significantly more THC for every euro spent this year than in 2021.

Table III-11 The value of the various cannabis products shown as mg THC/euro.

Product	mg THC/euro		
	n	average \pm sd	lowest - highest value
Strongest (Dutch) weed	49	12.5 \pm 4.8	(0.6 - 24.0)
Dutch weed (most popular)	61	15.8 \pm 4.7	(6.2 - 31.6)
Nederhash	19	30.4 \pm 8.3	(12.6 - 46.0)
Imported cannabis	4	7.8 \pm 10.2	(2.3 - 23.0)
Imported hash	62	27.8 \pm 13.3	(4.0 - 69.5)

The lowest and highest values are always shown in brackets; n = number of observations.

4 Discussion

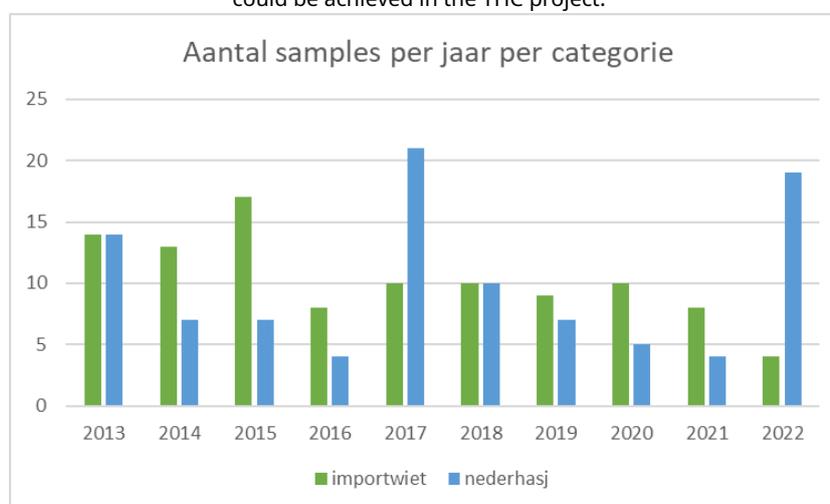
In the context of the THC monitor, a user quantity of several cannabis products has been purchased annually in about fifty coffee shops since 1999. This concerns Dutch weed (most popular variant), foreign hash, foreign weed, and hash prepared from Dutch weed (nederhash). In addition, cannabis samples are purchased that were deemed the “most strong” by the coffee shop employees. It should be noted that correctly assessing strength is not possible through assessment of smell, taste and/or appearance (Gilbert and DiVerdi, 2018). Samples in the “most strong” weed category are therefore from the *supposed* strongest strain: you are asked about the product that is thought to contain the most THC. The concentrations of THC, CBD and CBN in all purchased cannabis products have been determined in the laboratory.

4.1 Categories

Not all products are available in all coffee shops. Almost all coffee shops sell Dutch weed, some only hash. At the beginning of the 21st century, 1 in 2 coffee shops still sold weed imported from abroad (for example Jamaican, Thai or African weed). Nowadays only about 10% (occasionally) sell such products. What seems to be sold more often as not strong weed is Dutch weed grown outside, and also CBD weed (for sale this year in 6 of the 50 coffee shops visited).

As far as hash is concerned, hash has always been sold from Asian countries (for example India and Afghanistan), but mainly from Morocco. Since the beginning of this century, hash produced in the Netherlands (nederhash) has also often been present, usually available under names such as Ice-olator or skuff. For several years, hash has also been sold that has been produced in a new way, namely from Dutch cannabis-like plants. It is possible that this hash is made in Morocco or Spain, but many of these samples are said by the coffee shop staff to belong to the Dutch hash category. It is possible that the number of Dutch hash samples that could be purchased increased from 4 in 2021 to 19 this year. See also Figure IV-1.

Figure IV-1 Number of samples of Dutch hash and imported cannabis purchased in the past 10 years could be achieved in the THC project.



4.2 Purchase Prices

The average price for the most popular type of Dutch weed (€11.70 per gram in 2021, €11.17 per gram in 2022) did not change significantly this year. The same applied to imported cannabis (€3.79 compared to €4.67 in 2021) and the supposedly strongest cannabis strain (€14.21 in 2021, €15.45 in 2022). When looking at the long-term developments, it can be seen that there has been a significant increase for both the most popular and the strongest Dutch weed since 2007 (respectively from around €7 to around €11 and from around €7 to around €14). In addition to regular price inflation, more exclusive varieties are becoming available from the Netherlands, but in recent years also from abroad (USA and Canada). The measures during corona could also affect the availability of cannabis, and therefore the price. The price for a gram of imported weed has been between (approximately) €4 and €6 for years. The average price paid for a gram of imported hashish was around €7 at the beginning of this century and has since gradually risen to just over €10 in recent years. However, over the past year the price for a gram of imported hashish dropped significantly (€11.74 in 2021 versus €10.55 in 2022). It appears that the COVID-19 pandemic has not caused any major supply disruptions, which could have affected the price of imported hashish. This is in line with the findings of the UNODC (UNODC, 2021).

The average price for a gram of Dutch hash varies considerably over the years. On the one hand, this is due to the small number of samples that can be purchased and on the other hand, because the price for a gram of this product in the coffee shop is sometimes around €10 and other times as much as €50. - could be. This has to do with the method of production and the "raw materials" used to produce this hash. However, the long-term trend analysis does indeed show a gradual increase that is largely in line with that of the Dutch weed varieties.

4.3 THC and CBD levels

The most popular variety of Dutch weed contained an average of 17.2% THC in 2022 compared to 14.6% in 2021, a significant increase. The average THC content for the strongest weed and for imported weed remained the same (17.0% in 2021, 17.5% in 2022 and 4.0% in 2021, 2.4% in 2022 respectively). Hash made from Dutch weed (nederhash) in 2022 (35.7%) differed significantly in strength from the 2021 report (21.0%). The average THC content of hashish imported from abroad did not change significantly: from an average of 24.3% in 2021 to 26.8% in 2022.

When looking at the long-term trends for average THC content, it can be seen that both the strongest and most popular variants have been fairly consistent over the past 15 years and are between 15 and 18%. This is in contrast to many other countries, where increases in THC concentrations are still reported (Freeman et al., 2020, Zamengo et al., 2020). For imported weed, the content was almost always between 4 and 7% - this year the THC content is a lot lower, but it must be noted again that the number of purchased samples in this category is very limited. In hash imported from abroad, we have seen a gradual increase over the past 10 years from around 15% to around 25% THC. With Dutch hash, the average THC content fluctuates between 25 and 35%, a wide range. This is probably due to the limited number of samples that could be purchased in this category in the past. This year's significantly increased average content is undoubtedly a better reflection of reality, because a larger number of samples have been collected. In the coming years, the hope is to collect a similar number of samples in this category so that a thorough comparison can be made

Dutch weed varieties (the supposed source material for Dutch hash) can be made.

Although THC is the primary psychoactive compound in cannabis, the presence of CBD plays a pharmacological role. There are indications that CBD can modulate or even counteract some (unwanted) effects of THC (Niesink and van Laar, 2012, 2013, 2016, Freeman et al, 2019). The Dutch cannabis varieties contain only little CBD (median most popular 0.0%, median most strong 0.0%), while imported hashish contains more CBD (median 3.2%). However, in the past, this imported hashish contained an average of 7 to 9% CBD. Over the past year, the median CBD content in the most popular and strongest Dutch cannabis decreased (both from 0.1% in 2021 to 0.0% in 2022). Part of the explanation for this decline is that varieties sold as CBD weed were no longer included in the most popular or strongest weed category, unlike in previous years. This year, 6 types of cannabis were sold as CBD cannabis. Five of these contained a significant amount of CBD (median 13.2%); one sample contained no CBD, but only THC. For imported hashish, the median CBD content increased significantly (2.2% in 2021 and 3.2% in 2022). This appears to put a temporary end to a downward trend that has been visible in the CBD content of imported hashish in recent years.

Little is known about the meaning of the ratio of CBD to THC (CBD/THC ratio). Research in recent years has shown that significant amounts of CBD are required for effects described as positive (Niesink and van Laar, 2012 and 2016; Zuardi et al., 2012; Grotenhermen and Müller-Vahl, 2012; Morales et al., 2017), but more research remains necessary (Millar, 2019). It is clear that Dutch cannabis varieties have very low CBD/THC ratios, and that this is usually much higher for imported hashish varieties. However, the ratio of THC to CBD in imported hashish varieties can vary widely, which appears to be related to changes in the way hashish is produced abroad.

4.4 Moroccan hash: modern vstraditional

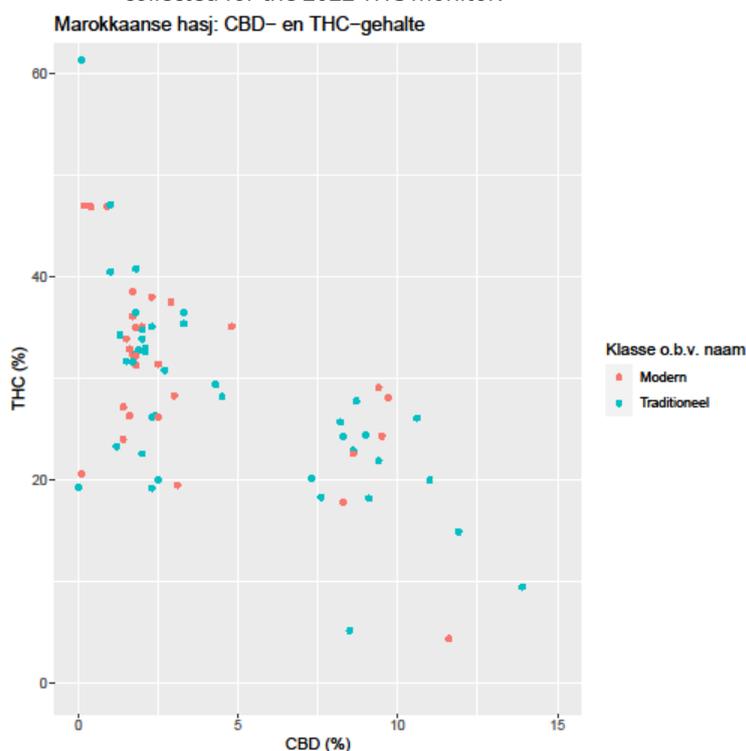
Over the past ten years, the average THC content in imported hash has increased from around 15% to around 25%. The main reason is that cannabis cultivation in Morocco has undergone drastic changes in the past decade (Rigter & Niesink, 2016; Rigter & Niesink, 2017; Rigter & Oomen, 2021). The strength of Moroccan hash has increased considerably due to the switch among some Moroccan cannabis farmers from "traditional" Kif cannabis variety to hybrids (*Cannabis indica*L. and others). These hybrids have much higher resin yields and a higher THC content (Chouvy & Afsahi, 2014). At the same time, Morocco saw improved plant breeding, improved sieving methods and fewer additives, which led to a better/different product. This trend of higher THC levels in hashish has also been observed in other countries (Freeman et al., 2020, Zamengo et al., 2020). Some of these new types of hash are also said to come from European countries (especially Spain). Coffee shop owners sometimes indicate that hash types are "mixed" or "composite". This can be done by mixing different hash powders together, but it is also said that oil (cannabis extracts) can be added to hash. The presence of synthetic cannabinoids on hashish and cannabis in Europe over the past two years shows that cannabis is now also sometimes "cut" (Oomen et al., 2022).

Traditional Moroccan hash is made from Moroccan cannabis strains. As previous reports from the THC monitor have shown, this traditional Moroccan hash usually contains an average of 17-20% THC, in combination with a relatively high percentage of CBD: usually between 7-9%. In addition to the traditional Moroccan hash varieties, a new type of hash has been increasingly seen in coffee shops since 2016. It's alright

This includes hash that is made in Morocco from Dutch cannabis-like plant species. This hash is often sold as “hash blocks” or under the name of the original cannabis variety (for example Amnesia hash). This modern Moroccan hash is said to contain on average about 20% more THC than the traditional Moroccan variants and only between 0.4 and 1.6% CBD (Source: <https://www.boerejongens.com/traditional-hash-vs-block-hash/>).

This year, 29 hash samples were purchased that were suspected of originating from Morocco, but were made from sinsemilla (Dutch) cannabis varieties. These modern hashish varieties have been compared with the traditional hashish varieties from Morocco (N=41). This year's modern Moroccan hashish varieties contain an average of 30.6% THC and the traditional varieties contain 28.2% THC. This year they no longer differ significantly from each other in terms of THC content, while this was the case in the past. This is mainly because the average THC content of traditional hash increased from 22.0% in 2021 to 28.2% this year. An explanation for this increase is that modernly produced hashish varieties are increasingly sold in coffee shops as traditional varieties. The CBD content of the modern Moroccan strains has remained the same over the past year from 2.3% to 3.4%, the same applies to the traditional strains (4.4% in 2021 and 4.6% this year).

Figure IV-2 CBD and THC levels of modern and traditional Moroccan hashish samples, collected for the 2022 THC monitor.



It seems that there is less and less difference between the modern and traditional types. We suspect that modern varieties are often sold under an old name (for example “Polm”, “Super Polm”, “Caramello”, “Hija” or “Twisla”). When we display the THC and CBD contents of the different groups of Moroccan hashish samples in a scatter plot (see Figure IV-2), we see two groups emerge: one with a lot of THC and little CBD, and one with both a significant amount of THC and CBD. However, a division into traditional and modern based on the name does not correlate with this: both variants show this dichotomy in terms of CBD and THC content. It is therefore difficult for a consumer to determine what kind of hash he or she is buying when the name alone is used

gone off. During a tour of coffee shop owners, it emerged that it is expected that more modern hash varieties will end up on the Dutch market. The sinsemilla varieties have a much higher yield, which would cause many farmers to switch. According to the coffee shop owners, a small portion of Dutch hash consumers continue to ask for traditional types of hash, mainly because of the taste and effect.

4.5 THC per euro and comparison with abroad

Strong hash and weed have always been around, but for the first time since the start of this research, there is no connection between the average price that a consumer pays per gram of hash or weed and the amount of THC contained in the sample. This means that the consumer cannot base his purchase on the price to determine his choice and a consumer who actually wants less strong hash can accidentally come into contact with much stronger hash. The coffee shop has a clear role here to provide good information about the expected strength when purchasing.

The value of the different cannabis products can be expressed in the amount of THC someone receives per euro spent (Freeman et al., 2018). This value differed significantly between the different cannabis products over the past year. Cannabis consumers in the Netherlands received an average of 7.8 mg THC per euro for imported weed, 12.5 mg THC per euro for the strongest Dutch weed, 15.8 mg THC per euro for the most popular Dutch weed, 30.4 mg THC per euro for Dutch hash and 27.8 mg per euro for imported hashish. For the most popular weed, imported hash and Dutch hash, a consumer received more THC for every euro spent this year than in 2021. In 2022, a consumer received more than double the amount of THC per euro he spent for Dutch hash (from 14.1 mg to 30.4). The number of Dutch hash samples that could be purchased increased from 4 in 2021 to 19 in 2022. Based on the name, we suspect that some of this year's samples sold as Dutch hash may be modern foreign hash. When purchasing modern types of hash from Morocco, people received on average more THC per euro (30.6.1 mg) than with traditional Moroccan hash (27.4 mg).

In Europe, users received an average of 12.7 mg THC per euro for cannabis and 16.4 mg THC per euro for hash (Freeman et al., 2018). A different picture is painted in a recent publication by Mahamad *et al.* This looked at the strength and price of legal and illegal Canadian weed in the two months after legalization began in 2018. Based on the current exchange rate and the data presented in the article, it can be calculated that illegal weed in Canada has a value of approximately 31.1 mg THC per euro, where legal Canadian weed has a value of approximately 22.5 mg THC per euro (Mahamad et al., 2020). The amount of THC in cannabis products sold in Dutch coffee shops is therefore above the values found in the EU, but below or equal to those in Canada. Potency and price play a role in consumers' decisions about which cannabis to purchase, but it is unknown whether the amount of THC per dollar spent has an impact.

4.6 Risks

According to Zinberg's model, the effects and risks of drugs can be explained by the drug, the set and the setting (Zinberg, 1984). As far as the drug is concerned, the proportion of hashish types that contain high amounts of THC and little CBD is alarming. This trend means that hash, which in the past generally contained (much) more CBD than Dutch cannabis varieties, is starting to look more like strong cannabis varieties. The contamination of cannabis with synthetic cannabinoids found outside the THC monitor in coffee shops is also very disturbing (Oomen et al., 2022), although last year

Much fewer samples contaminated in this way have been found in the Netherlands. Perhaps the biggest acute risk at the moment, however, is that the consumer cannot make a good estimate of the strength of the product based on the name or price of hashish. The individual consumer will have to be informed about this via the seller.

The setting of cannabis use has undergone major changes in recent years. During the lockdowns, the option to use in coffee shops was abolished and collection was only possible. The total ban on smoking tobacco products in coffee shops also came into effect during this period, as a result of which some coffee shops only retained a take-away function when consumption was allowed in the coffee shop again. However, this also offers opportunities in the field of *harm reduction*. The Trimbos Institute previously showed that the vast majority of visitors to coffee shops smoke cannabis with tobacco (Rigter et al., 2019). Although smoking cannabis is associated with serious respiratory complaints such as chronic bronchitis, smoking cannabis with tobacco appears to be more harmful than smoking cannabis alone (Strada et al., 2019). Smoking cannabis appears to be more harmful than vaporizing cannabis, although knowledge about this is still limited. Unlike smoking cannabis, vaporizing cannabis does not involve the inhalation of highly harmful combustion products, because the temperature at which cannabinoids (and terpenes) vaporize is far below the temperatures reached when smoking. Vaporizing cannabis does cause stronger acute psychoactive effects. Also, tobacco is rarely added to the cannabis when vaporizing cannabis. This reduces the risks associated with tobacco use. It should be noted that there are different types of evaporators. So-called "heated-product" vaporizers are comparable to the Volcano vaporizer, which is also used for a lot of scientific research into vaporizing cannabis and medical applications. Plant material can be placed in this type of evaporator, after which it is heated with an element to the evaporation point of the active substances. E-cigarettes, which use an oily vaporizing liquid, can also be used to consume cannabis. THC-containing oils produce stronger effects and less exposure to harmful substances than smoking cannabis (Troelstra et al., 2020). However, the use of THC-containing oils in e-cigarettes appears to entail other health risks: the excipient vitamin E acetate that is often used in these liquids appears to be able to cause serious lung disease (Chand et al., 2020). In the future we hope to conduct more research into the use of vaporizers and to what extent they are suitable as effective ones *harm reduction* for cannabis consumers.

5 Conclusions

- ✿ The average THC content in the most sold Dutch weed has increased this year from 14.6% to 17.2%.
- ✿ The CBD content of Dutch weed is lower than ever. The median CBD content of both the best-selling and strongest Dutch cannabis varieties fell from 0.1% to 0.0% this year.
- ✿ The average THC content in the Dutch hash increased from 21.0% to 35.7%. This year there were many more coffee shops where Dutch hash was sold: last year 4, this year 19.
- ✿ The average THC content in the imported hashish remained the same (24.3% in 2021 versus 26.8% in 2022), but the median CBD content was significantly higher (2.2% in 2021 versus 3.2% this year).
- ✿ Imported cannabis is for sale in fewer and fewer coffee shops (this year in 4 of the shops visited). In recent years, new cannabis (made from cannabis species originating from or bred in North America) and CBD cannabis have become increasingly available for sale.
- ✿ The price of a gram of all cannabis varieties remained the same in 2022, with the exception of imported hashish. The average price of this category fell from €11.74 to €10.55 in 2022.
- ✿ There appear to be two groups of foreign hashish varieties with different THC and CBD contents. This may correspond to newer Moroccan hash varieties (made with Dutch cannabis plants) and the traditional varieties, but this distinction cannot be made based on the name of the product alone.
- ✿ The value of cannabis products expressed as the amount of THC per euro spent is highest for imported hashish (30.4 mg THC per euro) and lowest for imported weed (7.8 mg THC per euro). When purchasing the most popular Dutch cannabis, the Dutch cannabis consumer received an average of 15.8 mg THC per euro.
- ✿ This applies to the most popular weed, the imported hash and the Dutch hash year received more THC for every euro spent than in 2021.
- ✿ For the first time ever, we see that there is no relationship between the price and strength of cannabis products – this applies to both hash and weed.

6 Summary

Since the 1970s, cannabis policy in The Netherlands has been different from that in many other countries. It is based on the idea that separating the markets for hard and soft drugs prevents cannabis users from resorting to the use of hard drugs. Therefore, so-called “coffee shops” emerged where the selling and use of cannabis are not prosecuted, provided certain conditions⁷ are with. The number of coffee shops has been steadily declining from almost 900 at the start of this millennium to 565 in 2021. Local authorities decide whether a coffee shop is allowed in their municipality. About 25% of Dutch municipalities have one or more coffee shops.

Nowadays, many of the cannabis products sold in these coffee shops originate from Dutch-grown cannabis, called “nederwiet”. It is estimated that over 80% of the cannabis products sold in coffee shops is Dutch-grown, and the rest of the sales is mostly hashish (mostly imported from Morocco). On behalf of the Ministry of Health, Welfare and Sports, the Trimbos institute investigates the potency of cannabis products sold in coffee shops. This study has been done annually since the winter of 1999-2000, the current being the twentysecond edition.

Δ^9 -Tetrahydrocannabinol (THC) is the main psychoactive compound in marijuana/weed (herbal cannabis) and hashish (cannabis resin). The aim of this study is to investigate possible changes in the concentration of THC in marijuana and hashish as sold in Dutch coffee shops. In addition, we examined whether there are differences between products originating from Dutch-grown cannabis (nederwiet) and those derived from imported cannabis. Besides THC, the concentrations of two other cannabinoids, cannabidiol (CBD) and cannabinalol (CBN), are measured.

Fifty (out of a total of 565) Dutch coffee shops were randomly selected and visited as part of this study. In each coffeeshop, cannabis samples were bought anonymously in several categories. In total, 61 samples of the most popular (*i.e.*, the most sold) variety of nederwiet, 49 samples of the (allegedly) most potent marijuana available, 4 samples of imported marijuana, 19 samples of Dutch hashish and 62 imported hashish samples were acquired. Additionally, 6 cannabis samples were bought which (allegedly) contained mostly CBD. As a rule, samples of 1 gram were bought.

Traditionally, hashish contains more THC than marijuana, and Dutch-grown marijuana products (which are mostly grown indoors) contain more THC than imported marijuana products (which are mostly grown outdoors). On average, imported hashish contained more THC than imported marijuana (26.8% versus 2.4%) and Dutch hashish contained more THC than the most popular Dutch marijuana (35.7% versus 17.2%). In 2022, the average THC content of the most potent marijuana did not differ significantly from compared to that of the most popular marijuana (17.5% versus 17.2%).

⁷Max 5 grams per person per day can be sold, no hard drugs or alcohol, no admission of and selling to minors, no advertising, no nuisance to neighborhood, max 500 grams of cannabis in stock, only admission of and sale to Dutch residents.

Compared to the previous measurement in 2021, the most popular Dutch weed was found to have a significantly different THC content (14.6% versus 17.2%). The average THC content in marijuana that was bought as most potent did not differ significantly from last year (17.0% in 2021 versus 17.5% in 2022). This fits the trend that can be observed in the past 15 years: the THC content of both the most popular and most potent Dutch weed fluctuates between 15 and 18%. Imported marijuana contained less THC than all other cannabis products (2.4%). The THC content of this cannabis did not differ significantly from last year. The number of coffee shops that sells imported cannabis is very limited.

On average, Dutch hashish (made from Dutch cannabis plants) contained 35.7% THC. The THC content of Dutch hashish has been fluctuating between approximately 25 and 35% throughout the years, a large range of concentrations. This is probably a result of the historically limited availability of these products in Dutch coffee shops. This year a much higher number of samples could be acquired in this category (19 vs 4). In 2022, the average THC content of imported was 26.8%. This is not significantly different from last year's measurement (24.3%). For the past 10 years, the THC content of imported hashish has been steadily increasing from 15% to approximately 25%. Historically, the THC content of imported hashish was often comparable to that of Dutch weed. Interestingly, imported hashish also contains a significant amount of CBD: a median of 3.2% vs 0.0% in Dutch weed. Although the median CBD content in imported hashish has significantly increased compared to last year (2.2%), this is still significantly lower than observations made a couple of years ago, when the median content often surpassed 7.5%. These changes in THC and CBD content might be a result of further transitions from traditional methods of producing hashish towards more modern methods, which use Dutch weed plants as source material. These modern (high THC, low CBD) and traditional (high THC and CBD) imported hashish products can no longer be distinguished based on their name.

Dutch marijuana, imported marijuana and Dutch hashish contain almost no CBD (median for most popular and most potent weed = 0.0%; imported weed = 0.1%). The median CBD content of both Dutch weed varieties decreased this year from 0.1% in last year's meeting. This can be explained at least partially by the fact that so-called "CBD weed" is no longer included in the categories "most potent" or "most popular" Dutch marijuana. This year, 6 samples were analyzed which were sold as CBD weed. Five of these did contain a significant amount of CBD (median 13.2%); one sample contained no CBD at all, only THC.

Because CBN is a degradation product of THC, the ratio between CBN and THC can give an indication of the freshness of the preparation. Levels of CBN were higher in imported marijuana and hash compared to products derived from homegrown cannabis. The CBN/THC ratio was also higher in the imported products.

The average price for the most popular Dutch weed (€11.70 per gram in 2021, €11.17 per gram in 2022) did not change significantly. The same was true for imported weed (€3.79 in 2022 versus €4.67 in 2021), as well as the most potent marijuana (€14.21 in 2021, €15.45 in 2022). When looking at the multi-year trends of the price of Dutch marijuana, an increase starting in 2007 can be observed (from about €7.00 to €11.00 for the most popular variety, and to €14.00 for the most potent variety). The price per gram of imported marijuana fluctuated between €4.00 and €6.00, and is considerably lower than that of other cannabis products (€3.79 in 2022). Historically, the price for a gram of Dutch hashish was always higher than that of other cannabis products, but this is no longer the case since last year (€12.53 in 2022 versus €13.80 in 2021; difference is not significant). Imported hashish has increased in price from approximately €7.00 per gram at the start

of this century, to a little bit more than €10.00 per gram in the last years. However, in the past year the price for a gram of imported hashish did decrease significantly (€11.74 in 2021 versus €10.55 in 2022). Interestingly, for the first time in the history of this monitor there is no longer a correlation between the THC content and the price of both marijuana and hashish. This underlines the importance of information given by coffee shop personnel to the customer.

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Imported cannabis

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Imported hash

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Imported cannabis

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Imported hash

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2018	ns	ns	ns	ns	*	ns	ns	****	**	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	*	ns	
2019	ns	ns	ns	*	***	ns	*	****	****	ns	ns	**	*	ns	****	*	*	ns	ns	ns	ns	ns	ns
2020	ns	ns	ns	*	***	ns	*	****	****	ns	ns	**	*	ns	****	*	*	ns	ns	ns	ns	ns	ns
2021	****	****	****	****	****	****	****	****	****	**	ns	****	****	****	****	****	****	****	*	ns	ns	ns	ns
2022	*	*	ns	****	****	***	****	****	****	ns	ns	****	****	**	****	****	****	****	ns	ns	ns	ns	ns

