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ANALYSIS AND TOXICOLOGICAL EVALUATION OF CANNABINOIDS IN HEMP FOOD PRODUCTS - A REVIEW

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KEYWORDS

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ABSTRACT

After having abolished the prohibition of the cultivation of the species *Cannabis sativa* L. (so-called fibre hemp) with minor content of the psychoactive Δ^9-tetrahydrocannabinol (THC), a wide variety of hemp food products is currently offered on the market. In this review, an introduction to the botany of the hemp plant and the current law situation in Germany and the European Union is presented. A survey of the analytic techniques used to verify compliance with the guidance values is given and the THC content of hemp food products is discussed in regard to its toxicology. In particular, the forensic-toxicological aspects regarding the influence of hemp food on drug tests are described.

INTRODUCTION

Hemp containing food products are currently experiencing a revival. After the legalization of fibre-hemp cultivation, hemp food products, mostly sold in esoteric stores, were consumed due to supposed psychoactive properties associated with a potential content of Δ^9-tetrahydrocannabinol (THC). Since the mid 1990s, hemp food has gradually expanded into the natural product market and is increasingly found in natural food stores for positive nutritional and health benefits. In 1995, the first hemp food product on the market was hemp oil [1]. Nowadays various hemp food products are available, e.g. hemp leaves (tea), hemp seeds, hemp oil, flour, beverages (beer, lemonade), and cosmetic products. In the meantime a flourishing trade is establishing itself via the internet.

After a short description of the hemp plant and an introduction into hemp foodstuff, the analytical possibilities to determine THC in food samples are described. The THC content of hemp food products is discussed in regard to its toxicology and possible influence on forensic drug tests.

HEMP – *Cannabis sativa* L.

The hemp plant *Cannabis sativa* L. (Cannabaceae), which is a very old culture plant, comes from the restrained wides of Central Asia until Northwest India. Their shoot axis fibres were already used in the second millennium BC in China, especially for the there invented paper manufacturing [2, 3] (Fig. 1).

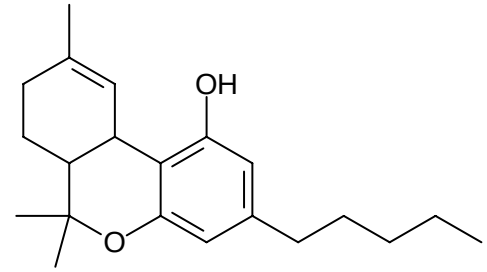
Glandular trichomes, especially densely on the underside of the leaves along the leave veins and in the area of the inflorescence, are found on the whole surface of the plant besides seeds and roots. These contain resin consisting from 80 to 90% of cannabinoids as well as essential oils, high-polymeric phenols, terpenes and waxes [4,5]. The cannabinoids belong to the chemical class of terpenophenolic compounds that only occur in the hemp plant. The psychoactive compound is Δ^9-tetrahydrocannabinol (THC). Besides 60 other known cannabinoids, cannabidiol (CBD) and cannabinol (CBN) are further main components [6] (Fig. 2). In reference to the content of THC, it is possible to distinguish between drug hemp and fibre hemp. The phenotypes of *Cannabis sativa* are characterized by the ratio of (THC+CBN)/CBD [7-10] (drug hemp > 1; fibre hemp < 1). Recently it was described, that the simultaneous determination of THC, CBD and CBN in hemp containing food products and following calculation of the *Cannabis*-phenotype-ratio allows the discrimination between fibre and drug hemp, even as a food ingredient [10].

Figure 1. Hemp, *Cannabis sativa* L., drawing of the plant, inflorescences, fruit and seed (drawing by *W. Müller* [3]). Tea is made of the leaves of the hemp plant, while flour and oil are made of the seed.

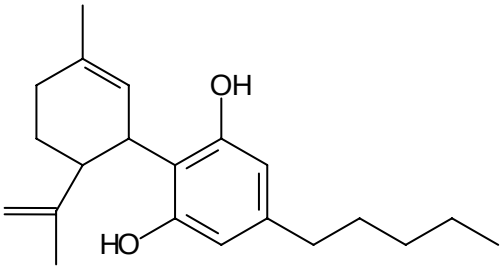
The biggest glandular trichomes are found in the bloom regions of the female hemp plant and in particular on the leaves of the seed hulls. The content of cannabinoids correlates with the quantity of the glandular trichomes [4,5]. Generally, all plant parts with the exception of the seeds can contain cannabinoids. Therefore traces of cannabinoids determined in hemp seed products result from contamination with cannabinoid rich plant parts. The concentration of THC in the seeds depends on the type of plant (fibre or drug hemp) as well as on the degree of contamination at the harvest. Therefore, the tidiness of the seeds plays the most decisive part in the concentration of THC in the seeds. The largest proportion of THC can be found on the surface of the seed coat. As a consequence only very low THC concentrations are found in the inside of the seeds (less than 2 mg/kg with drug hemp and less than 0.5 mg/kg with fibre hemp) [11]. For the application as food products it must be made sure that the THC content of the seeds is not increased by impurities, neither with THC-rich plant parts, nor by corresponding cultivation conditions [12].

Especially the flowers of the female plants excrete a cannabinoid-rich resin from the glandular trichomes, that is named hashish (THC-content 0.5-7%), while the inflorescences stuck together with resin are commonly called marihuana (THC-content 5-20%) [2,13]. Drug hemp is usually grown illegally or by chance as a by-product of the cultivation of hemp [2].

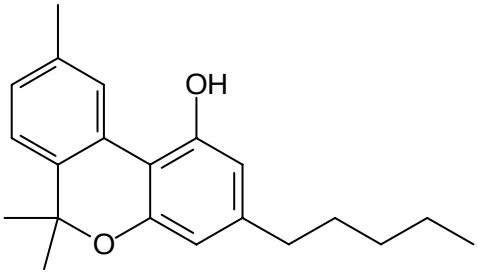
Because of the drug problem, the breeding of plants with low THC-content was started in France and in the former Soviet-Union in the 1970s, followed by Hungary in the beginning of the 1980s [14]. Present day, fibre hemp species show, in the European Union (EU) guidelines corresponding THC-content of less than 0.2%. Even the selection of phenotypes with less than 0.05% THC was successful [14, 15]. Psychoactive effects with the consumption of fibre hemp plant parts could not be observed [16].



Δ^9-tetrahydrocannabinol (THC)



cannabidiol (CBD)



cannabinol (CBN)

Figure 2. Structure of THC, CBD und CBN, the main cannabinoids of hemp (*Cannabis sativa* L.).

Besides the phenotype of the plant, the cannabinoid content depends strongly on the climatic circumstances of the cultivation. Some authors observed both with drug hemp and with fibre hemp higher THC-contents in warmer and dryer continental areas than in maritime climate [17-19]. The *Cannabis* plants are developing more glandular trichomes in these areas and therefore produce more cannabinoids [4]. *Bazzaz* et al. [20] showed a significant reduction of the cannabinoid-content for both tropic and temperate origins with rising temperature. Older examinations proved that the resin-content of the plants depends less on the climate but for the most part on the hemp species, therefore, the cultivation of THC rich hemp for pharmaceutical purposes is also possible in Central Europe [21,22]. It can not be excluded either, that low content THC species can develop high concentrations under certain cultivation conditions [23]. Generally, huge deviations can be observed in the resin and fibre content of the species *Cannabis*, so that it is often unclear whether the deviation's origin is the genetically difference or the difference in the environmental conditions [24].

The hemp plant is primarily a fibre supplier. As by-product, the fruits, small round nuts (usually called hemp seeds), are usually harvested and are sold traditionally as bird or fish feed. Because of their fat

content of 30-35%, they are also used for the extraction of oil. A green, middle strong drying oil is accumulated on that occasion, whose glycerides consist to 40-60% of linolic acid and to 14-28% of linolenic acid [2].

HEMP AS FOOD

All parts of the hemp plant are completely usable (Fig. 3). Besides the application of seeds and leaves as foodstuff, the usage of hemp in the manufacturing of textiles or paper is also possible. The press residue of oil extraction is used as animal feed. The most promising product of the *Cannabis* cultivation to be utilized as food is the seed and its derived products [25]. The protein of the hemp seed contains all 8 essential amino acids in the necessary proportions for the human nutrition [25, 26].

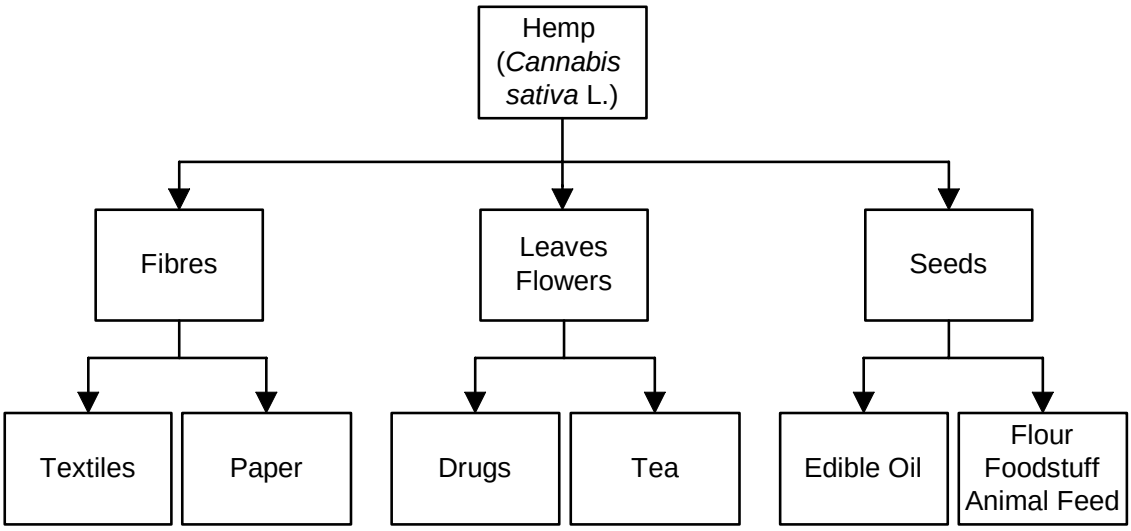


Figure 3. Possibilities of the industrial use of hemp.

Hemp oil contains the highest proportion of unsaturated fatty acids of all vegetable oils and contains nutritional valuable essential fatty acids (approx. 75%) [26, 27] A problem is, that the unsaturated fatty acid molecules are susceptible against oxidation, especially when they are exposed to light or heat [28]. Therefore, hemp oil shows an essentially shorter shelf life in comparison to other cold-pressed oils like olive oil. This disadvantage makes the commercial exploitation of hemp oil difficult [25, 29]. Further on, hemp oils are avoided by many consumers because of the unfamiliar taste and smell [28].

The application of hemp as food is currently restricted, because the available hemp species were bred in regard to a high fibre production not in regard to a high seed yield [30]. The oil content of the fruits varies between 9 and 34%. The most important breeding goal is, therefore, to obtain ripe seeds under Central European conditions [14]. There is still some breeding potential especially in regard to an increase of the gamma-linolenic acid content, as well as increasing the tocopherol content for the anti-oxidation protection of the oil [29].

FOOD LEGISLATION

The THC maximum limit for hemp (measured in the upper third of the plant) has been gradually lowered from 0.5% (1984) to 0.2% (since 2002) [31]. In Switzerland, all plant types of *Cannabis* can be grown legally and varieties with high THC content are usual. However, THC content limitations were applied for hemp food [28]. After decontrol of the fibre-hemp cultivation in 1996 [32], in Germany the former

federal institute for health protection of consumers and veterinary medicine (BgVV, today: Federal institute for risk assessment, BfR) estimated a provisional tolerable THC intake of 1-2 µg/kg/day [12]. From these estimations the following precautionary guidance values for THC in hemp-containing foods were derived in the year 2000: beverages (alcoholic and non-alcoholic): 5 µg/kg, edible oil: 5000 µg/kg, other food: 150 µg/kg [33].

The hemp cultivation for fibre production is subsidized in the European Union. The International Narcotics Control Board (INCB, an organ of the United Nations) determined that a considerable market for hemp food developed parallel into the expansion of the hemp cultivation in the EU, although the effects of these products on health are not yet adequately researched. Moreover, the use of hemp seeds or leaves in the food industry is seen to be problematic in regard of contributing to the overall benign image of *Cannabis* as a drug. Hemp foods are not necessary for nutrition, anyway [12,34]. None of these products can therefore be promoted by an EU allowance. In view of the biological similarities between hemp that is used for industrial purposes and such from which psychotropic substances are gained, the EU executes regular controls in order to test, whether the allowance encourages the illegal hemp cultivation. With most cultivators, the THC content is controlled annually. Therefore, it is guarantied that only seed of varieties with a low THC content according to the maximum limits is used. It turned out, that through the new, intensified regulations the risk of the cultivation of high-content THC species is not disposed of once and for all, but reduced to a negligible level [34].

ANALYSIS OF THC IN HEMP FOOD

Gas chromatography coupled with mass spectrometry (GC/MS) is the method of choice for the determination of cannabinoids in hemp food products [10, 11, 28, 35-46] (Tab. 1). In singular cases thin-layer chromatography [47], liquid chromatography coupled with UV and fluorescence detection [48] or mass spectrometry [27] were used, as well as immunochemical screening methods [37, 39, 42, 49]. As official community method [50] for the quantification of THC in hemp species, the gas chromatographic separation and detection by flame ionisation is commonly used.

Table 1. Methods for the analysis of different hemp food products

Matrix	Sample preparation	Method	Limit of detection	Ref.
Hemp beer	SPE, derivatization (methylation)	GC-MS	1 µg/l	[36]
Hemp beer	SPE, derivatization (BSTFA)	GC-MS Immunoassay	1 ng/ml	[42]
Hemp oil	FFE (methanol)	GC-MS		[43,45]
Hemp oil	FFE (methanol) SPE	GC-MS	1 mg/kg	[41]
Hemp oil	FFE (acetonitrile) SPE, possibly derivatization (MSTFA)	GC-MS Immunoassay		[44]
Hemp tea	FFE (petroleum ether)	GC-FID GC-MS		[38]
Seeds	FFE (chloroform/methanol (99:1), hexane/ethyl acetate (9:1)), SPE	GC/MS		[11]
Seeds	FFE (benzol)	TLC		[47]
Different hemp food products	FFE (methanol or ethyl acetate)	GC-MS Immunoassay		[37,39,40,67]
Different hemp food products	FFE (methanol, methanol/dichloromethane (9:1, v/v))	HPLC-UV HPLC-FD	0.01 ng	[48]
Different hemp food products	FFE (hexane), saponification	GC-MS	12.9-17.3 µg/kg	[46]
Different hemp food products	HS-SPME, on-fibre derivatization (MSTFA)	GC-MS	0.01-0.05 mg/kg	[10]

LLE: liquid-liquid-extraction, GC: gas chromatography, FID: flame ionisation detector, MS: mass spectrometry, TLC: thin-layer chromatography, SPE: solid-phase extraction, HS-SPME: headspace solid-phase micro extraction, BSTFA: *N*,*O*-Bis-trimethylsilyl-trifluoroacetamid, MSTFA: *N*-Methyl-*N*-trimethylsilyl-trifluoroacetamid

The result, which is obtained with the described gas chromatographic method, is called the "total THC content". Following a recommendation by the BgVV, this result is used for the assessment of hemp food products. Besides THC itself, precursors are determined, which can be transformed into THC under certain circumstances. The most important precursor acid is Δ^9-tetrahydrocannabinolcarboxylic acid (THCA). At higher temperatures, this acid can be transformed into THC, by a simple decarboxylation. THCA has no psychoactive effect, therefore the pragmatic reason for its co-quantification is, that with the usually applied gas chromatographic method the co-determination is not avoidable. A further argument is the possibility of a growing THC content in hemp food products, if these products are heated. Even if other methods are used, THCA has to be transformed into THC before the determination or in-situ. Especially the determination by high-performance liquid chromatography (HPLC) can result in a too low total THC content. Using HPLC, no decarboxylation as with the gas chromatographic method by the high temperatures of the injector and column, occurs [51]. Before HPLC analysis a thermal decarboxylation can be conducted, which transfers THCA quantitatively into the neutral THC without the possibility of oxidative cannabinol formation [51-54]. Another approach is the simultaneous determination of THC and THCA [55]. A gas chromatographic separation of THC and THCA is possible after a pre-analytical derivatization.

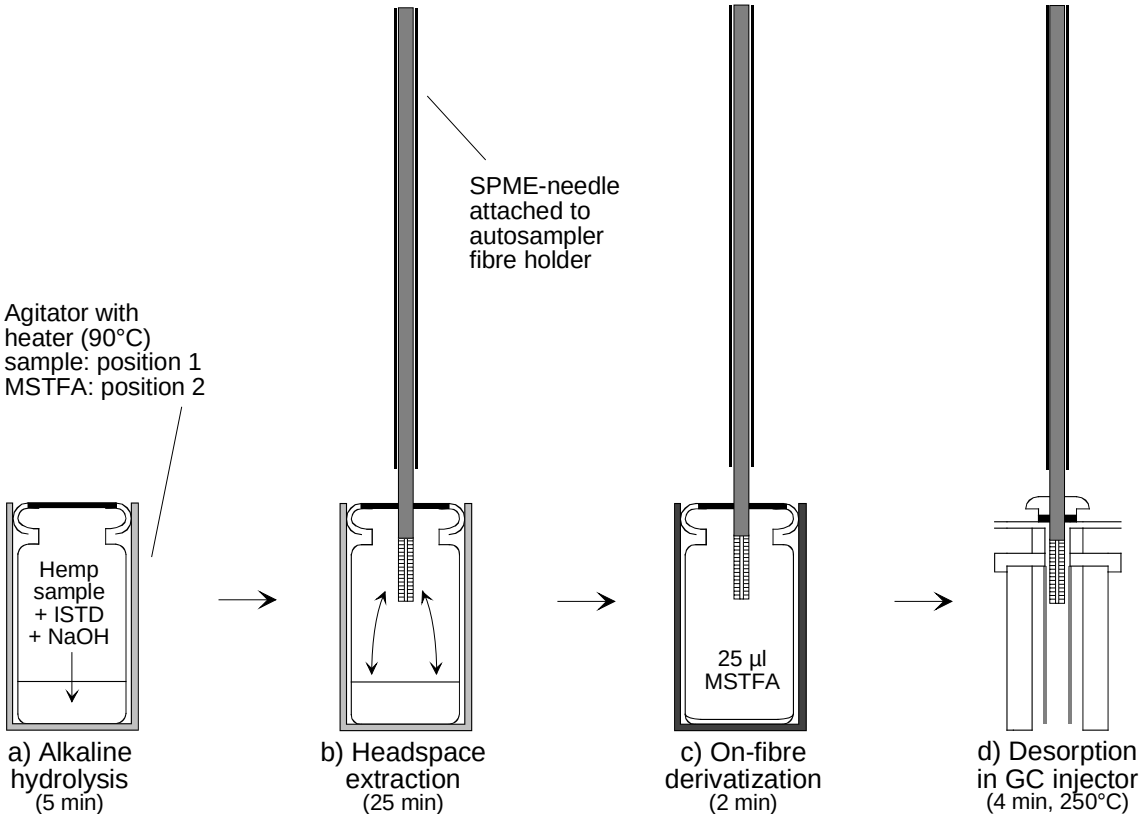


Figure 4. Procedure for a fully automated analysis of hemp food samples with alkaline hydrolysis, headspace solid-phase microextraction (HS-SPME), on-fibre derivatization and GC-MS according to Ref. [10].

As sample preparation the traditional liquid/liquid extraction (LLE) is used, which is time intensive and solvent consuming. For liquid matrices (e.g. hemp beer, hemp oil) the solid phase extraction (SPE) is recommended for sample preparation [36, 41, 42, 44]. As an alternative to the established sample preparations, the headspace solid-phase microextraction (SPME) can be used. In spite of the marginal volatility of the cannabinoids and the possible phenolate formation in the alkaline setting, this class of

compounds is reproducibly extractable out of the headspace by SPME. This is possible, because the lipophilic compounds have a comparatively high octanol/water distribution coefficient and therefore posses a high affinity to the unpolar polydimethylsiloxane (PDMS) SPME-fibre [56-58]. A totally automated HS-SPME method for the determination of THC, CBD and CBN in all kinds of hemp food products was recently introduced by *Lachenmeier* et al. [10] The food samples are hydrolysed after the addition of the deuterated internal standard with sodium hydroxide and directly analysed by HS-SPME/GC-MS. As already mentioned the adsorption of THC to the SPME-fibre is achieved by a PDMS coating. After the adsorption of the analytes, the SPME-fibre is treated with *N*-dimethyl-*N*-trimethylsilyl-trifluoro-acetamid (MSTFA) for derivatization in the headspace (on-fibre derivatization) of the sample. After this solvent free extraction and derivatization process, desorption is achieved by the penetration of the SPME-fibre into the hot injector of the GC/MS system (Fig. 4). By the extraction out of the headspace, matrix interferences are minimalised. A typical HS-SPME chromatogram of a hemp food sample is given in Fig. 5. A special advantage of the automated method is the time saving factor in comparison to the traditional methods like liquid/liquid extraction. The SPME method is easy to handle and provides the same reproducibility and sensitiveness as conventional methods, while at the same time it is solvent free and only needs small sample amounts.

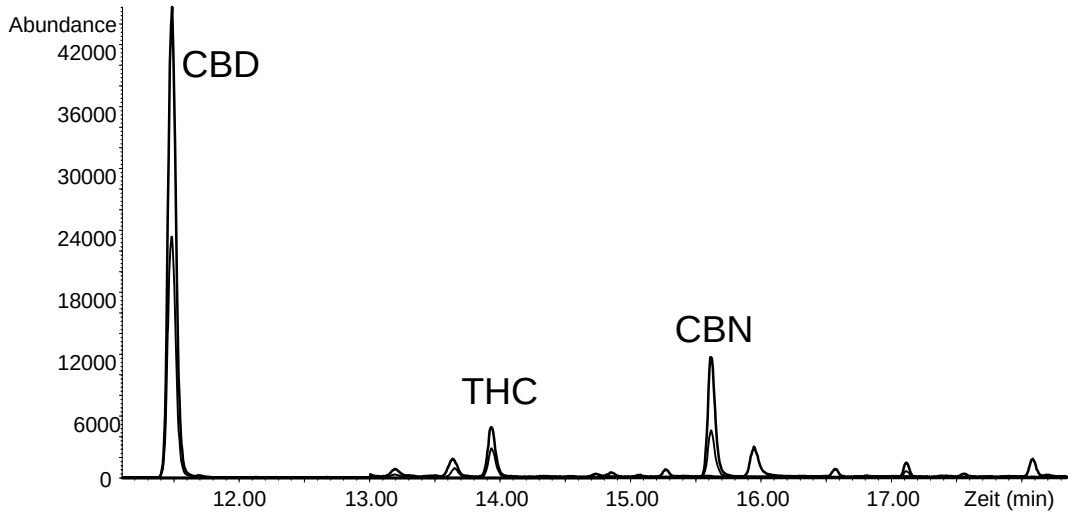


Figure 5. Typical HS-SPME/GC/MS-SIM-chromatogram of a hemp tea containing 15.5 mg/kg THC, 47.1 mg/kg CBD and 1.36 mg/kg CBN according to Ref. [10] (m/z 390,337,371,386,367,368).

THC-CONTENT OF HEMP FOOD PRODUCTS

Hemp food products, even those made of fibre hemp, commonly contain analysable THC amounts. Earlier analysis of hemp oil revealed a wide range of concentrations, between 11.5-117.5 mg/kg [44] and 7-150 mg/kg [40]. A Swiss working group reported the highest found concentrations in oil: 4.1-880 mg/kg [48], 3-1500 mg/kg [41], and even 2-3568 mg/kg [28]. They obviously examined products made of drug hemp.

In hemp tea THC contents of 1020-1480 mg/kg [48] and 5000 mg/kg [38] were discovered in the leaves and between 1.0 mg/kg [48] und 2.4 mg/kg [38] in the respective tea infusions. Low THC concentrations were only found in beverages, such as beer (0.004-0.016 mg/l [36]) and liqueur (0.02 mg/l [39]), as well as in seed (0-12 mg/kg [11], 3.9-5.2 mg/kg [48]). Besides the earlier studies of the year 1996-2000, no current data about the THC content of hemp food products are available. The CVUA Karlsruhe, part of the German official food control system, analysed the THC content of 19 hemp food products in 2004. The samples were mainly taken from drug stores and natural food stores (67%), some from conventional stores and a few directly from the manufacturer. Only 33% of the samples were taken in so-called head shops or in esoteric shops. In 15 products (79%) THC was detected, while in the remaining 4 samples no THC was found. In comparison to earlier experiments the THC contents determined in the recent years

were considerably lower. The reduced limit of THC in seeds seems to have the desired effect on the hemp food products.

The results of the CVUA Karlsruhe are confirmed by a publication that appeared lately in which 30 hemp food products were examined [10]. Only in isolated cases, the infringement of the THC limit was described. The THC content of hemp tea ranged from 4.37 to 15.53 mg/kg in the *Cannabis* leaves and from 0.04 to 0.23 mg/kg in the tea infusion, exceeding the upper limit of the German guidance value for beverages.

High contents of THC, beyond the guidance value of 0.15 mg/kg for other foods, were determined in seeds and flour (0.29-1.07 mg/kg), thin slices (0.20 mg/kg) and *Cannabis* pastilles (0.16 mg/kg). One oil sample with 11.48 mg/kg also exceeded the guidance value for edible oils of 5 mg/kg. However, the majority of the analysed samples revealed THC concentrations below the guidance values in the range 0.01-4.44 mg/kg. In two beverage samples (a soft drink and beer), THC could not be detected, whereas in all samples CBD and CBN were present. The prescribed use of certificated fibre hemp seed by the EU and the increase of controls of manufacturers obviously lead to a significant decline of THC concentrations in hemp food products. In the USA was also reported that through a more careful cleaning of the seed, since 1998, a significant decline of THC concentrations was achieved [59]. The maximum THC content in nowadays purchasable hemp food products [10] are ten to hundred fold lower than the ones found in the studies of the 90´s [28,38,40,41,44,48]. In respect to the own analysis results of the CVUA Karlsruhe between 1998 and 2003 and taking into account the values described in literature, a significant linear decrease in the THC concentrations of hemp tea ($N=19$, $R=-0.73$, $p<0.0001$) and hemp oil ($N=60$, $R=-0.23$, $p=0.05$) was observed. On the other hand, in the case of the food products seeds ($N=27$, $R=-0.29$, $p=0.13$) and beverages ($N=34$, $R=-0.21$, $p=0.22$) no decrease in respect of the 5% level of significance was provable.

FOOD-TOXICOLOGICAL ASPECTS

In humans, after oral application of drug hemp products (hashish, marihuana), a multiplicity of adverse effects can be observed [12,60] 10 to 20 mg of THC are regarded as effective intoxication dose at an inhalative application. THC is rapidly metabolised to 11-hydroxy-Δ^9-tetrahydrocannabinol (11-OH-THC), which is further metabolised to the main metabolite 11-nor-Δ^9-tetrahydrocannabinol-9-carboxylic acid (THC-COOH). This carboxylic acid is eliminated in equal parts in free form and as glucuronide in the urine. THC and 11-OH-THC are both psychoactive, while THC-COOH and its glucuronide do not show any pharmacological activity. The metabolite THC-COOH and especially its glucuronide have relatively long half-lifes up to eight days. These substances tend to cumulate in the body if regularly consumed. High concentrations can only be determined in persons, who regularly consume hashish and marihuana. Even after the habit of regular drug use is abandoned, these metabolites can be detected in blood for some weeks and in urine for more than three months [13].

The resorption of orally administered THC varies strongly interindividual as well as in regard of total content and resorption rate [61]. This should be one of the reasons for the individually very different perceived psychotropic effects. A single oral dose of 20 mg of THC caused symptoms as tachycardia, conjunctival irritations, “high feeling” or dysphoria within 1-4 hours in adults. One in five adults developed these symptoms after a single dose of 5 mg. A marihuana cigarette contains approximately 30-50 mg of THC [62].

In 1996/1997, some cases of intoxications with hemp foods were reported in Switzerland. 4 cases of accidentally THC intoxication were described by *Meier* and *Vonesch* [62]. After consumption of a salad that was prepared with hemp oil, gastrointestinal irritations and perceptual disturbances occurred. The used oil showed a THC content of 1500 mg/kg, which is significantly over the Swiss maximum limit. One portion of the edible oil (13 g) contained 20 mg of THC. This is a concentration that can easily cause the described symptoms. As a cause for the high content of the oil a mistake in the manufacturing process was assumed [48].

INFLUENCE OF HEMP FOOD ON FORENSIC DRUG TESTS

The presence of THC in hemp containing food stuff raised not only the problem of psychoactive effects, but it also lead to concerns about the validity of positive results of drug tests [63]. Positive results in blood- and urine analyses can have grave consequences for the person in question. Generally, a positive result in such tests is interpreted as evidence for previous consumption of *Cannabis* in the form of hashish or marihuana. For groups of people, who have to prove drug abstinence, such a misinterpretation can have grave consequences. On the other hand, attempts to justify one's behaviour in court by claiming that the positive test was caused by hemp food consumption are possible nowadays.

First studies after emergence of hemp food products, containing significantly higher THC levels than nowadays, described positive results in forensic-toxicological drug tests for hashish and marihuana after the consume of hemp oil [37,41,64-67] and other hemp food stuff [38,40]. Most of the studies were conducted in 1996-1997 with THC concentrations of more than 50 mg/kg. For example, after few hours of oral administration of hemp oil (151 µg/ml THC), THC-COOH could be detected in urine. After the application of 40-90 ml oil, THC-COOH could be detected in urine for up to 80 hours. THC serum levels up to 6 ng/ml were determined after intake of 40 ml of hemp oil [37,40, 67].

With the gradual reduction of THC in hemp food, also a reduction of its metabolites in the urine of the consumers could be observed. In a study in 2001 with a maximum content of 5 mg/kg of THC and a daily intake of up to 0.6 mg THC, no positive urine tests were obtained [59]. In a recent study [10] after the consume of 6 cups (0.2 l) of hemp tea (0.23 mg/kg THC) over a duration of 2 hours, no THC metabolites were found in the urine of six probands using an immunochemical standard screening method. This confirms previous results of other working groups that excessive consume of currently available hemp food products (e.g. hemp beer) does not cause positive urinalyses [36, 39, 42, 44, 59, 68-70]. Only the consumption of hemp food products with high THC contents, which are no longer available on the market, can produce positive results [71, 72]. In cosmetic products as hemp shampoo, the THC content is negligible, so that no influence on forensic-toxicological hair analyses could be proven [70, 73-75].

Nowadays one can assume that fibre hemp products do not influence forensic-toxicological drug tests, if these products comply with the effective limits.

FOOD REGULATORY ASPECTS

The lowest orally administered dose of THC, which after repetitive application causes the described effects in adults, is 2.5 mg/day. This is equal to the administration of approximately 40 µg per kg of bodyweight and day, if a bodyweight of 60 kg is assumed. Food products leading to the uptake of such or higher doses, if they are daily consumed have to be judged as being eligible to threat the consumers' health and should therefore be objected. To eliminate uncertainties, such as a variation in the individual sensitivity, kinetic specialties (redistribution, long half-life) or interaction with other hemp or food ingredients or certain drugs, the BgVV advises that a daily uptake of 1-2 µg/kg of bodyweight should not be exceeded. This advised uptake limit is 20 – 40 fold lower than the lowest known effective dose [12]. Marginal violations of the limit can usually be tolerated. Samples, which exceed the limit twice, have to be estimated as being deteriorated. Hemp food products, which extremely exceed the limit and therefore contain amounts of THC that are close to the lowest, known effective dose have to be judged as unfit for consumption. The CVUA Karlsruhe is of the opinion that the labelling of some products as "THC free" is a deception of the consumer, because a significant concentration of THC can be found in all the products. Also products with low hemp content but with a special stress on nutritional value of hemp should be rated likewise.

CONCLUSION

Critical product groups that should be intensively observed by the official food control in the future are especially so called hemp teas, because they are made of the glandular trichomes rich leaves, in which the cannabinoids are accumulated. Next to the covering leaves of the inflorescence, they contain the highest

concentration of cannabinoids. The similarities between these products and marijuana, which is likewise made of dried plant parts of the hemp plant (drug hemp), can lead to a belittlement of *Cannabis* as illicit drug. The fear remains, even if after the excessive consumption of fibre hemp no psychoactive effects or influence on forensic drug tests can be observed. Nutritional or organoleptical benefits, which could justify the consumption of such products, couldn't be proved either. It should be a goal to work towards Europe-wide applicable limits for THC in food products, which could then replace national guidelines.

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