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Article

Chemical Profiling of Cocaine Seized by Brazilian Federal Police in 2009-2012: Major Components

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Perfis químicos de cocaína podem fornecer informações relevantes para autoridades da área de segurança pública. Desde 2006, a Polícia Federal tem trabalhado em seu próprio perfil químico de impurezas da cocaína (projeto PeQui). No esforço de estabelecer rotinas de perfil químico, este trabalho descreve os resultados obtidos para identificação de componentes majoritários (pureza da cocaína, grau de oxidação e fármacos utilizados como adulterantes), através da análise por cromatografia gasosa com detector de ionização de chama (GC-FID) de 210 amostras apreendidas em diferentes estados brasileiros entre 2009 e 2012. A pureza média observada para cocaína foi de 71% (expressa como base) e o grau de oxidação, determinado pela medida relativa entre *cis*/*trans*-cinamoilcocaína e cocaína, mostrou-se dependente do local de apreensão. A maioria das amostras não oxidadas foram apreendidas nos estados que fazem fronteira com os países produtores. A forma de base livre é a mais comumente encontrada (59%) e mais de 50% das amostras analisadas não apresentaram nenhum adulterante majoritário. Dentre os fármacos adulterantes identificados, fenacetina foi o mais abundante (30% das amostras). Levamisol, cafeína e lidocaína também foram identificados. O projeto PeQui tem sido utilizado regularmente para prover informações técnicas cientificamente embasadas para a análise de inteligência em segurança pública e de dados estatísticos que podem contribuir para um melhor entendimento do tráfico de cocaína.

Cocaine chemical profiling can provide relevant information for law enforcement authorities. Since 2006, Brazilian Federal Police has been working on its own cocaine impurity profiling program (PeQui project). In the effort to establish chemical profiling routines, this work describes major component results (cocaine purity, degree of oxidation and pharmaceutical products used as cutting agents), identified by gas chromatography with flame ionization detection (GC-FID) analysis of 210 samples seized in several Brazilian states between 2009 and 2012. The mean purity of cocaine was 71% (expressed as base) and the degree of oxidation, determined by the relative content between *cis*/*trans*-cinnamoylcocaine and cocaine, depends on the location where the seizures were performed. Most of the not oxidized samples were seized on traditional cocaine producer country border states. Cocaine is mainly present in free base form (59%) and more than 50% of the analyzed samples did not have any major adulterant. Among the identified cutting agents, phenacetin was the most abundant (30% of the total samples). Levamisole, caffeine and lidocaine were also identified. The PeQui project has been used on regular basis to provide technical and scientifically based information to law enforcement intelligence analysis and statistical data that might contribute to the better understanding of the cocaine trafficking.

Keywords: cocaine, chemical profiling, purity, refining, cutting agents, PeQui

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Introduction

Several scientific and law enforcement institutions around the world have been implementing their own profiling programs, always trying to establish drug chemical characterization studies and routines to provide useful data for law enforcement authorities involved with illicit drugs issues.[1-5] Brazil is a major player in the illicit drugs market, considering the population size (200 million inhabitants) and the consumption of cocaine and cannabis. The UNODC 2012 World Drug Report (WDR)[6] states that there is an increase in cocaine use in Brazil that pushed the federal government to launch a national program in 2010 focused in crack, cocaine and other drugs, aiming to promote public policies to reduce drugs supply and demand, as well as investing in education and health care.[7] The WDR also found an increased tendency in federal seizures, focused in international or interstate apprehensions, that have more than tripled since 2004, reaching 27 tons in 2010, and how it could also reflect the role of Brazil as a country of departure for cocaine smuggled across the Atlantic Ocean.

It is also important to point that Brazil, as one of the world's ten largest chemical manufacturers, has a regionally relevant chemical industry and is the only country that borders all the main coca leaf producing countries.[8] Therefore, chemicals control represents a particular challenge to Brazilian authorities, demanding reliable and scientific based information about the current trends on drugs manufacturing. It's also crucial to be aware of the methodologies that have been used by cocaine producers or dealers to extract, refine, dilute and adulterate (e.g., adding pharmaceutical products, as phenacetin, caffeine and lidocaine) the illicit drug that passes through the Brazilian territory or has been consumed by local users.[9]

Since 2006, the Brazilian Federal Police (BFP) has been developing and implementing its own illicit drug chemical profiling program. The PeQui project ("Perfil Químico de Drogas" in Portuguese) was designed to provide police intelligence information and forensic chemistry results, regarding both drug origin and seizure correlations throughout detailed chemical analysis. As BFP mainly deals with federal and interstate crimes and drug trafficking, it is also relevant to aggregate to PeQui project scientific based information about street drugs seizures, usually performed by local law enforcement institutions. Some initiatives have already been undertaken,[10] but further studies still depend on sponsorship.

The BFP already has a network of 30 forensic chemistry labs, which includes all 27 Brazilian states and the National Institute of Criminalistics (NIC, in Brasília, Federal District). The NIC has the technical coordination attribution to develop and implement the PeQui project routines according to the different realities around the country (i.e., demand for drug analysis, availability of instrumentation, training and staff). As the majority of BFP state labs have at least one gas chromatograph coupled with both flame ionization detection (FID) and mass spectrometer (MS) detectors, the main developments were performed to be used by the GC-FID mode.

In the present study, the major components cocaine and *cis* and *trans*-cinnamoylcocaine were quantified by GC-FID, while the more common pharmaceutical cutting agents (adulterants) were qualitatively identified by retention times (benzocaine, phenacetin, caffeine, lidocaine, levamisole, hydroxyzine, procaine, diltiazem), considering previous works already published in Brazil[11,12] and elsewhere.[13-21] Currently is in development in NIC a method to lead to a more comprehensive quantification of major components in cocaine seized samples also by GC-FID.

The samples analyzed in the present study were seized during 2009-2012 in western Brazilian states [Amazonas (AM), Acre (AC), Rondônia (RO), Mato Grosso (MT), Mato Grosso do Sul (MS) and Paraná (PR)], which border with traditional coca leaf producing and cocaine processing countries (Colombia, Peru and Bolivia) and also in Brasília (FD) and São Paulo (SP), due to their economic and geographic relevance. In 2011, 72% of all 24 metric tons of cocaine apprehended by BFP were seized in those states.

This work's main goal is to establish a chemical profile of cocaine seizures in Brazil nowadays. The major components and levels of oxidation of the cocaine samples was determined and discussed.

Experimental

Chemicals

Cocaine·HCl standard (88.4% as base) were purchased from Lipomed AG and *trans*-cinnamoylcocaine (99.8%) was provided by the Drug Enforcement Administration (DEA) Special Testing and Research Laboratory (STRL) and stored at –20 °C. 2,2,2-triphenyl-acetophenone, dipentyl phthalate and caffeine (98.5%) were provided by Acros Organics; benzocaine (99.9%); lidocaine hydrochloride monohydrate, procaine hydrochloride (≥ 97%), tetramisole hydrochloride (levamisole), diltiazem hydrochloride (> 99%) and hydroxyzine dihydrochloride (≥ 98%) were purchased from Sigma and phenacetin (99.9%) was provided by TCI-EP. All working solutions

were prepared by dilution of reference materials with chloroform (HPLC Grade) provided by Tedia Brazil. 2,2,2-triphenyl-acetophenone and dipentyl phthalate were used as internal standards dissolved in a solution of chloroform and 3% (v/v) of diethylamine. Helium, synthetic air, nitrogen and hydrogen (> 99.995% of purity) were supplied by IBG.

Sampling

For cocaine seizures, the PeQui sampling strategy was established with a threshold seizure size (at least 5 kg) where profiling samples should be taken from. Samples from 2009-2012 seizures performed in 8 Brazilian states were sent to NIC and 210 samples were randomly selected to major components analysis. Table 1 shows the origin and sample numbers *per* state. Figure S1 (Supplementary Information) shows the Brazilian territory as well as the localization of the studied states.

Table 1. Origin of 210 analyzed samples

Brazilian state	Brazilian region	Number of samples analyzed (total = 210)
Acre (AC)	North	18
Amazonas (AM)	North	17
Rondônia (RO)	North	20
Federal District (FD)	Central-West	24
Mato Grosso do Sul (MS)	Central-West	16
Mato Grosso (MT)	Central-West	36
Paraná (PR)	South	39
São Paulo (SP)	Southeast	40

Sample preparation

All the samples were prepared following the PeQui Project methods, as described in the next sections.

Sample homogenization

Samples were manually crushed and homogenized. Only cocaine base samples were homogenized in the presence of liquid nitrogen. The cryogenic procedure is adequate to treat "sticky" cocaine base samples. In all cases, the final product was a homogeneous and finely divided solid, which was used in the following steps.

Sample preparation for quantification analysis

Amounts of 8.0 mg ± 0.5 mg of each previously crushed sample were mixed with 10.0 mL of internal standards solution [2,2,2-triphenylacetophenone (0.051 mg mL^{-1}) and dipentyl phthalate (0.490 mg mL^{-1}) in chloroform solution with 2% diethylamine] and carefully stirred until homogenization. Around 1 mL of fresh prepared solutions were transferred to glass vials, sealed and sent to chromatographic analysis.

Gas chromatography coupled to flame ionization detector (GC-FID)

Quantification analysis and identification of cutting agents were carried out in an Agilent Technologies 6890N gas chromatograph with a flame ionization detector, using an Agilent Technologies 7683B Series autosampler, according to the following conditions. Injection volume: 1.0 μL; split ratio = 50:1; chromatographic column: DB1-MS Methyl Siloxane, 35 m × 200 μm (i. d.) × 0.33 μm film thickness; oven temperature program: 150 °C for 2 min, 40 °C min^{-1} to 315 °C for 4 min; injection port temperature: 280 °C; FID temperature: 320 °C; carrier gas flow rate: 1.0 mL min^{-1} (helium).

Quantitative and qualitative determinations

Quantification of major components

Eight solutions of cocaine (from 0.014 to 1.441 mg mL^{-1}) and six solutions of *trans*-cinnamoylcocaine (from 0.002 to 0.222 mg mL^{-1}), all expressed as bases, were prepared in triplicate and used to obtain the analytical curves, with dipentyl phthalate (0.490 mg mL^{-1}) and 2,2,2-triphenyl-acetophenone (0.051 mg mL^{-1}) as internal standards, respectively. The *cis*-cinnamoylcocaine was determined with the *trans*-cinnamoylcocaine analytical curve.

Figures of merit, such as specificity, linearity, repeatability, accuracy and working range of the method were evaluated before analysis. The control samples results were all within acceptable limits.

Classification of oxidation levels was performed applying DEA/USA criteria: samples containing less than 2% of total cinnamoylcocaines (*cis*+*trans*-cinnamoylcocaine) relative to cocaine are classified as "highly oxidized"; between 2-6% are classified as "moderately oxidized"; more than 6% are classified as "minimally or not oxidized".[22]

Qualitative analysis of major components

Some typical cocaine cutting agents were identified by retention time comparison with available reference materials and mass spectrometry analysis, using the same conditions in the two injectors and two detectors (FID and MS) Agilent Technologies 6890N gas chromatograph.

Infrared (FTIR/ATR-Nicolet iS10 model, equipped with a SMART iTR accessory) and qualitative analyses were used to differentiate the cocaine form of samples (base or hydrochloride salt).

Results and Discussion

Qualitative analysis of major components

The GC-FID analysis showed that 51% of the samples did not have any significant adulteration with typical pharmaceutical products (Figure 1). That scenario can be justified considering that the samples seized by BFP are connected with international trafficking, i.e., before the adulteration steps to improve profit in street drugs level. It is interesting to note that SP state samples showed only 20% of non-adulterated samples.

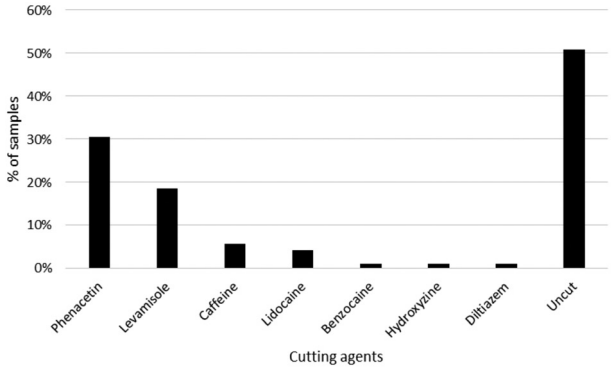


Figure 1. Presence of cutting agents in all analyzed samples.

The results show a predominance of phenacetin as the main adulterant (such as described in France by Evrard *et al.*[20]), being found in 30% of samples. Previous routine analysis of BFP used to identify phenacetin as typical adulterant found in cocaine seizures from north Brazil, but the results of this work showed that phenacetin is present as the main adulterant in all states studied. Levamisole (19%), caffeine (6%) and lidocaine (4%) were also found in a significant number of samples.

Table 2 lists the frequency of each cutting agent used to adulterate the samples *per* Brazilian state.

Figure 2 showed the same results as Figure 1, but separating the samples by region of seizure. Results of the presence of cutting agents in all set of analyzed samples are described in the Supplementary Information (Table S1).

Quantitative analysis of major components

The GC-FID quantitative analysis showed wide variations on the content of cocaine (expressed as base), covering the range of 12.0% to 93.4% purity, while the overall average content was 71.2%. Despite the geo-economics differences between the Brazilian states studied, the average levels of cocaine were similar, ranging from 64% to 74% (Figure 3). It is important to mention that the minimum purity in some states (AC, FD and SP) were above 47%, showing high cocaine levels for all samples analyzed from those sites. On the other hand, some samples from AM, RO and PR had less than 20% of cocaine.

Figure 4 shows the distribution of cocaine purity in all analyzed samples (Figure 4a) and *per* state (Figure 4b-4i). It can be seen that most samples (51.9%) had levels between 70 and 80% of cocaine. It is also observed that the samples from PR (south) showed the highest levels of cocaine, with 46% of the samples with purity of 80-90%. More detailed quantitative results in the set of samples analyzed are described in the Supplementary Information (Table S1).

Table 2. Cutting agents identified in analyzed samples

Brazilian state	Cutting agents identified[a] (number of samples)[b]							
	Uncut	Phe	Lev	Caf	Lid	Ben	Hyd	Dil
Acre (AC)	10	8	0	1	0	0	0	0
Amazonas (AM)	9	5	1	4	0	0	0	1
Rondônia (RO)	15	5	0	1	0	0	0	0
Federal District (FD)	14	9	6	2	0	0	0	0
Mato Grosso do Sul (MS)	8	6	1	0	1	0	1	0
Mato Grosso (MT)	18	9	9	0	0	0	0	0
Paraná (PR)	23	11	4	2	1	2	0	0
São Paulo (SP)	10	11	18	2	7	0	1	1
Total[c]	107	64	38	12	9	2	2	1

[a]Phe = phenacetin, Lev = levamisole, Caf = caffeine, Lid = lidocaine, Ben = benzocaine, Hyd = hydroxyzine, Dil = diltiazem; [b]One or more adulterants can be present in each powder; [c]Procaine was not detected in any sample.

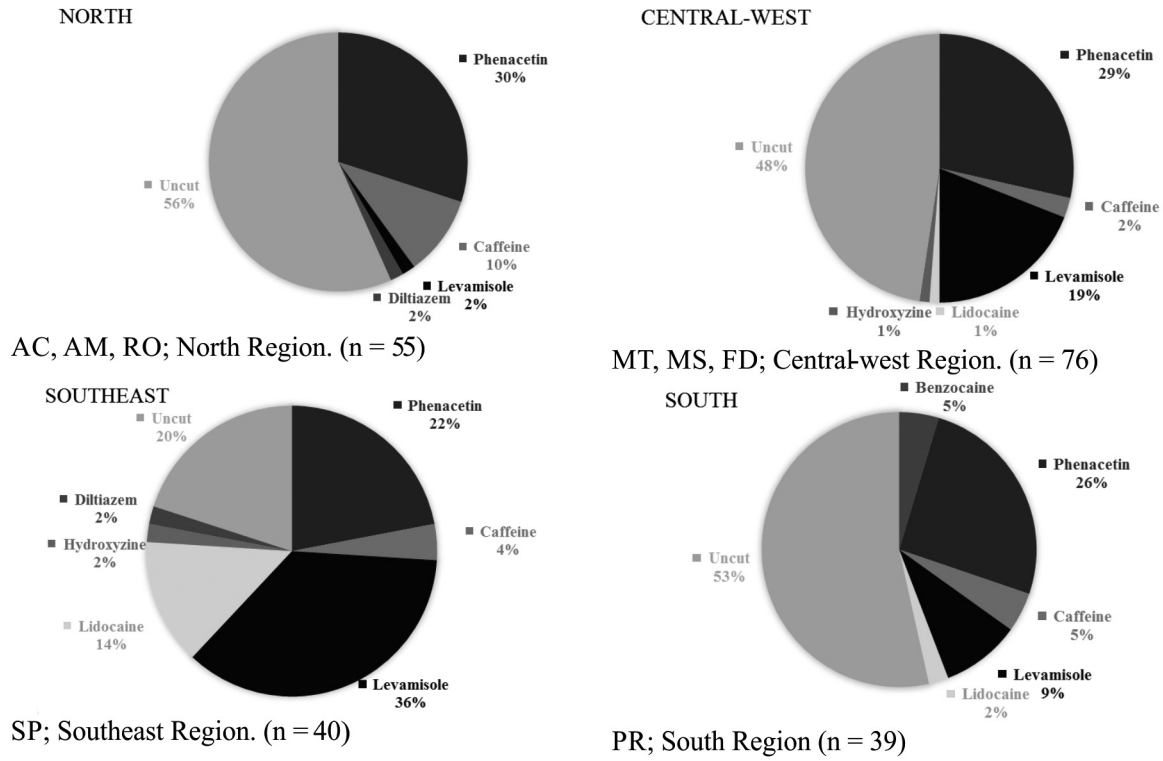


Figure 2. Presence of cutting agents in samples from different regions of Brazil.

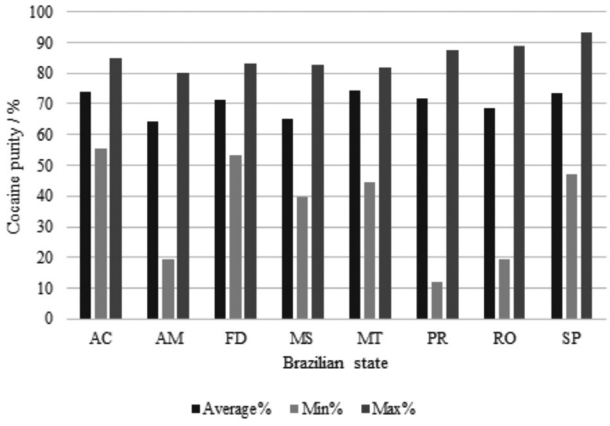


Figure 3. Cocaine purity (average, minimum and maximum), *per* state.

The ratio among *cis*+*trans*-cinnamoylcocaine and cocaine (oxidation levels) revealed that only a minority of samples (20%) underwent high oxidation, while minimally or not oxidized samples were responsible for 42% of the total (Figure 5a).[22] Figure 5b shows the scenario *per* state. Detailed results and classification are also described in the Supplementary Information (Table S1).

Most samples of free base cocaine (e.g., coca paste, coke base or *crack* cocaine)[9] suffered only moderate oxidation (21%) processes or were neither oxidized (72%) (Figure 6a). On the other hand, most cocaine hydrochloride samples undergone moderate (61%) or high (38%) oxidation (Figure 6b).

Conclusions

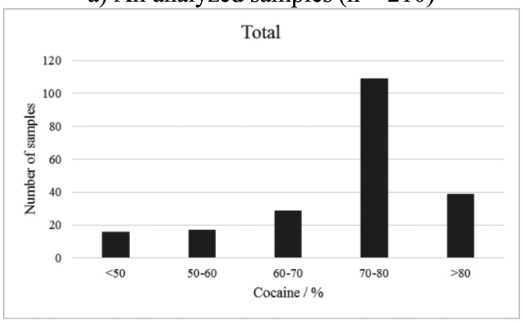
From a set of 210 samples seized by Brazilian Federal Police between 2009-2012, the chemical profiling routines of PeQui project to major components revealed that the illicit drug cocaine is mainly present in free base form (59%), with purity (expressed as base) in the range of 12 to 93% (mean 71%).

The oxidation levels, determined by the relative content between *cis*+*trans*-cinnamoylcocaine and cocaine determined in GC-FID analysis showed that most samples were composed of moderately (38%) and not oxidized (42%) cocaine. A tendency to high oxidation degree occurred mainly on cocaine hydrochloride samples.

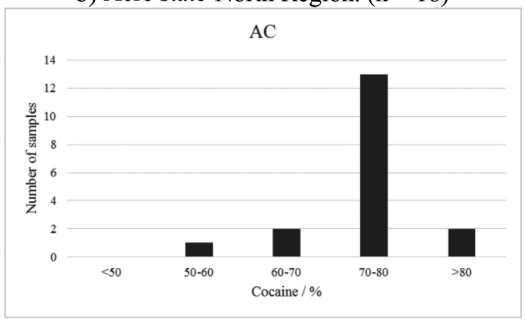
More than 50% of the samples analyzed did not have any adulterant, which is coherent with the cocaine international trafficking seizures performed by Brazilian Federal Police in a relative high purity scenario. Among the pharmaceuticals products identified as cutting agents, phenacetin was the most abundant (30% of the total samples) and was found in seizures all over the country. Levamisole (18%), caffeine (6%) and lidocaine (4%) were also identified, but with some regional bias.

The PeQui project has been used on regular basis to provide technical and scientifically based information to law enforcement intelligence analysis and statistical

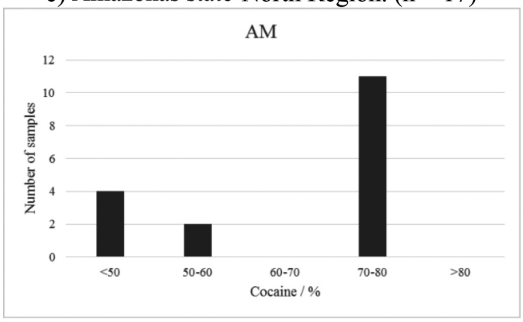
a) All analyzed samples (n = 210)



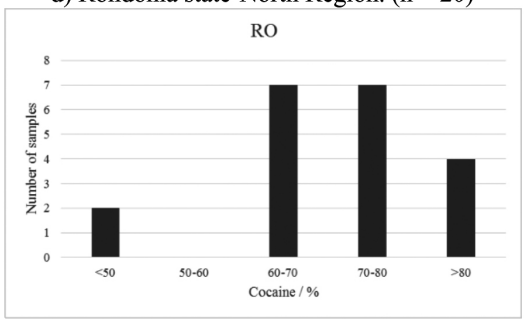
b) Acre state-North Region. (n = 18)



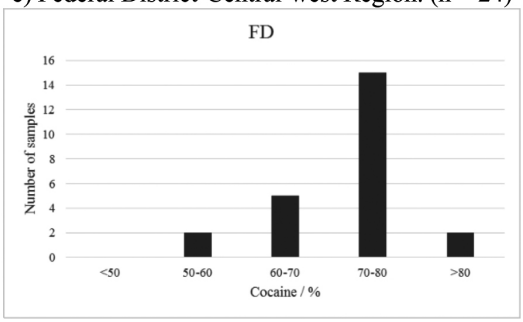
c) Amazonas state-North Region. (n = 17)



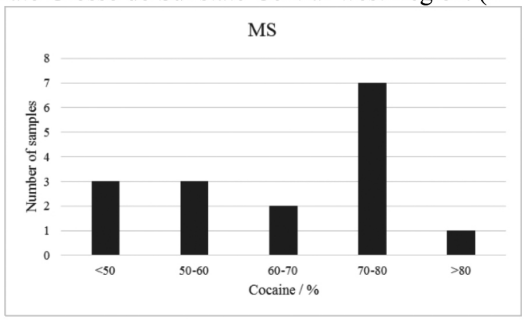
d) Rondônia state-North Region. (n = 20)



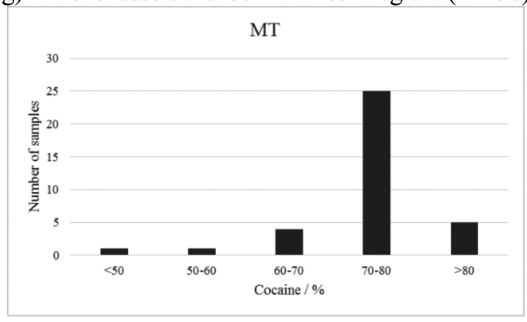
e) Federal District-Central-west Region. (n = 24)



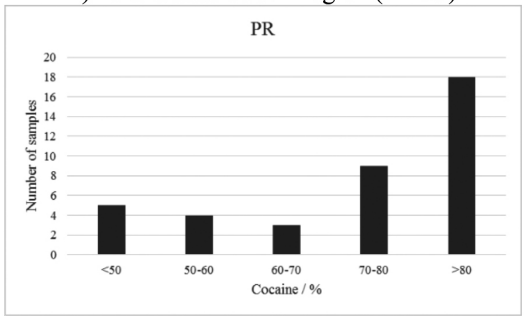
f) Mato Grosso do Sul state-Central-west Region. (n = 16)



g) Mato Grosso state-Central-west Region. (n = 36)



h) Paraná state-South Region (n = 39)



i) São Paulo state-Southeast Region. (n = 40)

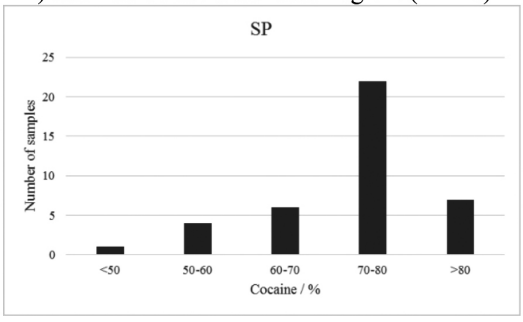


Figure 4. Distribution of cocaine purity in all analyzed samples (a) and *per* state (b-i).

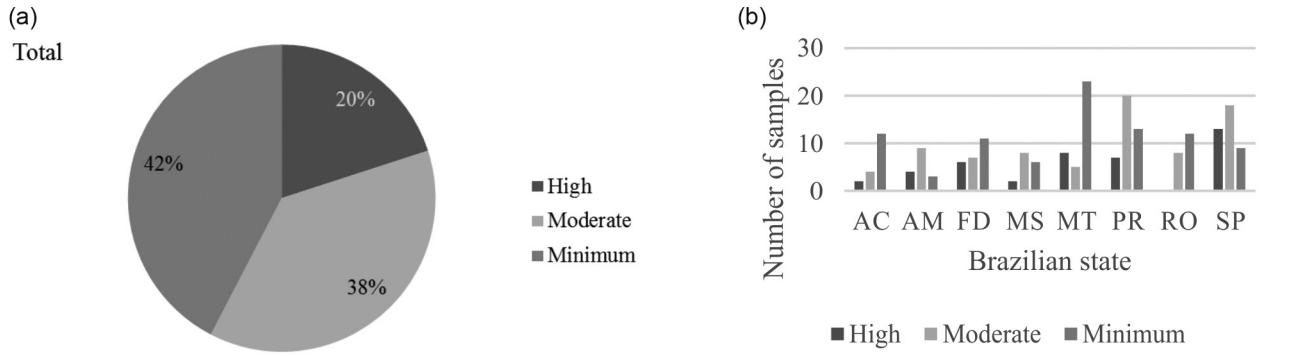


Figure 5. Oxidation levels of (a) all analyzed samples and (b) *per* state.

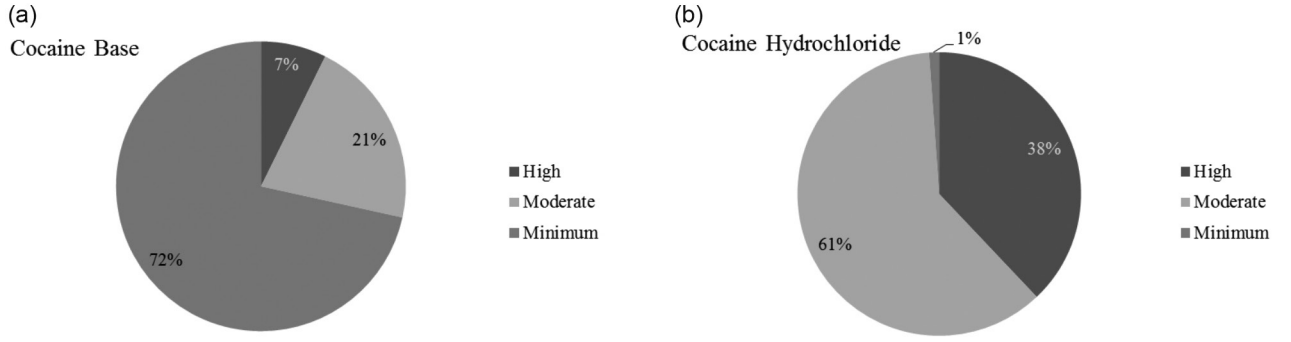


Figure 6. Oxidation levels of (a) free base cocaine (n = 123) and (b) cocaine hydrochloride (n = 87).

data that might contribute to a better understanding of the scenario of the cocaine international trafficking.

Supplementary Information

Supplementary data are available free of charge at http://jbcs.sbq.org.br as PDF file.

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Supplementary Information

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Figure S1. Brazilian territory and the localization of the studied states.

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Table S1. Brazilian state and year of apprehension. cocaine and (*cis*+*trans*)-cinnamoylcocaine levels, sample classifications based on oxidation degree, cocaine presentation form and cutting agents found

Sample	State	Cocaine / %	Total cinnamoylcocaine/ cocaine / %	Oxidation	Form	Cutting agents	Year
1	AC	82.6	13.2	Minimum	Base	Uncut	2011
2	AC	78.0	12.7	Minimum	Base	Fen	2011
3	AC	76.8	3.4	Moderate	Base	Fen	2010
4	AC	73.2	1.8	High	Base	Uncut	2010
5	AC	76.3	8.0	Minimum	Base	Uncut	2011
6	AC	76.0	11.5	Minimum	Base	Fen	2010
7	AC	71.8	6.8	Minimum	Base	Uncut	2010
8	AC	60.9	0.9	High	Base	Fen/Caf	2010
9	AC	66.6	7.6	Minimum	Base	Uncut	2011
10	AC	79.6	8.9	Minimum	Base	Uncut	2011
11	AC	73.5	9.1	Minimum	Base	Fen	2011
12	AC	85.0	7.3	Minimum	Base	Uncut	2011
13	AC	73.2	7.9	Minimum	Base	Fen	2011
14	AC	73.6	2.2	Moderate	Base	Uncut	2011
15	AC	55.6	12.3	Minimum	Base	Fen	2011
16	AC	71.0	8.3	Minimum	Base	Fen	2011
17	AC	77.4	2.5	Moderate	HCl	Uncut	2012
18	AC	76.8	2.5	Moderate	HCl	Uncut	2012
19	AM	41.1	0.8	High	Base	Fen/Caf	2010
20	AM	42.9	2.4	Moderate	Base	Fen/Caf	2010
21	AM	52.1	2.4	Moderate	Base	Uncut	2010
22	AM	19.3	0.0	High	Base	Uncut	2010
23	AM	70.2	11.9	Minimum	Base	Uncut	2010
24	AM	78.4	2.0	Moderate	HCl	Uncut	2009
25	AM	75.1	2.1	Moderate	HCl	Uncut	2009
26	AM	70.9	2.0	High	Base	Fen	2009
27	AM	77.6	1.7	High	HCl	Caf	2009
28	AM	40.8	11.9	Minimum	Base	Fen	2009
29	AM	56.9	0.5	High	HCl	Lev/Dil	2009
30	AM	71.8	5.1	Moderate	Base	Fen	2009
31	AM	79.6	2.5	Moderate	HCl	Uncut	2009
32	AM	79.4	2.2	Moderate	HCl	Caf	2009
33	AM	79.4	2.7	Moderate	HCl	Uncut	2009
34	AM	74.5	15.6	Minimum	Base	Uncut	2012
35	AM	79.9	4.9	Moderate	HCl	Uncut	2012
36	DF	76.5	0.3	High	HCl	Fen/Lev	2010
37	DF	60.0	4.4	Moderate	Base	Fen	2010
38	DF	72.0	4.7	Moderate	Base	Fen	2010
39	DF	71.3	11.5	Minimum	Base	Fen	2009
40	DF	77.6	11.6	Minimum	Base	Uncut	2009
41	DF	76.6	8.9	Minimum	Base	Fen	2010
42	DF	81.4	2.9	Moderate	HCl	Uncut	2010
43	DF	83.1	2.8	Moderate	HCl	Uncut	2010

Table S1. continuation

Sample	State	Cocaine / %	Total cinnamoylcocaine/ cocaine / %	Oxidation	Form	Cutting agents	Year
44	DF	72.3	0.3	High	HCl	Fen/Lev	2010
45	DF	75.1	0.4	High	HCl	Fen/Lev	2010
46	DF	61.8	3.0	Moderate	HCl	Fen/Caf/Lev	2010
47	DF	66.2	3.1	Moderate	HCl	Fen/Caf/Lev	2010
48	DF	79.9	2.0	High	HCl	Uncut	2009
49	DF	72.6	0.3	High	HCl	Lev	2009
50	DF	71.2	13.4	Minimum	Base	Uncut	2010
51	DF	74.0	6.6	Minimum	Base	Uncut	2010
52	DF	53.5	4.0	Moderate	Base	Uncut	2012
53	DF	70.6	14.6	Minimum	Base	Uncut	2012
54	DF	74.2	13.4	Minimum	Base	Uncut	2012
55	DF	65.3	7.3	Minimum	Base	Uncut	2012
56	DF	68.0	17.5	Minimum	Base	Uncut	2012
57	DF	67.6	16.6	Minimum	Base	Uncut	2012
58	DF	71.6	18.5	Minimum	Base	Uncut	2012
59	DF	70.3	0.0	High	HCl	Uncut	2012
60	MS	72.0	1.5	High	HCl	Hid	2009
61	MS	46.8	4.0	Moderate	Base	Uncut	2009
62	MS	78.2	2.4	Moderate	Base	Fen	2009
63	MS	74.8	6.8	Minimum	Base	Fen	2009
64	MS	76.4	2.5	Moderate	HCl	Uncut	2009
65	MS	55.7	0.9	High	Base	Uncut	2009
66	MS	59.4	2.7	Moderate	Base	Fen	2009
67	MS	82.6	10.3	Minimum	Base	Uncut	2009
68	MS	77.9	5.7	Moderate	Base	Fen	2009
69	MS	39.7	6.3	Minimum	Base	Uncut	2009
70	MS	73.6	5.9	Moderate	Base	Uncut	2009
71	MS	42.9	6.2	Minimum	HCl	Uncut	2009
72	MS	73.9	11.4	Minimum	Base	Uncut	2009
73	MS	69.2	3.3	Moderate	Base	Fen	2009
74	MS	63.8	11.3	Minimum	Base	Fen	2011
75	MS	52.9	3.0	Moderate	HCl	Lev/Lid	2011
76	MT	73.5	2.1	Moderate	HCl	Lev	2010
77	MT	75.8	7.6	Minimum	Base	Fen	2010
78	MT	71.0	9.1	Minimum	Base	Uncut	2010
79	MT	76.6	8.1	Minimum	Base	Uncut	2010
80	MT	78.1	8.7	Minimum	Base	Uncut	2009
81	MT	44.7	9.5	Minimum	Base	Fen	2010
82	MT	78.6	2.6	Moderate	Base	Uncut	2010
83	MT	69.5	13.6	Minimum	Base	Uncut	2010
84	MT	81.7	11.5	Minimum	Base	Fen	2010
85	MT	77.9	3.5	Moderate	HCl	Uncut	2010
86	MT	78.6	3.8	Moderate	HCl	Uncut	2010

Table S1. continuation

Sample	State	Cocaine / %	Total cinnamoylcocaine/ cocaine / %	Oxidation	Form	Cutting agents	Year
87	MT	52.4	8.1	Minimum	Base	Uncut	2010
88	MT	64.2	10.9	Minimum	Base	Uncut	2010
89	MT	72.9	11.4	Minimum	Base	Uncut	2010
90	MT	70.9	11.3	Minimum	Base	Uncut	2010
91	MT	66.3	7.6	Minimum	Base	Uncut	2010
92	MT	79.0	0.0	High	HCl	Lev	2012
93	MT	79.5	0.0	High	HCl	Lev	2012
94	MT	78.9	0.0	High	HCl	Lev	2012
95	MT	78.5	0.0	High	HCl	Lev	2012
96	MT	78.1	0.0	High	HCl	Lev	2012
97	MT	66.3	9.4	Minimum	Base	Fen	2012
98	MT	75.9	5.7	Moderate	Base	Fen	2012
99	MT	78.6	0.0	High	HCl	Lev	2012
100	MT	79.1	0.0	High	HCl	Lev	2012
101	MT	79.8	0.0	High	HCl	Lev	2012
102	MT	77.3	8.6	Minimum	Base	Uncut	2012
103	MT	71.7	8.5	Minimum	Base	Uncut	2012
104	MT	73.5	8.7	Minimum	Base	Uncut	2012
105	MT	74.0	8.6	Minimum	Base	Uncut	2012
106	MT	73.0	8.8	Minimum	Base	Uncut	2012
107	MT	72.8	8.8	Minimum	Base	Uncut	2012
108	MT	81.2	10.5	Minimum	Base	Fen	2012
109	MT	81.0	10.6	Minimum	Base	Fen	2012
110	MT	80.0	11.8	Minimum	Base	Fen	2012
111	MT	80.3	11.9	Minimum	Base	Fen	2012
112	PR	82.0	2.5	Moderate	HCl	Uncut	2010
113	PR	76.2	2.6	Moderate	HCl	Uncut	2010
114	PR	83.5	2.5	Moderate	HCl	Caf	2010
115	PR	85.7	3.1	Moderate	HCl	Uncut	2010
116	PR	85.0	2.6	Moderate	HCl	Uncut	2010
117	PR	68.7	1.1	High	HCl	Lev	2010
118	PR	86.4	2.6	Moderate	HCl	Uncut	2010
119	PR	86.7	2.4	Moderate	HCl	Uncut	2010
120	PR	87.5	1.4	High	HCl	Lev	2010
121	PR	87.0	2.6	Moderate	HCl	Uncut	2010
122	PR	67.6	2.2	Moderate	HCl	Uncut	2010
123	PR	12.0	0.0	High	Base	Uncut	2010
124	PR	76.7	10.2	Minimum	Base	Uncut	2010
125	PR	75.8	10.2	Minimum	Base	Uncut	2010
126	PR	82.4	7.3	Minimum	Base	Fen	2010
127	PR	85.2	4.8	Moderate	Base	Fen	2010
128	PR	42.6	3.3	Moderate	Base	Fen	2010
129	PR	46.4	3.7	Moderate	Base	Uncut	2010

Table S1. continuation

Sample	State	Cocaine / %	Total cinnamoylcocaine/ cocaine / %	Oxidation	Form	Cutting agents	Year
130	PR	50.5	7.1	Minimum	Base	Ben/Fen/Caf	2010
131	PR	81.6	8.5	Minimum	Base	Uncut	2010
132	PR	78.1	6.5	Minimum	Base	Uncut	2010
133	PR	78.3	7.6	Minimum	Base	Fen	2010
134	PR	57.5	2.6	Moderate	HCl	Lev	2010
135	PR	76.8	1.7	High	HCl	Uncut	2010
136	PR	77.6	10.9	Minimum	Base	Uncut	2010
137	PR	66.2	3.6	Moderate	HCl	Lev	2010
138	PR	34.3	2.3	Moderate	HCl	Fen	2010
139	PR	86.6	7.4	Minimum	Base	Fen	2010
140	PR	76.9	2.9	Moderate	Base	Uncut	2010
141	PR	85.2	2.9	Moderate	HCl	Uncut	2010
142	PR	80.9	2.8	Moderate	HCl	Uncut	2010
143	PR	73.2	6.4	Minimum	Base	Fen/Lid	2010
144	PR	84.3	3.0	Moderate	HCl	Uncut	2010
145	PR	84.3	2.8	Moderate	HCl	Uncut	2010
146	PR	51.0	12.3	Minimum	Base	Fen	2010
147	PR	40.8	11.0	Minimum	Base	Ben/Fen	2010
148	PR	84.1	0.3	High	HCl	Uncut	2010
149	PR	84.3	0.8	High	HCl	Uncut	2010
150	PR	55.1	12.9	Minimum	Base	Fen	2010
151	RO	75.1	7.9	Minimum	Base	Uncut	2010
152	RO	88.7	8.4	Minimum	Base	Uncut	2010
153	RO	81.6	2.9	Moderate	HCl	Uncut	2010
154	RO	76.0	7.9	Minimum	Base	Uncut	2010
155	RO	73.3	2.4	Moderate	Base	Fen/Caf	2010
156	RO	22.8	3.5	Moderate	HCl	Uncut	2010
157	RO	67.7	8.5	Minimum	Base	Uncut	2010
158	RO	64.4	11.7	Minimum	Base	Uncut	2010
159	RO	63.1	12.3	Minimum	Base	Uncut	2010
160	RO	69.5	14.1	Minimum	Base	Uncut	2010
161	RO	67.7	8.5	Minimum	Base	Fen	2010
162	RO	67.6	6.2	Minimum	Base	Uncut	2010
163	RO	76.9	11.0	Minimum	Base	Uncut	2010
164	RO	71.3	17.2	Minimum	Base	Uncut	2010
165	RO	82.4	5.8	Moderate	Base	Uncut	2010
166	RO	19.7	2.4	Moderate	HCl	Fen	2010
167	RO	65.6	2.2	Moderate	Base	Uncut	2010
168	RO	88.4	7.0	Minimum	Base	Uncut	2010
169	RO	79.3	2.8	Moderate	Base	Fen	2010
170	RO	77.0	4.3	Moderate	Base	Fen	2010
171	SP	77.0	2.7	Moderate	HCl	Uncut	2010
172	SP	85.1	1.1	High	HCl	Lev	2010

Table S1. continuation

Sample	State	Cocaine / %	Total cinnamoylcocaine/ cocaine / %	Oxidation	Form	Cutting agents	Year
173	SP	56.8	9.5	Minimum	Base	Fen/Caf/Lid	2010
174	SP	66.1	7.5	Minimum	Base	Fen/Caf	2010
175	SP	74.7	7.6	Minimum	Base	Fen	2011
176	SP	84.3	2.6	Moderate	HCl	Fen	2011
177	SP	60.0	8.8	Minimum	Base	Fen	2010
178	SP	79.3	3.2	Moderate	HCl	Fen/Lev	2010
179	SP	73.5	0.9	High	HCl	Lev/Lid	2010
180	SP	69.1	2.3	Moderate	HCl	Lev	2010
181	SP	81.7	1.7	High	HCl	Uncut	2010
182	SP	79.6	3.2	Moderate	HCl	Uncut	2010
183	SP	76.8	2.3	Moderate	HCl	Fen/Lev	2010
184	SP	71.7	10.6	Minimum	Base	Uncut	2010
185	SP	73.9	2.1	Moderate	HCl	Lev/Lid	2010
186	SP	77.2	3.0	Moderate	HCl	Fen/Lev	2010
187	SP	57.0	8.8	Minimum	Base	Fen	2010
188	SP	58.2	2.2	Moderate	HCl	Lid	2010
189	SP	69.5	1.5	High	Base	Uncut	2010
190	SP	69.7	8.8	Minimum	Base	Fen	2010
191	SP	71.9	2.9	Moderate	Base	Uncut	2010
192	SP	77.9	2.2	Moderate	HCl	Uncut	2010
193	SP	77.1	2.4	Moderate	HCl	Uncut	2010
194	SP	86.8	2.1	Moderate	HCl	Lid/Hid	2010
195	SP	71.5	0.0	High	HCl	Lev	2011
196	SP	82.2	4.2	Moderate	HCl	Lid	2011
197	SP	93.4	1.1	High	Base	Lid	2011
198	SP	77.1	0.0	High	HCl	Lev	2011
199	SP	70.5	0.0	High	HCl	Lev	2011
200	SP	68.3	0.0	High	HCl	Lev	2011
201	SP	47.1	9.2	Minimum	Base	Uncut	2011
202	SP	76.9	2.8	Moderate	HCl	Lev	2011
203	SP	72.4	1.3	High	HCl	Lev	2011
204	SP	75.5	2.3	Moderate	HCl	Uncut	2011
205	SP	77.4	1.7	High	HCl	Lev	2011
206	SP	79.3	0.0	High	HCl	Lev	2011
207	SP	71.4	0.0	High	HCl	Lev	2011
208	SP	64.3	9.4	Minimum	Base	Lid	2011
209	SP	70.4	4.1	Moderate	HCl	Lev	2011
210	SP	80.4	2.9	Moderate	HCl	Lev	2011