Forensic Science International xxx (2012) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

A survey of the potency of Japanese illicit cannabis in fiscal year 2010

Yukari Tsumura [a,*], Rikiya Aoki [b], Yoshio Tokieda [c], Mamoru Akutsu [d], Yasuharu Kawase [e], Tadashi Kataoka [f], Toshiyuki Takagi [g], Tomomi Mizuno [h], Masakatsu Fukada [i], Hiroshi Fujii [j], Kazumi Kurahashi [k]

[a] Kobe Branch, Narcotics Control Department, Kinki Regional Bureau of Health and Welfare (Kinki NCD), Ministry of Health, Labour and Welfare (MHLW), 29 Kaigandori, Chuo-ku, Kobe, Japan
[b] Hokkaido NCD, MHLW, Sapporo, Japan
[c] Tohoku NCD, MHLW, Sendai, Japan
[d] Kanto-Shin'etsu NCD, MHLW, Tokyo, Japan
[e] Yokohama Branch, Kanto-Shin'etsu NCD, MHLW, Yokohama, Japan
[f] Tokai-Hokuriku NCD, MHLW, Nagoya, Japan
[g] Kinki NCD, MHLW, Osaka, Japan
[h] Chugoku-Shikoku NCD, MHLW, Hiroshima, Japan
[i] Shikoku NCD, MHLW, Takamatsu, Japan
[j] Kyushu NCD, MHLW, Fukuoka, Japan
[k] Okinawa Narcotics Control Office (NCO), Kyushu Regional Bureau of Health and Welfare, MHLW, Naha, Japan

A R T I C L E I N F O

Article history:
Received 20 December 2011
Received in revised form 29 March 2012
Accepted 7 April 2012
Available online xxx

Keywords:
Cannabis potency
Δ^9-Tetrahydrocannabinol
Cannabinol
Cannabidiol
Japan
Sinsemilla

A B S T R A C T

In recent years, increased 'cannabis potency', or Δ^9-tetrahydrocannabinol (THC) content in cannabis products, has been reported in many countries. A survey of Japanese illicit cannabis was conducted from April 2010 to March 2011. In Japan, all cannabis evidence is transferred to the Minister of Health, Labour and Welfare after criminal trials. The evidence was observed at Narcotics Control Department offices in major 11 cities. The total number of cannabis samples observed was 9072, of which 6376 were marijuana. The marijuana seizures were further classified, and it was found that in terms of the number of samples, 65.2% of them were seedless buds, and by weight 73.0% of them were seedless buds. Seedless buds were supposed to be 'sinsemilla', a potent class of marijuana. THC, cannabinol (CBN) and cannabidiol (CBD) in marijuana seizures exceeding 1 g were quantified. The number of samples analyzed was 1115. Many of them were shown to contain CBN, an oxidative product from THC. This was a sign of long-term storage of the cannabis and of the degradation of THC. Relatively fresh cannabis, defined by a CBN/THC ratio of less than or equal to 0.1, was chosen for analysis. Fresh seedless buds (335 samples) contained an average of 11.2% and a maximum of 22.6% THC. These values are comparable to those of 'high potency cannabis' as defined in previous studies. Thus, this study shows that highly potent cannabis products are distributed in Japan as in other countries.

1. Introduction

In recent years, increased 'cannabis potency', or Δ^9-tetrahydrocannabinol (THC) content in cannabis products, has been reported in many countries such as the USA [1], UK [2,3], Netherlands [4], Germany [5], Italy [6], and New Zealand [7]. The World Drug Report 2011 by United Nations Office on Drugs and Crime (UNODC) noted that the average concentration of THC is presently at higher levels than 10–15 years ago; however, data for the past five years show a stable trend in some countries, although the pattern is not consistent for all products and all countries [5]. Two reviews on cannabis potency mention that the data on this issue are still not adequate and further research is required [8,9].

The higher potency of cannabis is attributed to genetic factors (selected seed varieties and cultivation of female plants), environmental factors (cultivation techniques), and freshness (production sites are close to the consumer and storage degradation of THC is avoided) [10]. Several papers report an increased ratio of non-fermented flowers, called 'sinsemilla', in the street market [1,11,12]. The World Drug Report 2006 noted that 'sinsemilla is distinct enough in appearance and potency to be considered a separate drug' [12]. Some reports mention the possibility of increases in mental disorders or emergency calls due to increased cannabis potency [5,11–13]. Driving under the

* Corresponding author at: Kobe Branch, Narcotics Control Department, Kinki Regional Bureau of Health and Welfare, Kobe Chiho Godochosha, 29 Kaigandori, Chuo-ku, Kobe 650-0024, Japan. Tel.: +81 78 391 0487; fax: +81 78 325 3769.
E-mail address: tsumura-yukari@mhlw.go.jp (Y. Tsumura).

0379-0738/$ – see front matter © 2012 Elsevier Ireland Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.forsciint.2012.04.005

influence of drugs (DUID) is also a significant issue of public concern that relates to cannabis use [12].

In Japan, cannabis is the second-most-often abused psychoactive drug next to methamphetamine, and its abuse is rapidly increasing. The number of arrested individuals in 2010 was 2367 [14], double that in 2000, 1224 [15]. Furthermore, several large-scale indoor cultivations of sinsemilla have been found in recent years.

The THC contents of Japanese cannabis were previously surveyed by the Ministry of Health and Welfare in 1970 [16]. However, this survey was of hemp used for fiber production, or wild cannabis. There are no sufficient data on the THC levels of abused cannabis in Japan. The aim of this study is to survey cannabis potency in Japan and compare it with the results of previous studies.

In Japan, all cannabis evidence is transferred after criminal trials from regional prosecutors' offices to the Minister of Health, Labour and Welfare via regional Narcotics Control Department (NCD). The survey of these seizures was conducted in NCD offices located in 11 major cities all over Japan.

UNODC has pointed out several problems with the comparison of THC level data from different countries or periods, such as differences in the classification of cannabis and in the analytical method, or a lack of randomness in sampling [12]. So the authors used UNODC's recommended method [17] for quantification and set clear criteria for sampling or classifying marijuana seizures to avoid possible bias or ambiguity.

Users of psychoactive drugs determine the dose of the drug by reference to its potency. So high potency cannabis would not necessarily be harmful, but a 'change' or 'difference' in the potency can cause unexpected overdoses and health problems [11]. So we compared our results with the THC levels, which were regarded to be higher than the previous ones. And we also determined the pattern of THC contents in marijuana samples. The present paper is the first report for cannabis potency in Asian area, covering almost whole seizures in one nation, using standardized methods for quantification.

2. Material and methods

2.1. Cannabis surveyed

Seized cannabis plants or products were surveyed after criminal trials. They were transferred to the Minister of Health, Labour and Welfare via regional NCD offices within a few months or years after seizure. Eleven major prosecutors' offices were targeted. The survey period was from April 2010 to March 2011. Seizures from the Sendai Regional Prosecutor's Office were not completely surveyed. They were examined only when exceeding 1 g in weight, and the survey of them started in October 2010.

2.2. Cannabinoids reference materials, reagents and devices

Cannabinoids reference materials: methanol solutions (1 mg/mL) of THC, cannabinol (CBN), and cannabidiol (CBD) were purchased from Cerilliant Co, Round Rock, TX, USA.

Internal standard solution (ISTD): tribenzylamine (TBA) in ethanol (0.5 mg/mL).
Ethanol: 99.5%, analytical grade
Mortar and pestle: made of agate or porcelain.
Finger musher: Assist AM. 79340.
Stainless steel sieve: 1 mm mesh, 75 mm diameter.
Membrane filter: 0.45 μm pore size.
Dry bath: heating ability of up to 150 °C.

2.3. Analytical procedures

2.3.1. Sample preparation

Quantification of cannabinoids was accomplished according to the UNODC's 'Recommended Methods for the Identification and Analysis of Cannabis and Cannabis Products' [17]. This method aims the quantification of total THC (THC + THC acid), so it has a heating process to convert THCA into THC. Stems, twigs, or seeds were removed from marijuana samples. The remaining buds and leaves were crushed by a finger masher or a mortar and pestle. The crushed marijuana was filtered through a sieve. A 200-mg quantity of sieved sample powder was weighed and 20 mL of ethanol was added. It was subjected to ultrasonic extraction for 15 min. The solution was filtered through a membrane filter, and 500 μL of filtrate was placed in a 2 mL vial and heated at 150 °C for 12 min. To the residue, 1.5 mL of ethanol was added and stirred. The calibration solutions were CBN solutions with ISTD. Their concentrations were 7 steps between 3.33 and 533.3 μg/mL, corresponding to 0.1–16% in the marijuana sample.

2.3.2. Gas chromatography (GC) conditions for cannabinoids

Instrument: Agilent 7890 or Shimadzu GC2010
Column: HP-5 or HP-5MS (30 m × 0.25 mm, 0.25 μm)
Carrier gas: He, 1.1 mL/min (constant flow)
Inlet temperature: 250 °C (original temp. of 280 °C was changed by technical requirements of our laboratories)
Oven temperature: 2 min at 200 °C, 10 °C/min 200–240 °C, 15 min at 240 °C
Split ratio: 20:1
Detector: flame ionization detector, 300 °C
Detector gas: H_2 35 mL/min, Air 350 mL/min
Injected volume: 1 μL
CBN was used as the reference material for the quantification of THC and CBD. The correlation factor was 1. The cutoff level was 0.1% for each cannabinoid.

2.3.3. Gas chromatography–mass spectrometry (GC–MS) conditions for discrimination of CBD and CBC

Instrument: GCMS-QP2010 Plus
Column: HP-5MS (30 m × 0.25 mm, 0.25 μm)
Scan range: m/z 40–400
Ionization conditions: electron ionization, 70 eV, 200 °C
The other conditions were same as those for GC.

2.4. Checking reference materials and GC response factor

The exact content level of each reference solution was tested at every purchase of a new lot. Test solutions were prepared by mixing 150 μL methanol solution of THC, CBN or CBD (1 mg/mL), 500 μL ISTD solution and 850 μL ethanol. They were injected onto GC, and the chromatographic peak area of each compound was compared to that of ISTD.

2.5. Method validation

2.5.1. Recovery tests

The accuracy of the quantification method for cannabinoids in marijuana was tested at three laboratories. Marijuana of low THC or CBN content was chosen and extracted with ethanol. A 500-μL volume of extract was taken and fortified with cannabinoids followed by heating and quantification using GC. Test solutions were prepared separately for each cannabinoid, and the fortification level was equal to 1% in marijuana.

2.5.2. Interlaboratory testing

The analytical method was tested at eight laboratories. Three marijuana seizures of adequate amounts were chosen. They were cut into 0.5–1-cm pieces and mixed well. These samples were packed in plastic bags in ca 1 g portions. They were transferred to the laboratories and analyzed in triplicate. The average, standard deviation and z-score of the cannabinoid levels detected in each laboratory were calculated.

2.6. Observation and classification of cannabis

Cannabis seizures were classified into 5 groups: marijuana, whole plant, hashish, hash oil and others (mixture with tobacco or herbs, burned residue, etc.). Marijuana samples were further classified into 4 groups: seeded buds, seedless buds, leaves and others (stems or twigs). A document describing the amount of cannabis was attached to every set of seizures. The amount of marijuana, hashish or hash oil was expressed in terms of weight. On the other hand, the amount of the whole plant was expressed in either weight or number for analytical or handling reasons. The number or weight of each seizure was recorded.

2.7. Selection of quantification samples

Marijuana seizures exceeding 1 g were subjected to quantifications of THC, CBN, and CBD in eight laboratories. Packages of marijuana with the same appearance and identical kinds of bags were assumed to have originated from identical lots, and one of the packages was picked up for analysis. If each package of the same origin contained less than 1 g but their sum total exceeded 1 g, two or more packages were combined to exceed 1 g. If one package contained much more than 1 g, 1 g was taken. When a large package contained a mixture of buds and leaves, the buds were taken.

Please cite this article in press as: Y. Tsumura, et al., A survey of the potency of Japanese illicit cannabis in fiscal year 2010, Forensic Sci. Int. (2012), http://dx.doi.org/10.1016/j.forsciint.2012.04.005

Table 1
Comparison of experimental and theoretical GC responses of cannabinoid reference solutions.

ID	Compound	Lot No.	Expiration date	Description in certification		Experimental GC response		Theoretical peak area [18] (CBN = 1)
				Prepared concentration (mg/mL)	Analyzed concentration (mg/mL)	Peak area (D = 1)	Peak area normalized by 'analyzed concentration' (D = 1)	
A[a]	THC	FC080603-01F	July 2010	1.000	1.004	0.993	0.980	0.982–1.00
B	THC	FE021710-01	February 2015	1.000	1.018	1.028	1.000	
C	CBN	FE061208-01	June 2012	1.000	0.990	0.998	0.999	1
D	CBN	FE111210-01	November 2014	1.000	0.991	1	1	
E	CBD	FE100108-01	December 2011	1.000	1.005	1.013	0.999	0.97–0.990
F	CBD	FE111510-02	June 2015	1.000	1.002	1.006	0.995	

[a] This solution was quantified in August 2010, a month later than the expiration date.

3. Results and discussion

3.1. Checking of reference materials and GC response factor

The GC responses of the lots of cannabinoid reference solution were examined and compared with each other to confirm the concentration and response factors. Table 1 shows the features of each reference solution and the experimental results. The provider of the reference solutions describes 'prepared concentration' and 'analyzed concentration' in the certification documents. 'Prepared concentration' was 1.000 mg/mL for all lots and the supplier recommended use of this value for the measurement of the concentration.

As THC is an unstable compound, the UNODC analytical manual recommends the use of CBN as a reference material for THC [17]. Poortman-van der Meer et al. mentioned that theoretical THC/CBN and CBD/CBN were 0.982–1.00 and 0.97–0.990, respectively, depending on the theoretical model adopted [18].

Among the six lots, THC solution A was tested after the expiration date, and the GC response was significantly lower than the theoretical one, so it was excluded from consideration. The other lots, B, E, and F, all gave GC responses exceeding the theoretical values. On the other hand, when the GC responses were normalized by the 'analyzed concentration', they were in better agreement with the theoretical values. The factors for THC/CBN and CBD/CBN were all in the range of 0.995–1.000. Thus, a factor of 1 and a concentration of 1.000 mg/mL were used to calculate THC and CBD concentrations based on CBN calibration curves in the following experiments and survey.

Quantification using CBN as a reference material can be somewhat inaccurate, but this method has many merits because THC is strictly controlled in Japan and it is very difficult to obtain, distribute and store. Furthermore, cannabinoid reference solutions are expensive.

3.2. Method validation

3.2.1. Discrimination of CBD and CBC

It is known that CBD has a retention time very close to that of cannabichromene (CBC) in GC [19]. Though the mass spectra of CBD and CBC resemble each other, they are distinguishable by the existence of the m/z 246 peak (CBD) or the absence of it (CBC) as shown in many commercial databases. Some of the samples in the present research were tested using gas chromatography–mass spectrometry and a chromatographic peak considered to be CBC was obtained, though it was not confirmed because of a lack of reference material.

One of these marijuana extracts was mixed with CBD reference solution to make equal concentrations of CBD and supposed CBC. The mixture was analyzed, and it was shown that the peaks of CBD and supposed CBC did not separate, even with a column of 30 m in length instead of the 15 m column recommended by UNODC [17]. However, CBD showed a retention time 0.04 min shorter than supposed CBC, so they were distinguishable on chromatogram. All samples in the survey were split into 2 groups by their retention time for CBD or CBC and none of them gave ambiguous peak.

3.2.2. Recovery test

Table 2 shows the recoveries of cannabinoids added to marijuana extracts at three laboratories. Some values exceeded 120% in spite of usage of the internal standard. This finding is considered to be due to an enhanced response by matrices that originated from marijuana. On the other hand, one recovery value for THC was 90.8%, suggesting that loss occurred during the analytical process, possibly in the heating step. This experiment showed both the larger and smaller results for THC as two possibilities. No further experiment could be done because of a shortage of cannabinoids solution.

3.2.3. Interlaboratory test

Table 3 shows the results of the quantification of cannabinoids in divided marijuana samples at eight laboratories. All three samples contained no CBD, but supposed CBC was detected in them. The THC and CBN detected were all below 1%, and their standard deviations were equal to or below 0.2% except for THC in Sample 3. The THC level in Sample 3 was 6.2% on average, and the relative standard deviation (RSD) between laboratories was 9.2%, better than the reported RSD of 29% in similar interlaboratory practice in Europe [18]. Fig. 1 shows the z-scores of the THC values detected in Sample 3 at eight laboratories. The z values of all laboratories were below 2.

As the interlaboratory test was conducted without any pre-quantification of THC to keep blindness, the THC levels found in 2 of the 3 samples included in the test happened to be rather low. They were not ideal samples to be representative for surveyed marijuana. However, the test was not repeated because test sample distribution needed so complicated legal procedures that the opportunity was limited to be only once.

Table 2
Recovery (%) of cannabinoids.

	Lab X	Lab Y	Lab Z
THC	104.2 (1.0)	90.8 (1.1)	126.1 (3.4)
CBN	122.3 (5.3)	104.8 (2.4)	127.4 (3.6)
CBD	123.1 (6.0)	108.8 (2.7)	104.4 (3.2)

One % of cannabinoid was added to extract of marijuana sample.
Standard deviation is shown in parentheses.
n = 3.

G Model
FSI-6802; No. of Pages 7

Table 3
Cannabinoids quantification results in 8 laboratories.

	THC (%)			CBN (%)		
	Average	Range	SD	Average	Range	SD
Sample 1	0.3	0.2–0.4	0.1	0.2	0.1–0.3	0.1
Sample 2	0.6	0.4–0.8	0.1	0.8	0.5–1.1	0.2
Sample 3	6.2	5.3–7.1	0.6	0.4	0.3–0.6	0.1

3.3. Collection and classification of cannabis

The total number of post-trial cannabis seizures collected was 9072. Fig. 2 shows the sample numbers from each area. The number from Tokyo was the largest, 1800, and the second largest was from Yokohama, 1687. Cannabis was incompletely collected in the Sendai area, so the number for Sendai does not reflect the true number of seizures in this area.

Table 4 shows the number and weight of each cannabis class: 1257 were whole plants, 6376 marijuana, and 886 hashish. The total weight was 286.6 kg for marijuana and 36.0 kg for hashish. The whole amounts of marijuana and hashish seizures made from 2008 to 2010 have been reported to be 181.7–382.3 kg and 13.9–33.4 kg per year, respectively [14]. Therefore, the present research covered the majority of Japanese cannabis seizures.

Marijuana seizures were further classified, and the results are shown in Figs. 3 and 4. Fig. 3 is expressed in terms of the number of seizures, and Fig. 4 in weight. Seedless buds were dominant among the classes, consisting 65.2% of the total in number and 73.0% in weight.

A survey in the USA in 2008 showed that 46.8% of seized marijuana was 'sinsemilla' [1], and another survey in the UK in 2008 showed this number to be more than 97% [3]. The present results show that seedless buds, 'sinsemilla', represent the majority of marijuana seizures in Japan as in these other countries.

Fig. 5 shows the ratio of the cannabis classes in each area. The ratio of leaves or others (stem, twig, etc.) was higher in Sapporo, Hiroshima and Naha. Police sometimes seize waste of cannabis cultivation, so it is difficult to distinguish whether the leaves were intended to be consumed or thrown away.

The ratio of seeded buds to seedless buds was higher in Sapporo and Fukuoka. In Hokkaido Prefecture, where Sapporo City is located, huge numbers of wild cannabis are eradicated every year. About 920,000 plants were eradicated in 2010 all over Japan, of which 810,000 were in Hokkaido Prefecture [14]. Thus, some extent of seeded buds from Sapporo was supposed to be wild cannabis taken for consumption. On the other hand, in Kyushu area, where Fukuoka City is located, no wild cannabis has been eradicated in recent years. The reason for the frequent encounter with seeded buds in this area is not specified.

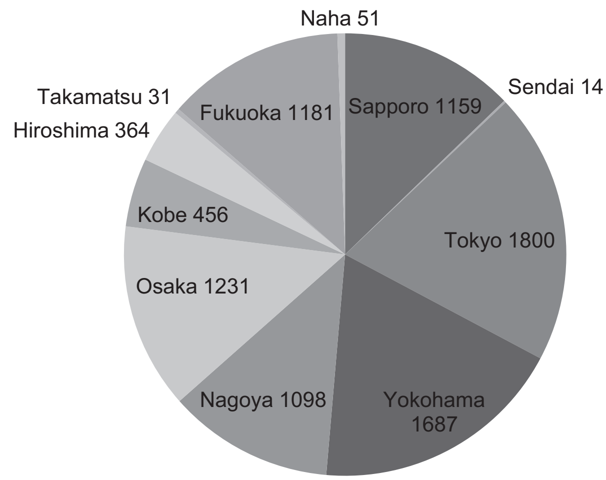

Fig. 2. Number of cannabis seizures in each area (total 9072).

Table 4
Cannabis seizures observed after criminal trials.

	Number of items	Weight (kg)		Number of plants
Whole plant	1257	8.300	+	2337
Marijuana	6376	286.559	+	5
Hashish	886	35.983		
Oil	5	0.026		
Others	548			
Total	9072	330.869		2342

Size of each item was expressed as weight or number of plants.
'Others' includes mixture with tobacco, burned residue, etc.

3.4. Cannabinoids levels in seized marijuana

3.4.1. THC and CBN

Marijuana seizures were selected for the quantification of cannabinoids. The total number quantified was 1115. The results for each class are shown in Table 5. The highest THC level was found in seedless buds, 8.3% average. The CBN level in these buds was 1.3% therefore the sum of THC and CBN was 9.6%.

Seized cannabis had been stored for long periods during criminal trials. It is known that CBN is not found in fresh cannabis. It is gradually produced by conversion from THC during storage time. The sum of THC and CBN levels is not equal to the initial THC level in marijuana, but is rather less than the initial level [20]. Thus, the sum is considered to be the lower limit of the initial THC level, but is not an exact value.

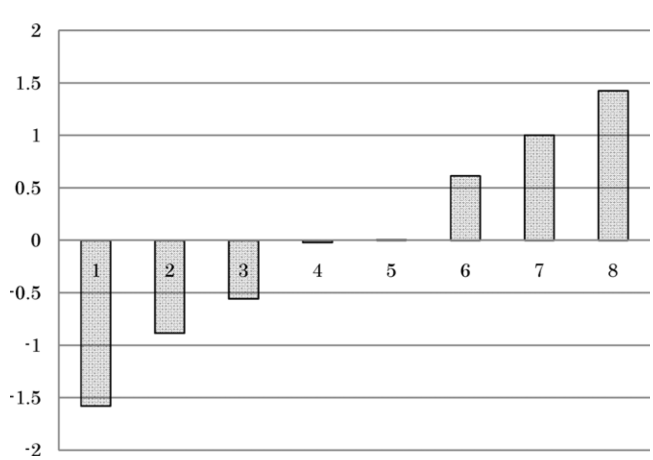

Fig. 1. *z*-Score of THC level in Sample 3 reported by 8 laboratories.

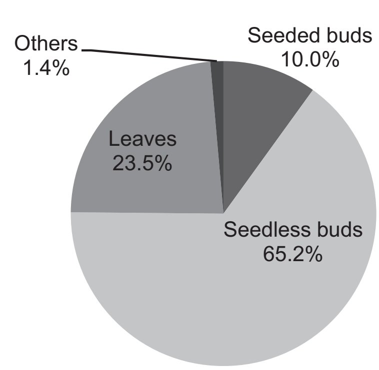

Fig. 3. Number of marijuana in each class (total 6376).

Please cite this article in press as: Y. Tsumura, et al., A survey of the potency of Japanese illicit cannabis in fiscal year 2010, Forensic Sci. Int. (2012), http://dx.doi.org/10.1016/j.forsciint.2012.04.005

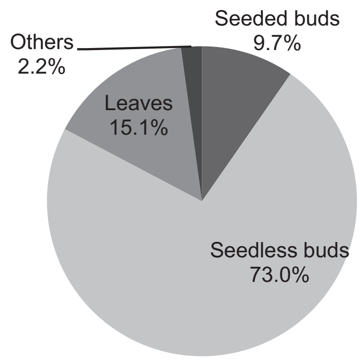

Fig. 4. Weight of marijuana in each class (total 286.6 kg).

Table 5
Cannabinoids levels in *all* marijuana samples tested.

	Number of samples	Average (range) (%)		
		THC	CBN	CBD
Seeded buds	100	3.8 (ND-16.4)	1.1 (ND-4.7)	0.2 (ND-4.3)
Seedless buds	758	8.3 (ND-22.6)	1.3 (ND-6.4)	0.1 (ND-11.5)
Leaves	254	1.8 (ND-14.2)	0.5 (ND-3.4)	0.2 (ND-6.2)
Powder and tablet	3	8.9 (0.3–23.6)	1.2 (0.1–3.2)	0.1 (ND-0.3)
Total	1115			

ND: not detected (<0.1%).

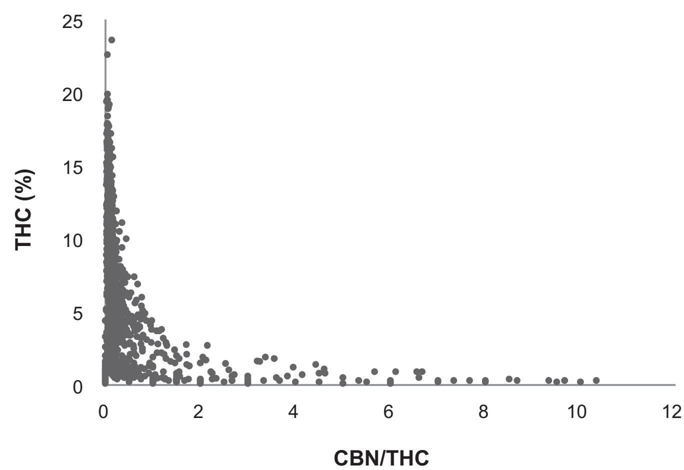

Fig. 6. Relationship between CBN/THC and THC levels in marijuana.

On the other hand, CBN/THC can be an indicator for the freshness of marijuana [20]. Fig. 6 shows the relationship between CBN/THC and THC levels in marijuana samples. It was shown that the higher the CBN/THC was, the lower THC was, indicating long storage, possibly at ambient temperature or without cover from lights.

So marijuana samples of CBN/THC not exceeding or equal to 0.1 were regarded as 'fresh' and the data were chosen for statistics. Table 6 shows the results. The number of data was 424. The average THC and CBN levels in seedless buds were 11.2 and 0.7%, respectively, making sum of 11.9%. They were considerably higher than that of unselected samples.

Fig. 7 shows numbers of seeded buds in each class of THC levels, and Fig. 8 shows the numbers of seedless buds. The most frequent THC levels were 5–10% for seeded buds and 10–15% for seedless buds.

3.4.2. Regional characteristics

Table 7 shows the THC levels of marijuana from each area. No apparent difference was observed among them.

An irregular marijuana seizure was found in the Yokohama area. It was in tablet form, and its weight was 2.5 g and its size was 13 mm in diameter with a thickness of 9 mm. It contained 23.6% THC, 3.2% CBN, and no CBD. This was larger than the usual ecstasy tablets and was partly shaved, indicating divisional use for smoking, not for oral administration.

3.4.3. CBD levels

CBD was found in 86 samples out of 1115. The highest level was 11.5% in a seedless buds sample. In most samples, the CBD content was below 2%. The World Drug Report 2006 mentioned the following: 'CBD is believed to 'moderate' the effects of THC, promoting relaxation and possibly even having an antipsychotic effect.' 'Where possible, it would be advisable to track both THC and CBD levels in future evaluations of 'potency' [12].' The present study shows that the majority of Japanese illicit cannabis products contain little or no CBD.

Supposed CBC was detected in 977 samples out of 1115. Its concentrations in marijuana were up to 1.7% if the response factor of CBC/CBN was assumed to be 1. In 52 samples, neither CBD nor CBC was detected.

3.5. Assessment for the results

Several researchers have reported increased THC contents in marijuana. Mehmedic et al. reported that 1093 Sinsemilla samples

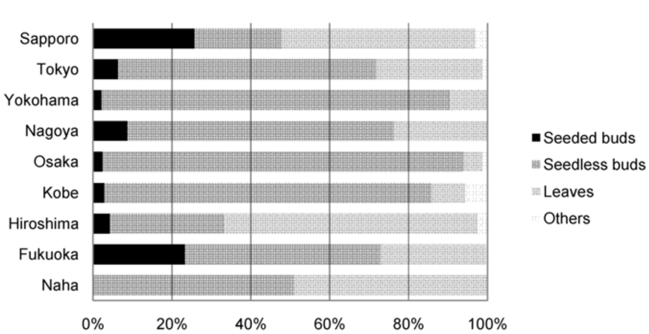

Fig. 5. Ratio of marijuana class in each area of Japan. Data from Sendai and Takamatsu are not included because the numbers were too small.

Table 6
Cannabinoids levels in *fresh*[a] marijuana samples tested.

	Number of samples	Average (range) (%)		
		THC	CBN	CBD
Seeded buds	28	7.1 (0.8–16.4)	0.4 (ND-1.3)	0.3 (ND-4.3)
Seedless buds	335	11.2 (0.2–22.6)	0.7 (ND-1.6)	0.1 (ND-11.5)
Leaves	60	3.3 (0.1–14.2)	0.2 (ND-1.3)	0.1 (ND-2.1)
Powder	1	2.7	0.1	0.3
Total	424			

ND: not detected (<0.1%).
[a] Samples with CBN/THC below or equal to 0.1.

Please cite this article in press as: Y. Tsumura, et al., A survey of the potency of Japanese illicit cannabis in fiscal year 2010, Forensic Sci. Int. (2012), http://dx.doi.org/10.1016/j.forsciint.2012.04.005

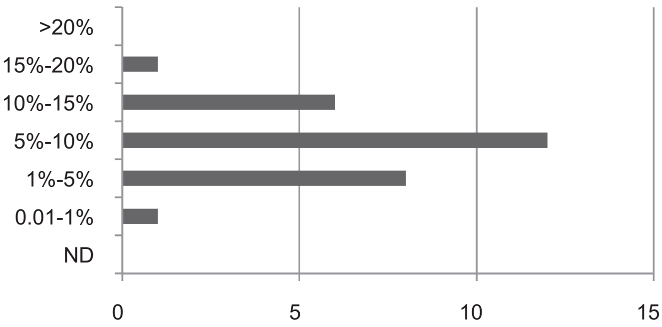

Fig. 7. Sample numbers of fresh *seeded* buds classified by THC levels.

in the USA in 2008 contained 11.5% THC on average [1]. Potter et al. reported that 247 Sinsemilla samples in the UK in 2004/5 contained a median of 13.98% THC [2]. The home office of the UK reported in 2008 that the average level of sinsemilla was 16.2% [3]. Pijlman et al. reported that 62 Nederwiet (Dutch domestic cannabis) samples from the Netherlands in 2004 contained an average of 20.4% and a median of 21.5% THC [4]. A German survey reported the average THC level in 9250 seized marijuana specimens to be 8% in 2009 [5]. Licata et al. reported that 98 Marijuana samples from Italy in 2004 contained an average of 15% THC [6]. Knight mentioned that an investigation of 43 cannabis seizures in New Zealand showed an average of 10.9% THC, and the experimental grow of the seized cannabis resulted in a range of 4.3–25.2% THC in sinsemilla [7].

We found an average of 11.2% THC in seedless buds. The highest was 22.6%. These levels are comparable to the 'high potency cannabis' in the studies mentioned above.

In Japan, the THC contents of licit or wild cannabis were surveyed by the Ministry of Health and Welfare in 1970 [16]. At that time, majority of abused cannabis was imported one, but many cases were also reported with domestic cannabis. Abusers stole them at farmers' fields or picked them in suburbs or remote area [16]. Thus the data represents certain part of cannabis being abused in that time and can be used for comparison, even though the information is limited. According to the report, THC levels were highest in products from Tochigi (a prefecture near Tokyo), 4%, followed by the wild cannabis in Hokkaido, 3.4%. The lowest was a product of Kyushu, 0.1%. The average THC in Japanese cannabis was around 1%. The present study showed greater THC contents in recent marijuana than was observed in the 1970 research, even in the leaves or seeded buds.

The origins of seized marijuana in the present survey are not clear. However, in Japan, import cases of cannabis are decreasing and cultivation cases are increasing dramatically in the last decade. Statistics for 2010 show the number of cultivation cases (196) is 8 times as high as that of import cases (25) [14]. That fact indicates that majority of Japanese illicit cannabis is domestic one now.

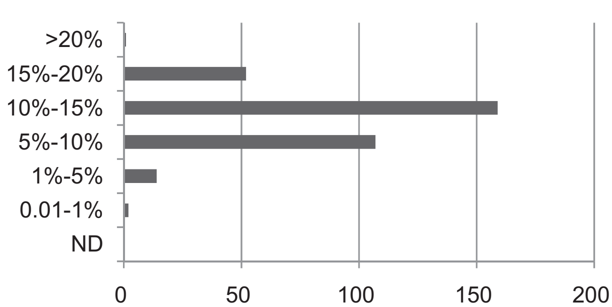

Fig. 8. Sample numbers of fresh *seedless* buds classified by THC levels.

Table 7
THC levels in fresh seedless buds in each area of Japan.

City	Number	THC levels (%)		
		Average	SD	Max
Sapporo	22	10.2	4.2	19.9
Sendai	6	12.7	2.1	16.2
Tokyo	86	11.7	3.7	19.5
Yokohama	39	12.7	3.9	19.2
Nagoya	35	11.9	3.2	22.6
Osaka	72	10.3	3.2	17.4
Kobe	37	9.6	3.2	17.9
Hiroshima	14	10.9	5.4	19.4
Fukuoka	22	11.1	3.2	17.4
Naha	2	13.3	4.0	17.2
Total	335			

With regard to the 'difference' in the THC levels of each marijuana product, we can see the distribution in Figs. 7 and 8. The most frequently encountered THC levels were between 10 and 15% in seedless buds. When these levels were considered as standard, almost all cannabis products contained less than two times these levels. Therefore, the possibility of an unexpected overdose of THC may not be large. However considering that some cannabis products with less than 5% THC were found, unexpected overdose cannot be completely avoided.

The present study is the first survey on Japanese illicit cannabis. It showed the distribution of 'high potency cannabis' in Japan as has been shown in many other countries, thus showing the necessity of continuous monitoring. Since the post-trial cannabis samples showed decreased THC content, cannabis should be surveyed immediately after seizure.

4. Conclusions

The features and cannabinoids contents of Japanese illicit cannabis products were investigated. Seedless buds, commonly known as 'sinsemilla', represent the majority of marijuana seizures in Japan. The average THC level in relatively fresh seedless buds was 11.2%. The highest THC level observed was 22.6%. These facts indicate the distribution of 'high potency cannabis' in Japan. The present paper is the first report for cannabis potency in Asian area, covering almost whole seizures in one nation, using standardized methods for quantification.

Acknowledgements

The authors highly appreciate the kind support of Dr. Yukihiro Goda and Dr. Ruri Kikura-Hanajiri who provided THC reference materials. This research was funded by a Health and Labor Sciences Research Grant from the Ministry of Health, Labour and Welfare.

References

[1] Z. Mehmedic, S. Chandra, D. Slade, H. Denham, S. Foster, A.S. Patel, S.A. Ross, I.A. Khan, M.A. ElSohly, Potency trends of Δ9-THC and other cannabinoids in confiscated cannabis preparations from 1993 to 2008, J. Forensic Sci. 55 (2010) 1209–1217.
[2] D.J. Potter, P. Clark, M.B. Brown, Potency of delta 9-THC and other cannabinoids in cannabis in England in 2005: implications for psychoactivity and pharmacology, J. Forensic Sci. 53 (2008) 90–94.
[3] S. Hardwick, L. King, Home Office Cannabis Potency Study, 2008, http://www.drugslibrary.stir.ac.uk/documents/potency.pdf.
[4] F.T. Pijlman, S.M. Rigter, J. Hoek, H.M. Goldschmidt, R.J. Niesink, Strong increase in total delta-THC in cannabis preparations sold in Dutch coffee shops, Addict. Biol. 10 (2005) 171–180.
[5] United Nations Office on Drugs and Crime (UNODC), World Drug Report, 2011, http://www.unodc.org/unodc/en/data-and-analysis/WDR-2011.html.

[6] M. Licata, P. Verri, G. Beduschi, Delta9 THC content in illicit cannabis products over the period 1997–2004 (first four months), Ann. Ist. Super. Sanita 41 (2005) 483–485.
[7] G. Knight, S. Hansen, M. Connor, H. Poulsen, C. McGovern, J. Stacey, The results of an experimental indoor hydroponic Cannabis growing study, using the 'Screen of Green' (ScrOG) method-Yield, tetrahydrocannabinol (THC) and DNA analysis, Forensic Sci. Int. 202 (2010) 36–44.
[8] J. McLaren, W. Swift, P. Dillon, S. Allsop, Cannabis potency and contamination: a review of the literature, Addiction 103 (2008) 1100–1109.
[9] F. Cascini, C. Aiello, G. Di Tanna, Increasing delta-9-tetrahydrocannabinol (Δ-9-THC) content in herbal cannabis over time: systematic review and meta-analysis, Curr. Drug Abuse Rev. 5 (2012) 32–40.
[10] EMCDDA, An overview of cannabis potency in Europe, January 2004.
[11] UNODC, Review of the world cannabis situation, Bull. Narc. 58 (2006) 1–155.
[12] UNODC, World Drug Report 2006, http://www.unodc.org/unodc/en/data-and-analysis/WDR-2006.html.
[13] M. Di Forti, C. Morgan, P. Dazzan, C. Pariante, V. Mondelli, T.R. Marques, R. Handley, S. Luzi, M. Russo, A. Paparelli, A. Butt, A.A. Stilo, B. Wiffen, J. Powell, R.M. Murray, High-potency cannabis and the risk of psychosis, Br. J. Psychiatry 195 (2009) 488–491.
[14] Compliance and Narcotics Division, Pharmaceutical and Food Safety and Bureau, Ministry of Health, Labour and Welfare, The general situation of administrative measures against narcotics and stimulants abuse, October 2011.
[15] Compliance and Narcotics Division, Pharmaceutical and Food Safety and Bureau, Ministry of Health, Labour and Welfare, The general situation of administrative measures against narcotics and stimulants abuse, November 2001.
[16] Narcotics Division, Pharmaceutical Bureau, Ministry of Health and Welfare, Cannabis, 1976.
[17] UNODC, Recommended methods for the identification and analysis of cannabis and cannabis products, 2009.
[18] A.J. Poortman-van der Meer, H. Huizer, A contribution to the improvement of accuracy in the quantitation of THC, Forensic Sci. Int. 101 (1999) 1–8.
[19] K.W. Hillig, P.G. Mahlberg, A chemotaxonomic analysis of cannabinoid variation in Cannabis (Cannabaceae), Am. J. Bot. 91 (2004) 966–975.
[20] S.A. Ross, M.A. Elsohly, CBN and D9-THC concentration ratio as an indicator of the age of stored marijuana samples, Bull. Narc. 49&50 (1997) 139–147.

Please cite this article in press as: Y. Tsumura, et al., A survey of the potency of Japanese illicit cannabis in fiscal year 2010, Forensic Sci. Int. (2012), http://dx.doi.org/10.1016/j.forsciint.2012.04.005