Article

Characterization of Some "Hashish" Samples in the Egyptian Illicit Trafficking Market Using a Thermal Separation Probe and Gas Chromatography−Mass Spectrometry

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ABSTRACT: Drugs that are illegal have long been a part of Egyptian society. The most widely misused form of narcotic is marijuana, also known as "bango", and other cannabis-related products like "hashish". The chemical profile of some available "hashish" in the local Egyptian illegal market and its possible country of origin are investigated using a gas chromatography−mass spectrometry technique in conjunction with a thermal separation probe (TSP/GC/MS). The TSP/GC/MS method reveals the presence of 23 different terpenes, of which caryophylla-4(12),8(13)-dien-5α-ol, isoaromadendrene epoxide, caryophyllene, and alloaromadendrene oxide-(1) are detected in high relative proportions. Ten cannabinoid components are also detected. These are cannabiorcochromene (CBC-C1), tetrahydrocannabivarin (THCV), delta-8-tetrahydrocannabinol (delta-8-THC), exo-THC, cannabichromene, cannabidiol (CBD), cannabielsoin (CBE), dronabinol (delta-9-THC), cannabigerol (CBG), and cannabinol (CBN). Phenotypic index (THC % + CBN %)/CBD % is measured for the test samples to identify both the nature of the samples (fiber- or drug-type cannabis) and the country of origin.
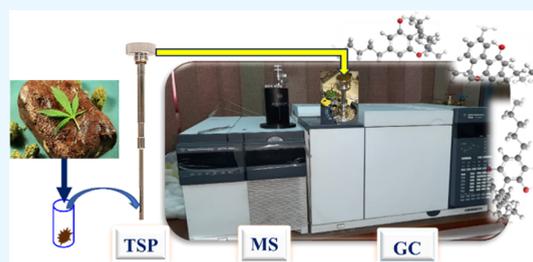
1. INTRODUCTION

Illegal narcotics found their way into Egyptian culture a long time ago. The most popular form of narcotic abuse is that of cannabis and its products including "hashish" and marijuana or "bango".[1] Cannabis analysis has become more important around the world, not just for quality inspection in the licensed recreational and medical cannabis industries but also for criminal and forensic purposes.

Hashish is constituted of around 400 compounds,[2,3] including over 60 cannabinoids, terpenoids, phenols, and other additions (adulterants and contaminants). Cannabinoids are a class of terpenophenolic chemicals generated exclusively by cannabis.[4] Major cannabinoids include Δ^9-tetrahydrocannabinol (THC), cannabinol (CBN), and cannabidiol (CBD),[4−8] with lesser cannabinoids remaining.

For the qualitative and quantitative determination of cannabinoids, a number of analytical procedures have been described. Thin-layer chromatography (TLC),[9] high-performance liquid chromatography (HPLC) fingerprinting,[10−12] and gas chromatography (GC) coupled with mass spectrometry (MS) are the most widely used techniques for assessing cannabinoids and terpenoids, while GC is the most used technique for analyzing cannabinoids and terpenoids.[13−17] Different countries, including Mexico, Colombia, Jamaica, Thailand, and the United States, have employed GC to distinguish cannabis.[13]

Characterization and analysis of natural and artificial illegal narcotics have been the subjects of detailed studies in our laboratories during the last two decades. Methods for the determination of heroin,[18] cocaine,[19] morphinen,[20] ethylmorphine,[21] amphetamine,[22] and harmine and harmaline[23,24] have been previously described. However, little is known about the composition and concentrations of the active and inactive ingredients of the most common form of drug abuse, "hashish", in Egypt.

The phenotype ratio [percentage of cannabinol (CBN) + percentage of Δ^9-tetrahydrocannabinol (THC) divided by percentage of cannabidiol (CBD)], is used to differentiate between drug-type and fiber-type cannabis. A phenotype ratio greater than 1.0 is classified as drug-type and less than 1.0 is classified as fiber-type.[25]

The present study aimed to investigate the nature and characteristics of some available "hashish" samples in the local Egyptian illegal market and to shed light on their possible origin by comparing the obtained results with studies conducted in other countries such as Morocco, Lebanon,
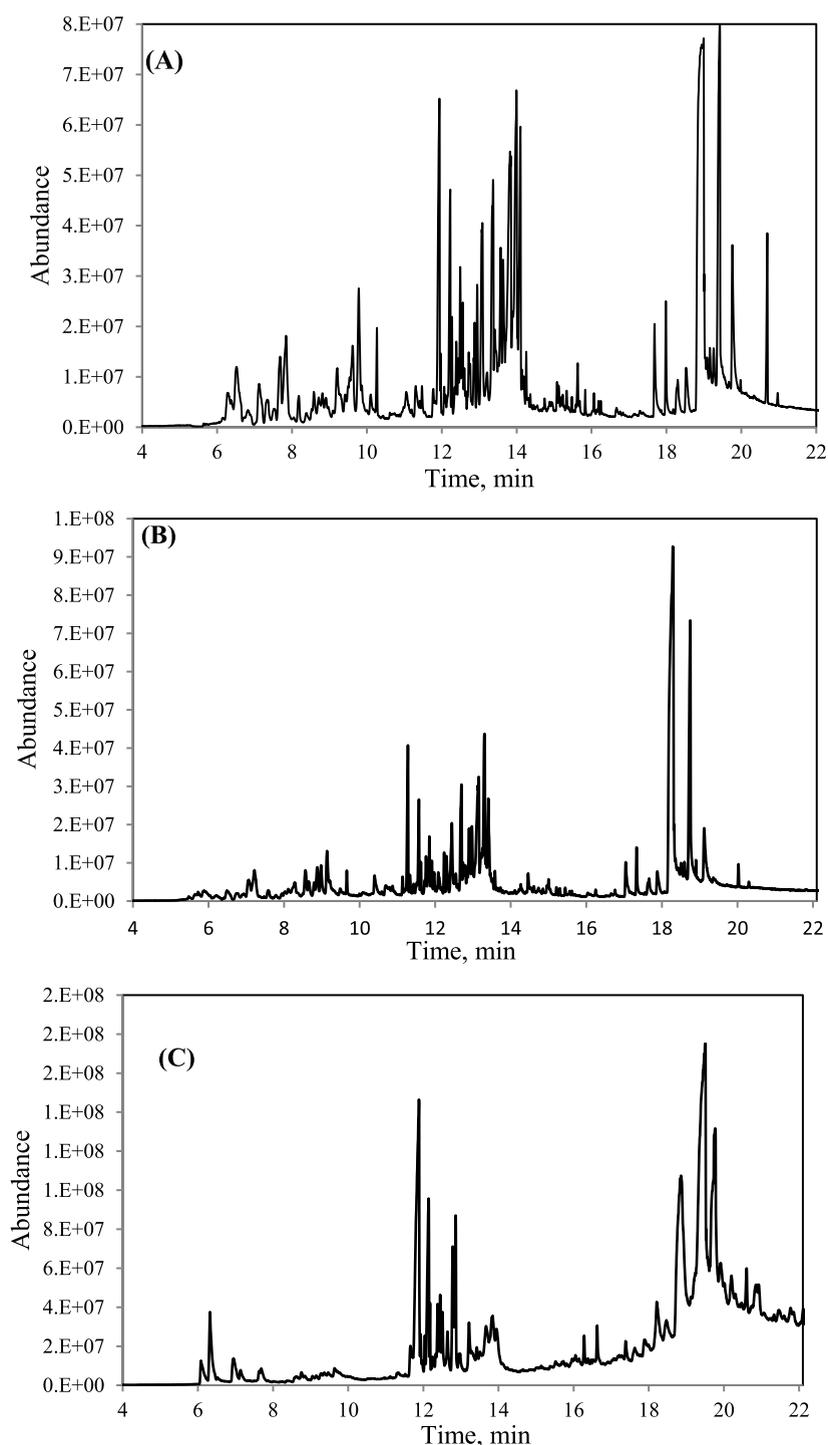
Figure 1. TICs of hashish samples (A), (B), and (C).

and Algeria. The identification of the chemical profile of hashish samples is based on the use of thermal separation probe and gas chromatography—mass spectrometry (TSP/GC/MS). The technique offers the advantages of simplicity and rapidity and is free from any sample pretreatment steps. The solid "hashish" sample is directly used.

2. METHODS

Three hashish samples, (A), (B), and (C), were gathered from the illicit market in different areas of Cairo town. The samples were kept in sealed containers and refrigerated until they were

analyzed. Hashish samples were first ground in a laboratory-grade knife mill, followed by further homogenization in an agate mortar. GC—MS was used to perform chromatographic analyses (Agilent Technologies 7890B GC Systems combined with 5977A Mass Selective Detector). The carrier gas was helium at a pressure of 7.0 psi, and the capillary column used was HP-5MS ultra inert: 30.0 m × 0.25 mm × ID 0.25 μm film thickness. Samples were analyzed by holding the column at 40 °C for 3 min post-injection and then increasing the temperature to 300 °C with a heating ramp of 15 °C/min and a hold of 3.0 min. At 200 °C, injections were performed in

Table 1. Volatile Contents (Terpenes) of Some Local Egyptian Hashish Samples (A), (B), and (C)

no.	compound name	retention time	molecular mass	formula	peak area, %		
					sample (A)	sample (B)	sample (C)
1	5,5-dimethyl-1-vinylbicyclo [2.1.1] hexane (hashishene)	6.288	136	$C_{10}H_{16}$	0.68	0.68	0.68
2	α-pinene	6.521	136	$C_{10}H_{16}$	1.84	1.76	1.71
3	trans-2-caren-4-ol	7.124	152	$C_{10}H_{16}O$	1.12	1.30	
4	p-mentha-1,4(8)-diene	7.685	136	$C_{10}H_{16}$	1.33	1.50	0.84
5	cis-sabinene hydrate	7.845	154	$C_{10}H_{18}O$	2.26	2.50	0.58
6	trans-pinocarveol	9.208	152	$C_{10}H_{16}O$	1.63	2.25	
7	cis-carveol	9.622	152	$C_{10}H_{16}O$	1.54	2.12	
8	naphthalene, 1,2,3,4,4a,5,6,7-octahydro-4a-methyl-	9.785	150	$C_{11}H_{18}$	2.28	2.50	
9	bergamiol	10.268	196	$C_{12}H_{20}O_2$	0.68	0.00	
10	caryophyllene	11.932	204	$C_{15}H_{24}$	4.46	3.15	9.29
11	humulene	12.222	204	$C_{15}H_{24}$	2.35	2.06	3.90
12	alloaromadendrene	12.274	204	$C_{15}H_{24}$	0.51	0.46	9.89
13	α-gurjunene	12.495	204	$C_{15}H_{24}$	1.34	1.39	0.36
14	β-guaiene	12.726	204	$C_{15}H_{24}$	0.63	0.72	1.10
15	(±)-cadinene	12.879	204	$C_{15}H_{24}$	0.97	1.34	
16	γ-himachalene	12.950	204	$C_{15}H_{24}$	1.10	1.20	
17	nerolidol	13.079	222	$C_{15}H_{26}O$	2.94	3.20	
18	caryophyllene oxide	13.368	220	$C_{15}H_{24}O$	3.61	3.81	0.86
19	aristolene epoxide	13.578	220	$C_{15}H_{24}O$	2.29	2.40	
20	selin-6-en-4α-ol	13.642	222	$C_{15}H_{26}O$	1.95	1.89	
21	caryophylla-4(12),8(13)-dien-5α-ol	13.826	220	$C_{15}H_{24}O$	6.88	6.03	1.78
22	isoaromadendrene epoxide	13.992	220	$C_{15}H_{24}O$	5.94	7.03	2.20
23	alloaromadendrene oxide-(1)	14.097	220	$C_{15}H_{24}O$	3.37	3.64	
				Sum	51.70	52.93	33.19

Table 2. Main Cannabinoid Contents of Some Local "Hashish" Samples (A), (B), and (C)

no.	compound name	retention time (min)	molecular mass	formula	peak area, %		
					sample (A)	sample (B)	sample (C)
1	cannabiorcochromene (CBC-C1)	16.665	258	$C_{17}H_{22}O_2$	0.82	0.92	
2	tetrahydrocannabivarin (THCV)	17.687	286	$C_{19}H_{26}O_2$	1.08	1.19	0.46
3	delta-8-tetrahydrocannabinol (delta-8-THC)	17.988	314	$C_{21}H_{30}O_2$	0.90	0.94	0.74
4	exo-THC	18.299	314	$C_{21}H_{30}O_2$	0.68	0.76	2.14
5	cannabichromene	18.530	314	$C_{21}H_{30}O_2$	0.79	0.94	1.40
6	cannabidiol (CBD)	18.964	314	$C_{21}H_{30}O_2$	16.25	27.09	12.47
7	cannabielsoin (CBE)	19.266	330	$C_{21}H_{30}O_3$	0.82	1.15	
8	dronabinol (delta-9-THC)	19.410	314	$C_{21}H_{30}O_2$	6.76	10.00	23.16
9	cannabigerol (CBG)	19.670	316	$C_{21}H_{32}O_2$	0.8	1.00	
10	cannabinol (CBN)	19.767	310	$C_{21}H_{26}O_2$	2.18	2.80	9.83
				Sum	31.08	46.79	50.20

a splitless mode. Under electron impact ionization (EI), the MS scan range was 50−450 atomic mass units (70 eV). Application of the samples was performed through direct sample introduction (DSI). Compound identification was achieved by comparing the retention times with the standards in the relevant literature[2,26−28] and NIST/EPA/NIH mass spectral library Version 2.2 (Jun 2014).

DSI was performed using a thermal separation probe (TSP) (Agilent Technologies) that is inserted into a split−splitless injector. The TSP holds a disposable glass microvial (the actual dimensions are 1.6 mm OD, 1.2 mm ID, and 15 mm length). For each analysis, about 1 mg of the "hashish" sample is placed in a TSP microvial. This technique enables thermal vaporization of the semivolatile compounds, while the nonvolatile residue is maintained inside the microvial. The samples are directly introduced without any prior treatment in a disposable minivial inside the gas chromatograph inlet.

3. RESULTS

3.1. Nature of Terpenes in "Hashish". Three different "hashish" samples, (A), (B), and (C), were collected from the illegal market and characterized by identifying and measuring their main chemical components in relation to the possible country of origin. Using the present TSP technique, 23 different terpenes and 10 cannabinoids were detected in measurable quantities in all tested hashish samples. The total ion chromatograms (TICs) of samples (A), (B), and (C) are illustrated in Figure 1. Two separation windows can be distinguished at 6−17 min due to volatile compounds (terpenes) and at 17−22 min due to the main active components of hashish (cannabinoids).

Table 1 shows the different detected terpenes and their retention times (minutes), molecular mass, relative peak area, and molecular formula. The identified terpenes in the tested samples were 5,5-dimethyl-1-vinylbicyclo[2.1.1]hexane (hashishene), α-pinene, trans-2-caren-4-ol, p-mentha-1,4(8)-

diene, *cis*-sabinene hydrate, *trans*-pinocarveol, *cis*-carveol, naphthalene, 1,2,3,4,4a,5,6,7-octahydro-4a-methyl-, bergamiol, caryophyllene, humulene, alloaromadendrene, *α*-gurjunene, *β*-guaiene, (±)-cadinene, *γ*-himachalene, nerolidol, caryophyllene oxide, aristolene epoxide, selin-6-en-4*α*-ol, caryophylla-4(12),8(13)-dien-5*α*-ol, isoaromadendrene epoxide, and alloaromadendrene oxide-(1). The results also reveal that among the above 23 identified terpenes, caryophylla-4(12), 8(13)-dien-5*α*-ol, isoaromadendrene epoxide, caryophyllene, and alloaromadendrene oxide-(1) were detected in relatively high proportions in the tested (A), (B), and (C) "hashish" samples. Samples (A) and (B) displayed almost the same order of relative proportions of terpenes. Sample (C) shows that the main components are in a different concentration order. In contrast to samples (A) and (B), alloaromadendrene and caryophyllene are present in the highest proportions in sample (C).

3.2. Nature of Cannabinoids in "Hashish".

Table 2 includes the main detected cannabinoids in the three examined "hashish" samples. Ten cannabinoid components were detected. These are cannabiorcochromene (CBC-C1), tetrahydrocannabivarin (THCV), delta-8-tetrahydrocannabinol (delta-8-THC), *exo*-THC, cannabi-chromene, cannabidiol (CBD), cannabielsoin (CBE), dronabinol (delta-9-THC), cannabigerol (CBG), and cannabinol (CBN). Figures 2−11 display the mass spectra of the detected cannabinoids.
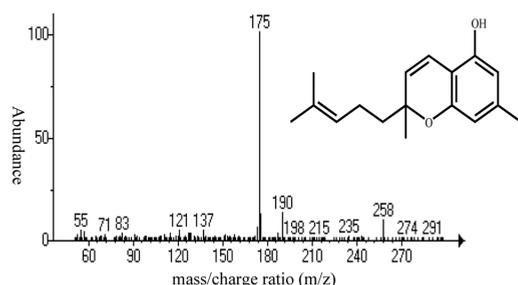
Figure 2. Mass spectrum of cannabiorcochromene (CBC).
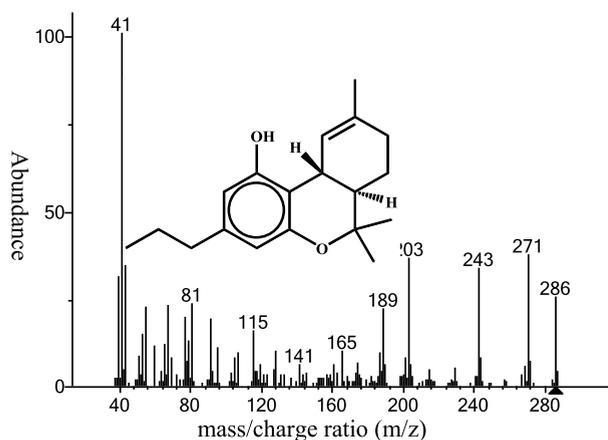
Figure 3. Mass spectrum of tetrahydrocannabivarin (THCV).

3.3. Discussion.

Three main compounds are detected in the three tested hashish samples in appreciable concentrations. These are cannabidiol (CBD), cannabinol (CBN), and dronabinol or tetrahydrocannabinol (THC) in the ratio of about 16:2:6 and 27:3:10 and 13:10:23 for samples (A), (B), and (C), respectively. The three tested "hashish" samples
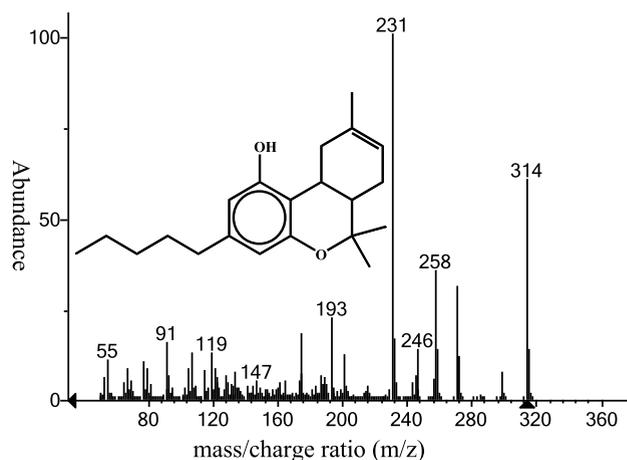
Figure 4. Mass spectrum of delta-8-tetrahydrocannabinol (delta-8-THC).
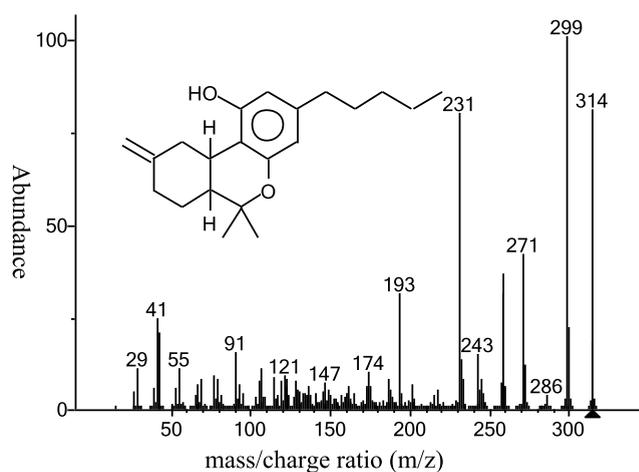
Figure 5. Mass spectrum of exo-tetrahydrocannabinol (*exo*-THC).
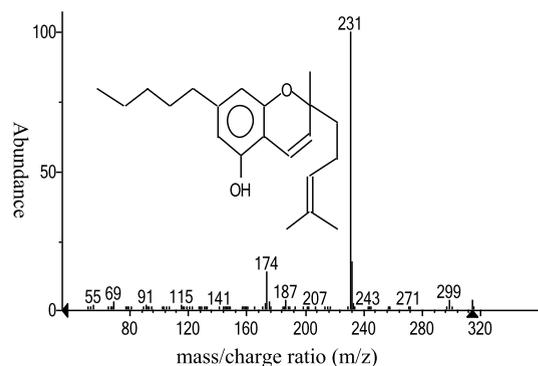
Figure 6. Mass spectrum of cannabichromene.

contain almost the same terpenes and cannabinoids with different proportions and concentrations.

The cannabis is called "drug-type" if the ratio of tetrahydrocannabinol (THC % + CBN %)/CBD %) is greater than 1.0 and "fiber-type" if the ratio is less than 1.0.[29] Later, the United Nations Office on Drugs and Crime (UNODC)[30] recommended the use of the same principle for following the phenotypic index (*X*) for "hashish" classification by combination of the three cannabinoid levels in one index
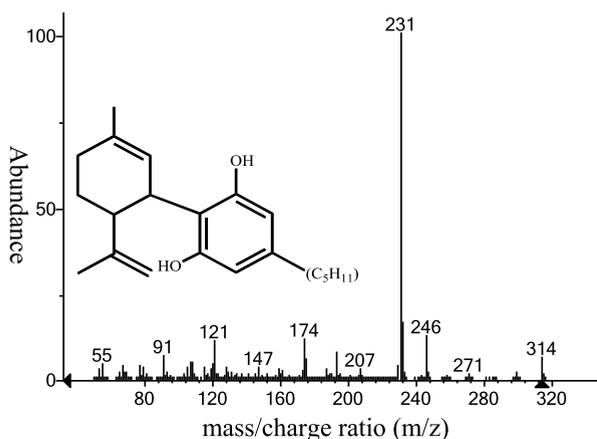
Figure 7. Mass spectrum of cannabidiol (CBD).
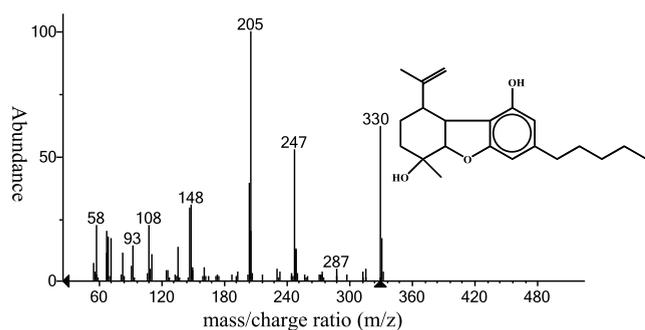
Figure 8. Mass spectrum of cannabielsoin (CBE).
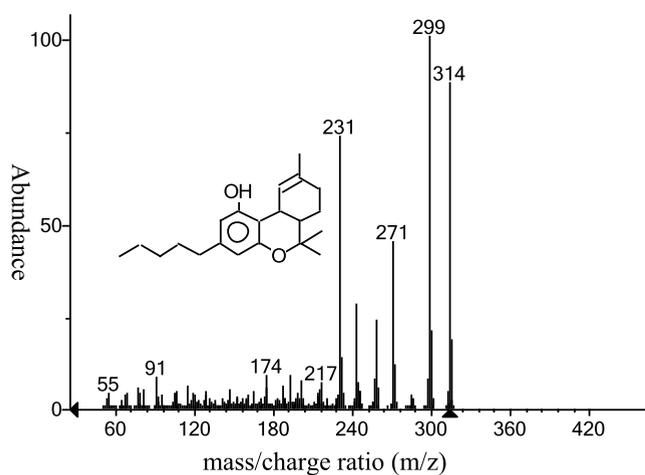
Figure 9. Mass spectrum of dronabinol (delta-9-THC).

$$X = \frac{[\text{THC}] + [\text{CBN}]}{[\text{CBD}]}$$

where [THC], [CBN], and [CBD] are the highest relative proportions expressed by the peak area of THC, CBN, and CBD in the TIC, respectively. If the ratio is greater than 1, the sample is categorized as drug-type cannabis, or chemotype-I, whereas if the index is less than 1, the sample is described as fiber-type cannabis, or chemotype-III. It is worth noting that cannabinol (CBN) is a THC breakdown product, not a natural cannabinoid. In the present study, each of the tested samples, (A), (B), and (C), was evaluated according to their phenotypic index (X), and the results are presented in Table 3.
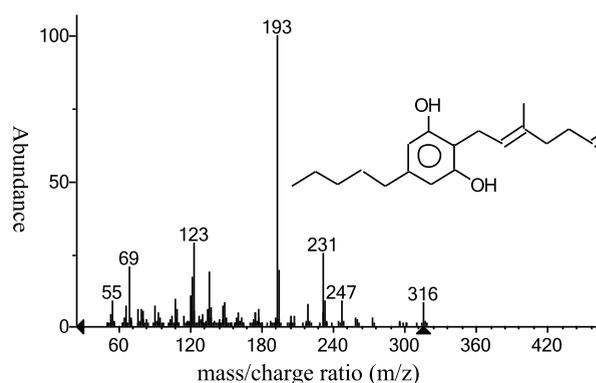
Figure 10. Mass spectrum of cannabigerol (CBG).
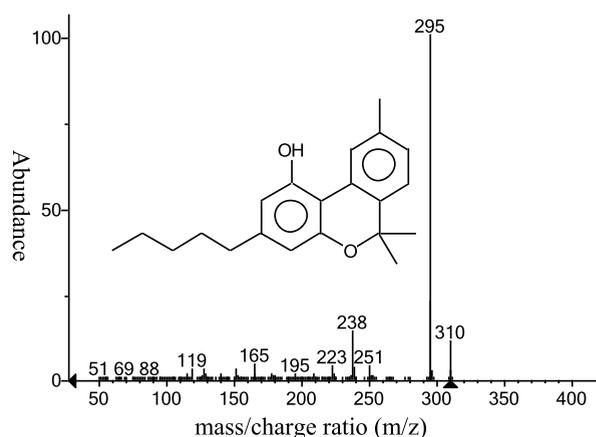
Figure 11. Mass spectrum of cannabinol (CBN).

Table 3. Phenotypic Index (X) of the Three Local "Hashish" Samples (A), (B), and (C)

sample	THC, %	CBN, %	CBD, %	phenotypic index (X)
(A)	6.76	2.18	16.25	0.55 < 1 fiber type cannabis
(B)	10.00	2.80	27.09	0.47 < 1 fiber type cannabis
(C)	23.16	9.83	12.47	2.64 > 1 drug type cannabis

3.4. Origin of Hashish Samples. The country of origin of the three tested "hashish" samples was identified by comparing their phenotypic index (X) with the literature-reported phenotypic index values.[25,31] Previous studies reported that a phenotypic index value (X) of 0.33−0.68 reveals a "hashish" of Lebanese origin and a value of (X) > 2.6 indicates Moroccan or Indian origin.[25] The present study shows that the (X) index of samples (A) and (B) is 0.55 and 0.47, respectively, which is very close to the (X) index values of Lebanese "hashish".[25] Detection of cannabielsoin (<2%) in samples (A) and (B) and not in sample (C) is a further support of the Lebanon origin. On the other hand, "hashish" sample (C) displays an (X) phenotypic index of 2.64, which agrees fairly well with the (X) value of Moroccan-origin "hashish".[25] It can be seen that sample (C) contains a relatively high level of THC compared to samples (A) and (B). THC is known to have a number of side effects that are similar to the negative symptoms of schizophrenia, such as muted affect, emotional withdrawal, psychomotor slowness, a lack of spontaneity, and a reduction in rapport.[32−35]

4. CONCLUSIONS

The content of cannabinoids and terpenes in Egyptian-seized hashish was investigated using (GC−MS) with a TSP, which offers a good and fast "screening" technique. The suitability and applicability of the method are demonstrated by analyzing three hashish samples where 23 terpenes and 10 cannabinoids are identified and detected in appreciable contents. Phenotypic indices (THC % + CBN %)/CBD %) of samples (A) and (B) are 0.55 and 0.47, respectively, which are very close to the (X) index values of Lebanese "hashish" (fiber-type cannabis). "Hashish" sample (C) displays an (X) phenotypic index of 2.64, which agrees fairly well with the (X) value of Moroccan-origin "hashish" (drug-type cannabis).

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Notes

The authors declare no competing financial interest.

■ ABBREVIATIONS

TSP/GC/MS	thermal separation probe and gas chromatography−mass spectrometry
CBC-C1	cannabiorcochromene
THCV	tetrahydrocannabivarin
delta-8-THC	delta-8-tetrahydrocannabinol
exo-THC	cannabichromene
CBD	cannabidiol
CBE	cannabielsoin
Delta-9-THC	dronabinol
CBG	cannabigerol
CBN	cannabinol
AMU	atomic mass unit
EI	electron ionization
DSI	direct sample introduction
TICs	total ion chromatograms

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