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Original scientific paper

Δ^9-Tetrahydrocannabinol content in cannabis samples seized in Novi Sad during 2008

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Abstract: The three main cannabinoids Δ^9-tetrahydrocannabinol (Δ^9-THC), cannabidiol (CBD) and cannabinol (CBN) were identified and determined quantitatively using a GCD (GC-EI) instrument in 280 samples of illicit herbal cannabis, seized by the Police authorities in Novi Sad, during 2008. The samples were sent to the Institute of Forensic Medicine, Clinical Center Vojvodina, for forensic chemical analysis. The cannabinoid content of the samples enabled the classification of the cannabis into three chemical phenotypes and the differentiation into drug and textile-cannabis, using the Waller classification index. This differentiation has great forensic significance in the classification of certain cases as a criminal action. The experimental results showed that the Δ^9-THC content in illicitly circulated cannabis slightly decreased from January to December 2008, as did the quality of the drug-cannabis. The reasons for the quality variations could lie in the geographical origin of the cannabis plants, the conditions of plants storage, various parts of the plants in samples and the time elapsed between harvesting and chemical analysis.

Keywords: cannabinoids; forensic samples; GCD analysis; phenotype; Waller index.

INTRODUCTION

Cannabis (*Cannabis sativa* L.) is a plant widely distributed throughout the world and its cultivation is prohibited in most countries, including Serbia. The fibre-type plants are legally cultivated in some regions under specific permission.

The three main cannabinoids found in *Cannabis sativa* L. are the psychoactive Δ^9-tetrahydrocannabinol (Δ^9-THC) and the non-psychoactive cannabidiol (CBD) and cannabinol (CBN). The highest cannabinoid content is found in the resin secreted by the flowering buds of the plants. Δ^9-THC, which is the main psychoactive constituent, is found in similar amounts in male and female canna-

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bis grown under the same conditions. It was shown that in the various parts of cannabis plant, the Δ^9-THC content decreases in the following order: bracts, flowers, smaller stems, larger stems, roots and seeds.[1]

Textile (fibre-type) cannabis is cultivated for a wide variety of hemp-based products, such as: edible seed oil, essential oils, flour, beverages (beer, lemonade and liqueur), cosmetics, lubricants, fuels and fibres for the paper and building industries.[1,2] Resinous (drug-type) cannabis is illicitly cultivated for its psychoactive pharmacological action.[3]

Since cannabis is most commonly administered by smoking or ingesting, the THC predominantly acts on the central nervous (CNS) and cardiovascular systems. Common CNS effects include euphoria, a sense of well-being, relaxation, tachycardia, alteration in blood pressure and hallucinations at high doses.[4,5]

For court testimonies and police authority purposes, seized cannabis samples, after chemical analysis, are classified into three chemical phenotypes: drug, intermediate and fibre-type, according to the Δ^9-THC content and the Waller classification index, *W*, (Eq. (1)):[6,7]

$$W = \frac{\%\ \Delta^9\text{-THC} + \%\ \text{CBN}}{\%\ \text{CBD}} \quad (1)$$

1. % Δ^9-THC > 0.3 and $W > 1$; the plant is classified as a drug-type (resinous cannabis) and could be abused as a psychoactive drug;

2. a) % Δ^9-THC < 0.3 and $W > 1$ or b) % Δ^9-THC > 0.3 and $W < 1$; the plant is classified as an intermediate-type and could be abused as a psychoactive drug;

3. % Δ^9-THC < 0.3 and $W < 1$; the plant is classified as a fibre-type (textile cannabis) and could not be abused.

It is necessary to emphasize that a low content of Δ^9-THC (% Δ^9-THC < < 0.3) in intermediate-type cannabis samples is not incompatible with their resinous character. As it is known that in these samples CBN, a degradation product of Δ^9-THC, is present in a large amounts, the % Δ^9-THC + % CBN would approximate the Δ^9-THC content. When the Waller classification index is low ($W < 1$) in intermediate-type cannabis samples, the CBD content is high, which indicates that the samples originated from relatively young potent plant.[6]

According to the law in European Union countries, the maximum permitted content of Δ^9-THC in fibre-type cannabis varieties is 0.3 %.[8,9] Based on the Δ^9--THC content and the Waller classification index, forensic cannabis samples are differentiated into drug cannabis, if they are drug or intermediate-type, and textile cannabis, if they are fibre-type. This differentiation has great forensic significance in the classification of certain cases as a criminal action.

EXPERIMENTAL

Sample preparation

Two hundred and eighty illicit herbal cannabis samples, seized by Police authorities in Novi Sad during 2008, were sent to the Institute of Forensic Medicine, Clinical Center Vojvodina, for forensic chemical analysis. The stems and seeds were manually separated from the dried plant material, leaving leaves, blossoms, small structural parts of the inflorescence and bracts. The resulting material was weighed and ground in a mortar. Each sample consisting of 50 mg ground powder was heated with 5 ml petroleum ether (boiling range 40–60 °C) at 60 °C for 20 min.[10,11] After cooling, the petroleum ether extract was filtered and evaporated to dryness. The residue was reconstituted in 1.9 ml petroleum ether, 0.1 ml of epi-androsterone as the internal standard (IS) was added at a concentration 7 mg ml^{-1} in ethanol,[7] and a 1-µl aliquot of the resulting solution was injected into the GCD instrument.

Gas chromatographic analysis

The cannabinoid content (% Δ^9-THC, % CBD and % CBN) was determined chromatographically using a G 1800 A GCD instrument, equipped with an HP 6890 autosampler. GCD is an advanced gas chromatography (GC) system introduced by Hewlett Packard in 1994. The GCD consists of a chromatograph, electron ionization (EI) detection system for *m*/*z* up to 425 and a data acquisition system. The EI detection system generates retention time, abundance and mass spectral data that are comparable with those obtained with a GC–mass spectrometry (MS) instrument.

The conditions for the analysis were as follows: column HP-5MS (30 m×0.25 mm i. d., film thickness 0.25 µm); injection port temperature: 250 °C; interface temperature: 280 °C; split mode: 1:11; oven temperature: initial, 50 °C; initial time: 0 min; heating rate: 25 °C min^{-1}, final temperature: 250 °C, final time: 10 min; helium flow rate: 1 ml min^{-1}.

Standard solutions

Stock standard solutions containing Δ^9-THC, CBD and CBN at 1 mg ml^{-1} concentration in methanol, purchased from Sigma–Aldrich, Germany, were diluted with petrol ether and calibration standards were prepared at the concentrations: 500, 250, 100 and 50 µg ml^{-1}, containing epi-androsterone (IS) at a concentration 350 µg ml^{-1}.

RESULTS AND DISCUSSION

The major constituents of the seized cannabis samples were identified and quantitatively determined using a GCD instrument. The retention times of Δ^9-THC, CBD, CBN and epi-androsterone were 14.44, 12.99, 15.70 and 15.22 min, respectively. For quantitative analysis, the chosen characteristic mass fragments were monitored in the SCAN mode: *m*/*z* 314, 299 and 231 for Δ^9-THC, *m*/*z* 231, 174 and 314 for CBD, *m*/*z* 295, 238 and 310 for CBN, and *m*/*z* 290, 246 and 107 for epi-androsterone.

The cannabinoid content of the cannabis samples led to the differentiation of the cannabis into drug, intermediate and fibre-type, then into drug and textile cannabis, according to the Waller classification index.

Typical total ion chromatograms (TIC) of drug, intermediate and fibre-type cannabis samples are presented in Figs. 1–3, respectively.

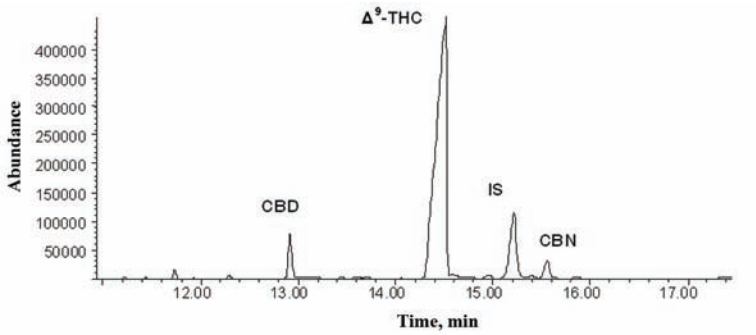

Fig. 1. TIC gas chromatogram of a drug-type cannabis sample.

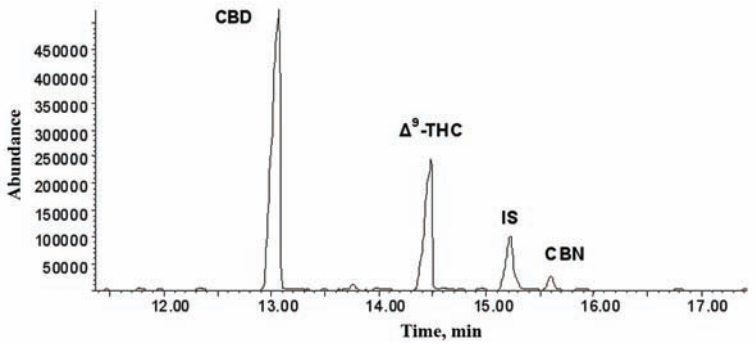

Fig. 2. TIC gas chromatogram of an intermediate-type cannabis sample.

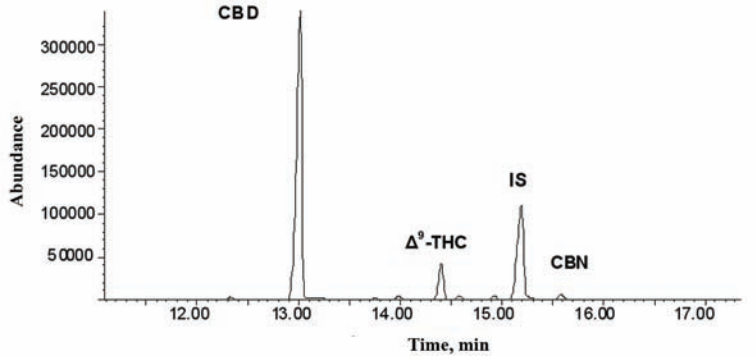

Fig. 3. TIC gas chromatogram of a fibre-type cannabis sample.

The percentage of Δ^9-THC and the Waller classification index of the 280 cannabis samples seized during 2008 are presented in Table I.

The percent of drug, intermediate and fibre-type cannabis during 2008 is presented in Fig. 4 and the percent of cannabis samples classified as a drug or textile during 2008 is presented in Fig. 5.

TABLE I. % Δ^9-THC and Waller classification index of 280 cannabis samples during 2008

Sample	Month	% THC	*W* index	Sample	Month	% THC	*W* index	Sample	Month	% THC	*W* index
1	January	3.001	3.69	95	June	0.158	1.48	189	October	2.126	6.38
2		2.143	1.75	96		3.670	10.15	190		0.059	0.03
3		3.433	7.11	97		0.910	8.56	191		0.037	0.02
4		4.633	5.23	98		3.520	7.32	192		0.507	8.36
5		4.262	4.25	99		0.366	7.63	193		1.124	4.62
6		0.570	8.03	100		1.207	13.03	194		0.643	1.06
7		0.765	7.56	101		1.317	13.59	195		1.413	4.32
8		0.466	9.05	102		2.844	43.80	196		1.814	5.8
9		0.844	6.23	103		0.127	0.17	197		1.579	4.65
10		0.577	11.13	104		0.652	15.66	198		0.035	1.61
11	February	0.346	6.35	105		2.586	2.78	199		0.226	1.06
12		1.378	4.28	106		2.372	9.30	200		0.328	1.94
13		0.013	0.02	107		0.452	0.86	201		0.028	0.35
14		1.642	1.42	108		3.640	50.43	202		0.359	0.49
15		1.804	2.35	109		0.257	6.20	203		1.223	1.27
16		1.602	2.08	110		0.816	7.04	204		1.568	5.03
17		4.000	1.27	111		2.007	16.78	205		0.086	0.19
18		3.789	1.27	112		3.094	2.81	206		0.612	0.45
19		1.159	17.42	113		2.306	2.62	207		0.599	3.10
20		1.323	1.02	114		1.596	2.88	208		0.479	6.73
21		2.443	2.04	115		0.988	4.89	209		1.788	2.68
22		4.359	1.96	116		0.563	3.53	210		3.781	3.35
23		2.146	17.90	117		1.432	14.97	211		0.801	3.04
24		1.160	18.50	118		1.978	23.16	212		1.949	0.84
25		0.469	60.02	119		1.048	6.51	213		0.163	0.05
26		0.823	5.23	120		0.102	26.59	214		0.784	0.63
27		0.052	0.07	121		0.156	20.94	215		0.910	0.43
28		1.231	7.24	122		1.931	19.02	216		0.152	0.36
29		1.036	6.26	123		0.479	16.26	217		2.114	15.52
30	March	0.823	14.92	124		0.301	50.89	218		1.031	12.83
31		0.167	2.33	125	July	0.705	0.35	219		0.405	0.99
32		0.323	7.81	126		0.714	0.42	220		0.118	0.34
33		0.329	3.77	127		0.538	0.28	221		0.373	0.49
34		0.132	0.82	128		0.627	0.39	222		1.482	0.47
35		2.014	7.80	129		1.111	2.35	223		0.639	4.78
36		0.516	2.40	130		0.941	1.38	224		0.808	9.01
37		1.331	7.16	131		0.771	1.05	225		0.559	3.26
38		2.159	22.95	132		0.673	0.52	226		0.755	1.35
39		2.909	11.77	133		1.592	4.23	227		1.609	2.45
40		0.981	2.62	134		0.351	2.85	228		1.748	1.20
41		0.698	2.40	135		1.796	3.17	229		0.693	0.58
42		0.803	0.48	136		1.300	1.27	230		0.831	0.71
43		1.942	1.01	137		1.043	1.48	231		0.780	2.60
44		0.105	0.91	138		0.638	3.00	232		0.196	0.38
45		0.685	5.05	139		0.694	0.22	233		0.195	0.38

TABLE I. Continued

Sample	Month	% THC	*W* index	Sample	Month	% THC	*W* index	Sample	Month	% THC	*W* index
46		4.614	15.39	140		0.401	3.46	234		0.278	0.24
47		0.352	1.12	141		0.744	3.24	235		0.208	0.45
48		2.608	8.01	142		0.943	4.05	236		0.768	3.65
49		0.665	3.05	143		1.490	3.05	237		0.028	0.04
50	April	1.264	0.83	144		0.695	0.56	238		0.615	2.90
51		0.458	0.25	145		0.732	0.83	239		0.063	0.17
52		0.965	0.22	146		1.792	0.95	240		0.663	8.36
53		0.536	0.16	147		0.889	0.58	241		0.689	6.89
54		0.690	0.35	148	August	1.869	2.43	242		0.353	0.71
55		0.391	0.18	149		1.746	8.74	243		0.836	1.43
56		0.852	0.24	150		0.995	3.89	244	November	0.381	1.71
57		0.301	5.25	151		1.727	3.20	245		1.249	0.80
58		1.055	2.86	152		0.518	4.78	246		0.699	2.34
59		1.608	3.45	153		0.080	9.29	247		1.425	5.52
60		0.283	2.16	154		0.095	8.89	248		1.321	3.47
61		0.696	8.46	155		0.129	3.92	249		0.504	4.35
62		0.528	1.31	156		1.450	17.50	250		1.082	7.95
63		0.301	31.10	157		1.737	0.70	251		0.765	7.00
64		0.355	28.12	158		0.227	1.64	252		3.321	20.87
65	May	2.211	5.26	159		0.943	3.16	253		0.757	6.58
66		0.120	0.08	160		1.840	4.25	254		1.763	2.81
67		0.817	6.66	161		1.591	4.10	255		1.326	2.55
68		0.454	1.41	162		1.418	3.85	256		0.646	0.53
69		1.426	16.99	163		0.699	0.28	257		0.447	3.42
70		0.531	3.71	164		1.085	2.31	258		1.038	4.06
71		0.416	4.47	165		0.717	0.35	259		0.420	2.50
72		0.659	5.22	166	September	1.770	1.12	260		0.568	8.27
73		0.612	5.11	167		0.906	4.24	261		2.191	1.86
74		0.676	5.89	168		1.081	2.05	262		0.984	0.88
75		0.622	7.53	169		0.962	13.11	263		0.605	0.54
76		0.448	8.09	170		1.770	1.12	264		0.905	0.85
77		0.695	8.04	171		0.900	4.54	265		1.012	10.42
78		0.676	6.11	172		0.952	2.38	266		0.684	3.60
79		0.919	5.00	173		0.925	3.25	267		3.911	6.21
80		0.770	3.12	174		0.826	2.68	268	December	0.060	0.70
81		0.380	3.15	175		0.835	9.35	269		0.486	4.65
82	June	4.479	14.05	176		1.434	7.57	270		0.422	3.73
83		1.662	26.76	177		0.818	9.44	271		2.144	0.34
84		2.333	4.02	178		0.664	5.78	272		0.280	1.11
85		1.003	3.47	179		0.130	2.29	273		1.705	1.90
86		2.290	21.96	180		0.716	8.65	274		0.494	0.59
87		0.734	1.85	181		0.175	0.23	275		1.923	1.44
88		1.358	8.91	182		0.351	0.54	276		1.912	0.78
89		0.310	4.23	183	October	0.190	0.28	277		1.045	1.36
90		4.479	8.70	184		0.060	0.03	278		0.244	0.05

TABLE I. Continued

Sample	Month	% THC	*W* index	Sample	Month	% THC	*W* index	Sample	Month	% THC	*W* index
91		1.782	21.20	185		1.333	4.28	279		0.797	4.98
92		0.688	11.43	186		1.446	1.37	280		2.282	2.46
93		0.480	67.32	187		0.731	0.42	279		0.797	4.98
94		1.609	1.93	188		0.712	0.48	280		2.282	2.46

According to the present work, the Δ^9-THC content varied from 0.013 to 4.633 % and the Waller classification index from 0.02 to 67.32 % in the 280 cannabis samples seized during 2008 (Table I). The percent of drug, intermediate and fibre-type cannabis during 2008 was 77.5, 14.3 and 8.2, respectively. The most cannabis samples classified as a drug-type were seized in January and in May until September. During 2008, the monthly percent of drug-type cannabis varied from 46.7 to 100 %, of intermediate-type from 0 to 53.3 % and of fibre--type from 0 to 24.6 % (Fig. 4). The percent of drug cannabis varied from 69.2 to 100 % and that of textile cannabis from 0 to 24.6 % during 2008 (Fig. 5). The results showed that the Δ^9-THC content in the illicitly circulated cannabis slightly decreased from January until December 2008, as did the quality of the drug--cannabis. The reasons for the quality variations could lie in the geographical origin of the cannabis plants, the conditions of plants storage, differing parts of the plants in the samples and the time elapsed between harvesting and chemical analysis. The highest Δ^9-THC yield reached in the studied samples was 4.633 %.

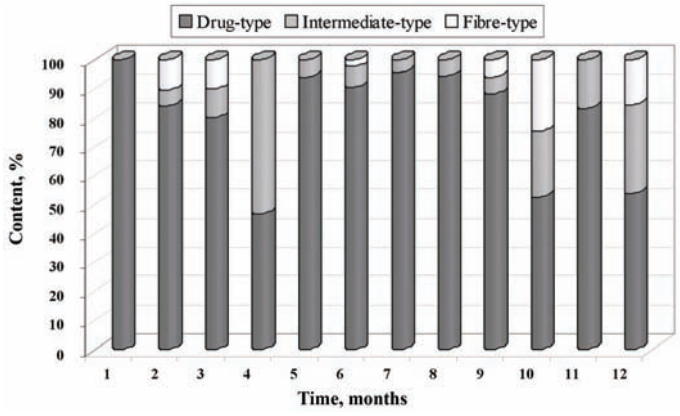

Fig. 4. Percent of drug, intermediate and fibre-type cannabis during twelve months in 2008.

It is well known that there are wide variations in the relative amounts of cannabinoids in cannabis plants. This variation depends on numerous factors. The predominant factors are the genetic characteristics of the seed stock and the environment in which the plant is grown, such as: light, temperature, moisture

and oxygen.[12,13] Some investigators concluded that the concentration of THC in marihuana is not dependent on the local growing conditions, but on the seed from which it is grown. It was also observed that THC will eventually decompose to CBN and that the original amount of THC present in marihuana can be computed by adding the amount of CBN to the THC present at the time of assay.[14]

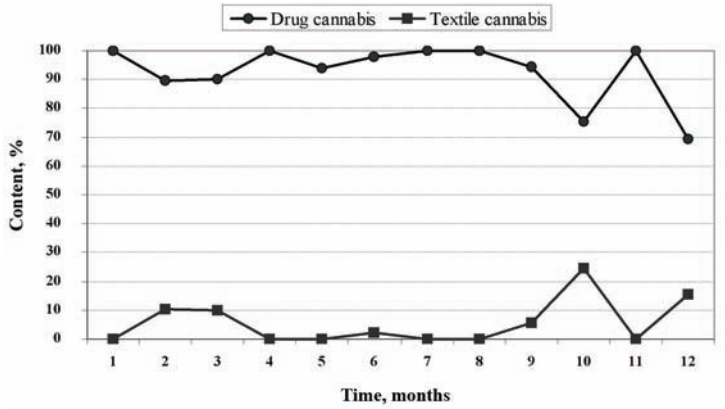

Fig. 5. Percent of drug and textile-type cannabis during twelve months in 2008.

By assaying marihuana for its contents of THC, CBD and CBN, a great deal of information can be obtained regarding the potential source of the sample, its potency as a drug and the approximate time since it was first processed. It would also follow that if many confiscated samples had the same concentration of THC, CBD and CBN, it would be likely that they came from the same source, which could then be sought as a distribution point.

Bearing in mind that seeds are freely transferred from one country to other, some investigators concluded that there is little valid basis for attempts to correlate the cannabinoid content with the country of origin and allocation of cannabis all over the world. However, Faubert Maunder[15] is of opinion that the presence of CBD and its ratio to Δ^9-THC is useful criterion for indicating the country of origin if the gross appearance of the sample is taken into account. Some investigators found that plants that are drug phenotype generally originate from countries south of latitude 30 deg N. Plants that are fibre phenotype originate north of the same latitude.[14] Cannabis plant material appears on the illicit market in different forms (buds, kilobricks, marihuana and sinsemilla) and that reflects to some extent on its country of origin. The concentration of CBN is a good indication of the age of samples as well as the storage conditions, indicating either old plant material or poor storage conditions.

Diagnostic tools that allow independent descriptions of the sources of cannabis are essential for unravelling market dynamics.[16] In this regard, Ritter[17] called for pursuing multi-disciplinary approaches to understanding drug markets. A no-

vel forensic approach to understanding the cannabis market is the employment of stable isotope analyses of seized cannabis. Stable isotope analysis has the potential to improve significantly the understanding of cannabis trafficking because stable isotopes function as natural recorders revealing aspects of the geographic origin and growth environment of a plant.[18,19]

Based on the experience of some investigators, a concentration of THC in marihuana from 0.5 to 1.5 % can be considered as a "good" quality marihuana. If the concentration of THC is less than 0.5 %, the marihuana would be of poorer quality and cigarettes with a concentration of THC in excess of 1.5 % would be very good to excellent marihuana. Some attention must be given to the samples with THC content greater than 1.5 %. It is in this range that smoking marihuana can produce a diminution in the ability an individual to perform tasks requiring concentration, coordination and judgment.[20]

CONCLUSIONS

As cannabis is an illicit drug, it is only available to the public through illegal channels. Consequently, the chemical analysis of confiscated material is important for the understanding of the health problems to the public associated with the use of any form of the drug. The analytical data generated could be employed to show trends in increasing or decreasing potency, to help identify the country of origin whenever possible and to provide information for policymaking decisions at the national and possibly international level. In addition, the analytical data should provide information to the scientific community in studying health problems associated with cannabis use.

ИЗВОД

САДРЖАЈ Δ9-ТЕТРАХИДРОКАНАБИНОЛА У УЗОРЦИМА КАНАБИСА ЗАПЛЕЊЕНИМ У НОВОМ САДУ 2008. ГОДИНЕ

МАЈА ЂУРЕНДИЋ-БРЕНЕСЕЛ, НИКША АЈДУКОВИЋ, КАТАРИНА ШТАЈНИЦ-РИСТИЋ, ВЛАДИМИР ПИЛИЈА и ИГОР ВЕСЕЛИНОВИЋ

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Три основна канабиноида Δ9-тетрахидроканабинол (Δ9-THC), канабидиол (CBD) и канабинол (CBN) су идентификована и квантификована на GCD (GC-EI) инструменту у 280 узорака биљног материјала – канабиса, заплењених од стране органа истраге у Новом Саду 2008 године. Заплењени узорци су достављени Институту за судску медицину Клиничког центра Војводине, како би се извршила форензичка хемијска анализа узорака. На основу садржаја канабиноида у узорцима извршена је класификација канабиса на три хемијска фенотипа и диференцијација на канабис-дрога и канабис-текстилни тип, применом Waller-овог класификационог индекса. Наведена диференцијација има изузетан форензички значај у утврђивању извесних случајева као противзаконитих. Експериментални резултати у овом раду указују да садржај Δ9-THC-а у канабису на илегалном тржишту, благо опада у периоду од јануара до децембра 2008. године, а такође и квалитет канабиса типа дроге. Варијације у квалитету канабиса могу потицати од географског порекла биљки, услова њиховог чувања,

различитих уситњених делова биљке који се могу наћи у заплењеним узорцима или пак од временског периода између бербе и хемијске анализе узорака канабиса.

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REFERENCES

1. M. Pellegrini, E. Marchei, R. Pacifici, S. Pichini, *J. Pharm. Biomed. Anal.* **36** (2005) 939
2. O. Zoller, P. Rhyn, B. Zimmerli, *J. Chromatogr. A* **872** (2000) 101
3. C. Giroud, L. Rivier, *TIAFT Bull.* **26** (1996) 30
4. V. H. Curran, C. Brignell, S. Fletcher, P. Middleton, J. Henry, *Psychopharmacology* **164** (2002) 61
5. H. P. Rang, M. M. Dale, J. M. Ritter, P. K. Moore, *Pharmacology*, 5th ed., Churchill Livingstone, Edinburgh, 2003, p. 608
6. M. Erceg, in *Renaissance of hemp*, R. Kastori, Ed., Research Institute of Field and Vegetable Crops, Novi Sad, 1996, p. 149
7. K. Mechtler, J. Bailer, K. Hueber, *Ind. Crops. Prod.* **19** (2004) 19
8. P. Cappelletto, M. Brizzi, F. Mongardini, B. Barberi, M. Sannibale, G. Nenci, M. Poli, G. Corsi, G. Grassi, P. Pasini, *Ind. Crops. Prod.* **13** (2001) 101
9. F. E. Dussy, C. Hamberg, M. Luginbühl, T. Schwerzmann, A. Briellmann, *Forensic Sci. Int.* **149** (2005) 3
10. I. Barni-Comparini, S. Ferri, F. Centini, *Forensic Sci. Int.* **24** (1984) 37
11. K. Wehr, R. Dieter Maier, *Int. J. Legal Med.* **102** (1989) 509
12. J. E. Pitts, J. D. Neal, T. A. Gough, *J. Pharm. Pharmacol.* **44** (1992) 947
13. E. K. Shibuya, J. E. Souza Sarkis, O. Negrini Neto, M. Z. Moreira, R. L. Victoria, *Forensic Sci. Int.* **160** (2006) 35
14. J. Manno, B. Manno, D. Walsworth, R. Herd, *J. Forensic Sci.* **19** (1974) 884
15. M. J. Faubert Maunder, *J. Pharm. Sci.* **62** (1970) 313
16. J. M. Hurley, J. B. West, J. R. Ehleringer, *Int. J. Drug Policy* **21** (2010) 222
17. A. Ritter, *Int. J. Drug Policy* **17** (2006) 453
18. J. B. West, A. Sobek, J. R. Ehleringer, *PLoS One* **6** (2008) e2447
19. J. B. West, J. M. Hurley, J. R. Ehleringer, *J. Forensic Sci.* **54** (2009) 84
20. C. L. Hart, A. S. Ward, M. Haney, S. D. Comer, R. W. Foltin, M. W. Fischman, *Psychopharmacology* **164** (2002) 407.