Research, Society and Development, v. 10, n. 15, e430101523113, 2021
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v10i15.23113

Chemical characterization of an Ipecac active germplasm bank – a Brazilian endangered medicinal species

Caracterização química de banco ativo de germoplasma de ipeca - uma espécie medicinal brasileira ameaçada de extinção

Caracterización química de un banco de germoplasma activo de ipecacuana - una especie medicinal brasileña en peligro de extinción

Received: 11/10/2021 | Reviewed: 11/16/2021 | Accept: 11/18/2021| Published: 11/29/2021

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Abstract
The active germplasm bank (AGB) of *Carapichea ipecacuanha* (Brot.) L. Andersson at Embrapa Eastern Amazon, in the city of Belém, PA, was the first of its kind to be opened in Brazil for this endangered medicinal species and holds important accessions for agricultural and reproductive research, including the production of active principles. This study aimed to chemically characterize 42 accessions from that AGB by simultaneously quantifying cephaeline and emetine contents in roots using high-performance liquid chromatography with a diode-array detector (HPLC-DAD). Cephaeline concentrations ranged from 'undetected' to 1.76%, whereas emetine concentrations were found between 0.64% and 2.49%. The overall emetine/cephaeline ratio varied from 0.43 to 3.52. The differences among mean concentrations of alkaloids observed by comparing the Scott-Knott test at 5% probability suggest the chemical variation among the samples assessed. Therefore, it is concluded such chemical differences may favor the selection of genetic material for commercial purposes based on the production of emetine and/or cephaeline, likewise may contribute to breeding programs.
Keywords: Emetine; Cephaeline; Liquid chromatography; Poaia.

Resumo
O banco ativo de germoplasma (BAG) de *Carapichea ipecacuanha* (Brot.) L. Andersson da Embrapa Amazônia Oriental, na cidade de Belém, PA, foi o primeiro do tipo a ser instalado no Brasil para essa espécie medicinal ameaçada de extinção e detém importantes acessos à pesquisa agrícola e reprodutiva, incluindo a produção de princípios ativos. Este estudo teve como objetivo caracterizar quimicamente 42 acessos desse BAG quantificando simultaneamente os teores de cefalina e emetina em raízes por meio de cromatografia líquida de alta eficiência com detector de arranjo de diodos (HPLC-DAD). As concentrações de cefalina variaram de 'não detectado' a 1,76%, enquanto as concentrações de emetina foram encontradas entre 0,64% e 2,49%. A relação emetina/cefalina variou de 0,43 a 3,52. As diferenças entre as concentrações médias de alcaloides observadas pela comparação com o teste de Scott-Knott a 5% de probabilidade sugerem variação química entre as amostras avaliadas. Portanto, conclui-se que tais diferenças químicas podem favorecer a seleção de material genético para fins comerciais a partir da produção de emetina e/ou cefalina, da mesma forma que podem auxiliar programas de melhoramento.
Palavras-chave: Emetina; Cefalina; Cromatografia líquida; Poaia.

Resumen
El banco de germoplasma activo (BGA) de *Carapichea ipecacuanha* (Brot.) L. Andersson de Embrapa Amazônia Oriental, en la ciudad de Belém, PA, fue el primero de su tipo en instalarse en Brasil para esta especie medicinal en peligro de extinción y cuenta con importantes accesos a la investigación agrícola y reproductiva, incluida la producción de principios activos. El objetivo de este estudio fue caracterizar químicamente 42 accesiones de esta BAG, cuantificando simultáneamente el contenido de cefalina y emetina en raíces mediante cromatografía líquida de alta resolución con detector diodo array (HPLC-DAD). Las concentraciones de cefalina variaron de "no detectado" a 1,76%, mientras que las concentraciones de emetina se encontraron entre 0,64% y 2,49%. La relación emetina/cefalina osciló entre 0,43 y 3,52. Las diferencias entre las concentraciones medias de alcaloides observadas al comparar la prueba de Scott-Knott al 5% de probabilidad sugieren una variación química entre las muestras evaluadas. Por tanto, se concluye que tales diferencias químicas pueden favorecer la selección de material genético con fines comerciales a partir de la producción de emetina y/o cefalina, de la misma forma que pueden ayudar a los programas de mejoramiento.
Palabras clave: Emetina; Cefalina; Cromatografía líquida; Poaia.

1. Introduction

Carapichea ipecacuanha (Brot.) L. Andersson (Rubiaceae) is an endangered species with high medicinal and economic value commonly known in Brazil as Poaia or in English as Ipecac. It is a distylous subshrub occurring exclusively in the understory of dense forests in countries of South America such as Brazil, Colombia, and Ecuador, spreading into Central America until Nicaragua. In Brazil, it is found mainly in the states of Rondônia, Bahia, Pernambuco, Goiás, Mato Grosso, Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo (Silva, et al., 2019; Bruniera, 2020).

The commercial potential of *C. ipecacuanha* is based on its amebicidal, emetic, and expectorant properties mainly due to the presence of isoquinoline alkaloids cephaeline and emetine. The concentration of those active principles in Brazilian ipecac has made the country one of the major exporters of the product worldwide. However, although the commercial exploration of the species began as early as the 18th century, little has been done in terms of its cultivation in the country (Silva, et al., 2019; Silva, et al., 2020).

According to Silva et al. (2019), *C. ipecacuanha* is a species vulnerable to extinction due to the effects of predatory exploitation, allied with fragmentation and deforestation of its natural habitat, as well as its required cross-pollination, which makes subpopulations rarer.

In face of that, both production and exportation in Brazil have considerably decreased over the years. In the 1960s, the country exported up to 80 tons of dry *C. ipecacuanha* roots, particularly to Europe. However, between the 1980s and 1990s, exports did not go beyond 7.5 t.year^{-1}. This production is currently at 1 ton of roots per year, with an estimated value of BRL 118 thousand, and is confined to the state of Mato Grosso (Skorupa & Assis, 1998; IBGE, 2018).

Between 1988 and 1991, Skorupa and Assis (1998) carried out expeditions in ten Brazilian states to collect *C. ipecacuanha* genetic material to create an active germplasm bank (AGB). In total, 86 germplasm samples were collected and the first AGB was opened at the headquarters of Embrapa Eastern Amazon in the city of Belém, PA (Mondal & Moktan, 2020). That collection of living material allows preserving genetic variability and chemical diversity, supporting agricultural and reproductive researches, including the assessment of the potential of those germplasms in the production of active principles. Today, it is an action recommended by the 2030 Agenda (PNUD, 2015).

The present study aimed to chemically characterize 42 accessions from the *C. ipecacuanha* AGB at Embrapa Eastern Amazon by simultaneously quantifying cephaeline and emetine contents in their roots.

2. Methodology

Plant material

The experiment was conducted in a field trial with sampled plants in the Medicinal Plant Garden of Embrapa Eastern Amazon in Belém, PA, located at 1°27’21” S and 48°30’4” W at an altitude around 10 m and mean annual temperature of 30 °C.

The states of origin of the 42 accessions were Mato Grosso (MT), Rondônia (RO), Rio de Janeiro (RJ), Minas Gerais (MG) and Bahia (BA). The plants are grown in beds containing cured corral manure with 70% shade. Root samples of these 42 accessions from the *C. ipecacuanha* AGB 24 months old were collected in July 2019. The voucher specimen was deposited at IAN Herbarium of Embrapa Eastern Amazon under registration no. 194095.

Chemicals and solvents

Ultrapure water from a Millipore Milli-Q® Direct purification system was used throughout the experiment. Ammonium hydroxide and ethyl ether used in the extraction step were purchased from Neon (SP, Brazil) and Dinâmica (SP, Brazil), respectively. Acetonitrile (HPLC grade) was supplied by J.T.Baker (NJ, USA); sodium acetate, by Sigma-Aldrich (Merck, HE, Germany); and glacial acetic acid, by Dinâmica (SP, Brazil). The analytical standards of emetine hydrochloride and cephaeline hydrochloride were obtained from European Pharmacopoeia Reference Standard (Merck, HE, Germany).

Alkaloid extraction

The root samples were washed in running water, dried in an oven with forced air circulation (Model 315-SE Fanem, SP, Brazil) at 50 °C for 48 h, and ground in an electric mill (Model A11 BS32 IKA, BW, Germany). The water content was performed according to Brazilian Pharmacopeia (ANVISA, 2019) to calculate the alkaloid content on a dry basis.

Alkaloids were extracted (triplicate) and quantified based on adapted methodology from Garcia et al. (2005) and Silva (2014). Three 100 mg sub-samples were placed in 15 mL conical tubes with lids, added with 2 mL 0.1 mol.L^{-1} NH_4OH, and stirred in a vortex mixer (Model 771 Fisatom, SP, Brazil) for 1 min. Next, the samples underwent extraction with 10 mL ethyl ether under agitation for 5 min at room temperature. The mixtures were centrifuged at approximately 1902xg for 5 min (Model Excelsa Baby II 206-R Fanem, SP, Brazil) at room temperature. Next, the organic phase was transferred and evaporated until fully dry in a water bath at 45 °C (Model Q218-1 Quimis, SP, Brazil). The residue obtained was redissolved in 10 mL acetonitrile and filtered in a 0.22 µm Millex®-GV membrane (Merck Millipore, HE, Germany).

Separation, identification, and quantification of alkaloids

Cephaeline and emetine were simultaneously quantified in the extracts using a Finnigan Surveyor (Thermo Fisher Scientific, MA, USA) liquid chromatograph with a diode-array detector (HPLC-DAD) equipped with an autosampler. The chromatographic separation was carried out in a LiChroCART® 250-4,6 Purospher® STAR RP-18E (5 µm) column and LiChroCART® Purospher® STAR RP-18E pre-column (Merck, HE, Germany). The mobile phase was composed of (A) 0.25 mol.L^{-1} sodium acetate (pH = 5) and (B) acetonitrile, which were filtered through 0.45 µm Sartolon Polyamid membrane (Sartorius Biotech, NI, Germany). The following solvent gradient system was used: B 10% from 0 to 2 min, B 10-60% from 2 to 8 min, B 60% from 8 to 14 min, B 60-10% from 14 to 20 min, and 10% B maintained for 0.1 min. The flow rate was 0.8 mL.min^{-1} and the column was maintained at room temperature (21 ± 2 °C). The automated sampler was maintained at 10 °C and the sample injection volume was 10 µL. Acquisition of the UV-Visible spectra was performed in the 200-600 nm range and the wavelength of 280 nm was selected to obtain the chromatograms with higher peak intensity. The software Xcalibur™ 2.0 (Thermo Fisher Scientific, MA, USA) was employed in data handling.

Partial validation of the chromatographic method was obtained by determination of parameters selectivity, linearity, repeatability, and intermediate precision according to Resolution no. 166 (ANVISA, 2017a). The softwaresExcel™ 2010 (Microsoft, WA, USA) and Minitab® 19 (Minitab Statistical Software, PA, USA) were used for the calculations.

Data Analysis

Initially, the results of cephaeline and emetine quantification were submitted to the Shapiro-Wilk test to verify data normality. One-way ANOVA was used to verify differences among the datasets, with Bartlett's test applied to assess homoscedasticity. Next, the Scott-Knott test was employed to identify where the differences among the data analyzed were. The descriptive level (p-value) adopted in all tests was $p \leq 0.05$. The analyses were carried out using the software Excel™ 2010, Minitab® 19, and R version 4.1.2.

Ethics and legal aspects

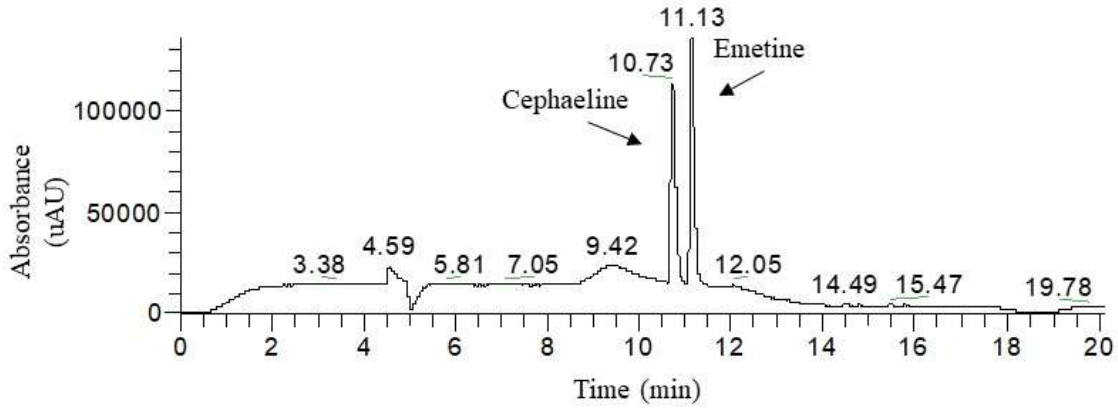
The present study was performed according to the Brazilian Ministry of Environmental rules, considering biodiversity rights. The registration number SisGen is A2C1D3D (October 12, 2018).

3. Results and Discussion

Validation parameters

Aiming at showing the chromatographic method adopted is appropriate to identify and quantify cephaeline and emetine in root *C. ipecacuanha* samples, experiments were carried out to determine validation parameters. Initially, the selectivity of the method was assessed by comparing the retention times (RT) observed for the analytical standards with those observed for the sample. Figure 1 presents a chromatogram with RT values observed for cephaeline (10.73 min) and emetine (11.13 min) standards. Figure 2 illustrates a typical chromatogram from *C. ipecacuanha* root extract while indicating the RT of chemical markers cephaeline (10.88 min) and emetine (11.28 min). Both chromatograms show satisfactory separation efficiency between alkaloid peaks under the chromatograms conditions established.

Figure 1. Chromatogram of the cephaeline (RT = 10.73 min) and emetine (RT = 11.13 min) standards. Column: LiChroCART® 250-4,6 Purospher® STAR RP-18E. Column temperature: 21 ± 2 °C. Mobile phase: (A) 0.25 mol.L^{-1} acetate buffer (pH = 5) and (B) acetonitrile. Gradient elution. Flow rate: 0.8 mL.min^{-1}. Sample injection volume: 10 µL. Analysis time: 20 min. Detection: 280 nm.

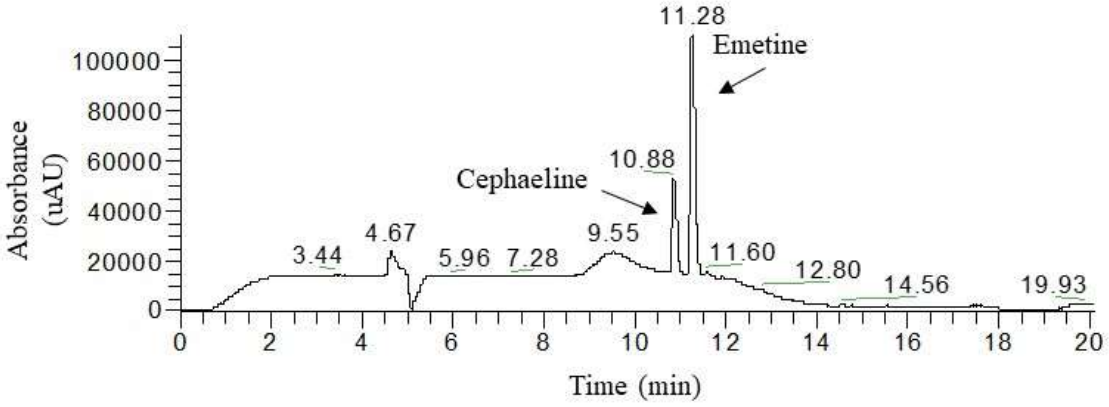


Source: Authors.

The purity of the chromatographic peaks was determined after scanning the standard and the sample using a diode-array detector, in which the spectrum of the peak obtained in the separation was compared to the spectrum of the high purity standard, and this result indicated the presence of the pure compound in the sample. Additionally, the purity of three points of the

chromatographic peak attributed to emetine was evaluated, as well as cephaeline, comparing the UV spectra obtained at the beginning and the end of the elution. These results corroborated the selectivity of the method because suggested there was no co-elution of the other matrix compounds, under the conditions established. The UV spectra exhibited three absorption bands at 220 ± 3 nm, 239 ± 2 nm, and 282 ± 1 nm.

Figure 2. Typical chromatogram of *Carapichea ipecacuanha* root extract. Column: LiChroCART® 250-4,6 Purospher® STAR RP-18E. Column temperature: 21 ± 2 °C. Mobile phase: (A) 0.25 mol.L^{-1} acetate buffer (pH = 5) and (B) acetonitrile. Gradient elution. Flow rate: 0.8 mL.min^{-1}. Sample injection volume: 10 µL. Analysis time: 20 min. Detection: 280 nm.



Fonte: Autores.

The linearity of the method was assessed by the calibration curves of emetine and cephaeline standards. The intercept, slope, and standard errors were calculated. The residuals from both ordinary least squares regression analyses were firstly evaluated (α = 0.05): they showed no outliers by Grubbs's test; presented normal distribution by Ryan-Joyner test; exhibited homogeneity of variances by Levene's test; and they were not autocorrelated by Durbin-Watson test. Next, hypothesis tests were performed to inspect the regression coefficients in the simple linear regression models.

The slope of the cephaeline curve was significant, as well as that of emetine by Student's t-test. Both coefficients of determination were suitable. The analysis of variance (ANOVA) lack of fit F-test was performed and showed that F-value was lower than the tabulated F ($F_{crit,95\%}$ = 8.79), and therefore, the linear regression presented no lack of fit at the purposed linear range for both cephaeline and emetine according to Guide no. 10 (ANVISA, 2017b). All of these results are summarized in Table 1.

Table 1. Calibration curves to determine cephaeline and emetine by high-performance liquid chromatography. Y = area of the peak. X = analyte concentration (mg.mL^{-1}). R^2 = coefficient of determination. $t_{calculated}$ = t-value of Student's t-test (α = 0.05). $F_{calculated}$ = F-value of ANOVA lack of fit F-test (α = 0.05).

Alkaloid	Linear range (mg.mL^{-1})	Calibration curve	R^2	$t_{calculated}$	$F_{calculated}$
Cephaeline	0.046 – 0.232	Y = 3088062.X - 53776	0.9997	175.59	1.55
Emetine	0.043 – 0.216	Y = 3953591.X - 25639	0.9991	106.98	3.12

Source: Authors.

The results obtained in the repeatability assays based on six replicates, expressed by the estimate of the relative standard deviation (RSD), were 1.92% for cephaeline and 3.81% for emetine, indicating the method presents a good precision in terms of

repeatability. Intermediate precision was assessed based on the results generated by different analysts on distinct dates. The results, expressed by the estimated RSD, were 4.55% for cephaeline and 5.05% for emetine, which shows the method yields acceptable precision (ANVISA, 2017a).

Alkaloids contents

The equations of the analytical curves were used to quantify alkaloids in the 42 *C. ipecacuanha* root samples. The results, calculated on a dry basis, showed normal data distribution and equivalence of covariances by the Shapiro-Wilk test and Bartlett's test, respectively. The presence of outliers in the datasets was assessed using Grubbs's test, which showed that random variability is inherent to the data. According to Table 2, there is a statistically significant difference between groups as demonstrated by one-way ANOVA ($p \leq 0.05$). A Scott-Knott test is denoted with letters in Table 3.

Table 2. Results of analysis of variance (one-way ANOVA) for cephaeline and emetine.

		Cephaeline				Emetine			
Source	DF	SS	MS	F	p	SS	MS	F	p
Treatment	41	17.9142	0.43693	243.32	2.2971e-72	28.9860	0.70698	306.36	1.6016e-76
Error	84	0.1508	0.00180			0.1938	0.00231		
Total	125	18.0651							

Source: Authors.

Table 3 presents the results as descriptive statistics as means ± standard deviation. For cephaeline, the contents range from 'undetected' (sample 38) to 1.76% (sample 4). For emetine, concentrations from 0.64% (sample 11) to 2.49% (sample 33) were found. The mean emetine concentrations found in samples 6 and 33 were the highest among the samples. Sample 33 also had the highest emetine/cephaeline ratio (E/C) among the samples, along with sample 36. The E/C ratio ranged from 0.43 to 3.54 in the samples studied.

The main indication of these alkaloids is to induce vomiting, after the ingestion of toxic compounds or after an overdose drug (Fujii & Ohba, 1998), especially cephaeline, although it is more toxic and irritating than emetine (Patel & Patel, 2021). In the opinion of Garcia et al. (2005), the biosynthesis, accumulation, and the ratio between emetine and cephaeline may be under the control of genetic components that reflect the geographic origin of the plant material.

Table 3. Cephaeline and emetine determined on a dry basis by high-performance liquid chromatography in *Carapichea ipecacuanha* accessions from the active germplasm bank of Embrapa Eastern Amazon, Belém, PA, Brazil. State of origin of the samples: Mato Grosso (MT), Rondônia (RO), Rio de Janeiro (RJ), Minas Gerais (MG), and Bahia (BA). Values are the mean ± standard deviation. ND = not detected. The same letter in the columns does not differ statistically according to the Scott-Knott test at 5% probability.

Sample	Accession code	Brazilian code/origin (city/state)	Cephaeline (%) Mean ± SD	Emetine (%) Mean ± SD	Emetine/ Cephaeline
1	577	BRA-000078/Barra do Bugres, MT	0.97 ± 0.02 h	1.71 ± 0.02 g	1.76
2	602	BRA-000141/Pontes e Lacerda, MT	1.60 ± 0.05 b	2.15 ± 0.02 c	1.34
3	607	BRA-000159/Vila Bela da Santíssima Trindade, MT	1.35 ± 0.05 d	2.01 ± 0.05 d	1.49
4	610	BRA-000167/Costa Marques, RO	1.76 ± 0.08 a	1.67 ± 0.07 g	0.95
5	689	BRA-000183/Barra do Bugres, MT	1.49 ± 0.02 c	0.89 ± 0.01 m	0.60
6	690	BRA-000191/Barra do Bugres, MT	1.39 ± 0.03 d	2.37 ± 0.03 b	1.71
7	695	BRA-000221/Barra do Bugres, MT	1.46 ± 0.02 c	1.78 ± 0.04 f	1.22
8	696	BRA-000230/Barra do Bugres, MT	1.59 ± 0.02 b	2.05 ± 0.03 d	1.29
9	700	BRA-000248/Tangará da Serra, MT	1.54 ± 0.06 b	1.29 ± 0.07 j	0.84
10	701	BRA-000256/Tangará da Serra, MT	1.73 ± 0.07 a	0.85 ± 0.06 m	0.49
11	702	BRA-000264/Tangará da Serra, MT	1.50 ± 0.03 c	0.64 ± 0.03 o	0.43
12	707	BRA-000272/Salto do Céu, MT	0.83 ± 0.01 i	1.04 ± 0.02 l	1.25
13	708	BRA-000281/Salto do Céu, MT	0.68 ± 0.01 j	2.00 ± 0.01 d	2.94
14	712	BRA-000299/Rio Branco, MT	1.37 ± 0.04 d	1.34 ± 0.03 j	0.98
15	714	BRA-000302/Rio Branco, MT	1.39 ± 0.02 d	0.67 ± 0.01 o	0.48
16	745	BRA-000329/Porciúncula, RJ	0.86 ± 0.01 i	1.58 ± 0.01 h	1.84
17	746	BRA-000337/Porciúncula, RJ	1.15 ± 0.05 f	1.29 ± 0.03 j	1.12
18	753	BRA-000361/Caratinga, MG	1.09 ± 0.08 g	1.66 ± 0.05 g	1.52
19	767	BRA-000426/Ibicaraí, BA	0.85 ± 0.03 i	1.73 ± 0.02 g	2.04
20	775	BRA-000442/Rolim de Moura, RO	1.57 ± 0.07 b	1.47 ± 0.06 i	0.94
21	776	BRA-000451/Rolim de Moura, RO	0.98 ± 0.05 h	0.76 ± 0.04 n	0.78
22	777	BRA-000469/Rolim de Moura, RO	1.27 ± 0.02 e	1.54 ± 0.04 h	1.21
23	801	BRA-000523/Rolim de Moura, RO	1.48 ± 0.02 c	1.43 ± 0.02 i	0.97
24	802	BRA-000531/Rolim de Moura, RO	0.89 ± 0.01 i	1.91 ± 0.06 e	2.15
25	803	BRA-000540/Rolim de Moura, RO	0.96 ± 0.03 h	2.21 ± 0.05 c	2.30
26	806	BRA-000574/Rolim de Moura, RO	0.82 ± 0.03 i	1.07 ± 0.06 l	1.30
27	808	BRA-000591/Rolim de Moura, RO	1.09 ± 0.06 g	1.72 ± 0.06 g	1.58
28	811	BRA-000621/Rolim de Moura, RO	0.58 ± 0.01 k	1.17 ± 0.05 k	2.02
29	814	BRA-000655/Rolim de Moura, RO	0.79 ± 0.03 i	1.58 ± 0.05 h	2.00
30	815	BRA-000663/Rolim de Moura, RO	1.36 ± 0.07 d	1.29 ± 0.06 j	0.95
31	819	BRA-000680/Cacoal, RO	0.87 ± 0.04 i	1.97 ± 0.05 d	2.26
32	826	BRA-000701/Costa Marques, RO	1.05 ± 0.03 g	1.83 ± 0.04 f	1.74
33	827	BRA-000710/Costa Marques, RO	0.71 ± 0.03 j	2.49 ± 0.04 a	3.51
34	828	BRA-000728/Costa Marques, RO	1.04 ± 0.05 g	1.70 ± 0.08 g	1.63
35	829	BRA-000736/Costa Marques, RO	0.87 ± 0.04 i	1.69 ± 0.05 g	1.94
36	833	BRA-000744/Costa Marques, RO	0.62 ± 0.03 k	2.18 ± 0.10 c	3.52
37	834	BRA-000752/Costa Marques, RO	0.38 ± 0.01 l	0.69 ± 0.02 o	1.82
38	836	BRA-000761/Costa Marques, RO	ND m	1.80 ± 0.05 f	-
39	837	BRA-000779/Costa Marques, RO	1.19 ± 0.06 f	0.82 ± 0.04 m	0.69
40	838	BRA-000787/Costa Marques, RO	1.15 ± 0.07 f	1.45 ± 0.04 i	1.26
41	839	BRA-000795/Costa Marques, RO	0.82 ± 0.02 i	1.32 ± 0.09 j	1.61
42	845	BRA-000825/Cerejeira, RO	0.99 ± 0.07 h	2.00 ± 0.05 d	2.02

Source: Authors.

The differences between mean concentrations of the alkaloids indicated chemical variation among the samples studied. That allows selecting material for commercial purposes based on emetine and/or cephaeline production.

According to Skorupa and Assis (1998), Brazilian samples of *C. ipecacuanha* exhibited values between 0.6% and 0.7% for cephaeline and from 1.5% to 1.7% for emetine. Han et al. (2013) also found contents between 0.70% and 0.74% for cephaeline and between 1.47% and 1.68% for emetine in samples from Brazil. That shows the amplitude of the variation in alkaloid concentration, as well as the mean contents found in the samples from the Embrapa AGB, are higher.

Several authors have investigated alkaloid production in *C. ipecacuanha* roots by assessing genetic diversity, plant age, and/or environmental factors such as fertilization conditions, luminosity, season, etc. Moreover, the emetine and/or cephaeline concentrations observed for some samples from the AGB were higher than all those reported in previous studies, considering the cultivation conditions defined (Costa, et al., 2000; Garcia, et al., 2005; Silva, 2014; Duarte, 2016; Rosales-López, et al., 2020).

At this moment when the development of bioproducts from Brazilian plants has been stimulated (Palhares, et al., 2021), quantifying the active principles of *C. ipecacuanha* allowed knowing the quality and potential of the AGB, which may favor introducing the species as a viable crop alternative based on the selection of genetic material targeting the production of emetine and/or cephaeline.

4. Conclusion

The *Carapichea ipecacuanha* active germplasm bank of Embrapa Eastern Amazon maintains the genetic diversity of a species in danger of extinction with adequate management.

It was found that both the amplitude of variation in concentrations of cephaeline and emetine, as well as the mean concentrations of those alkaloids are higher than values reported in the literature. It is concluded, therefore, that the information on the quality and potential of the AGB may enable selecting genetic material for commercial purposes based on the production of the main active principles, likewise may contribute to breeding programs.

For future research, our group intends to work on *in vitro* conservation involving all accessions, as well as the indication of the three accessions with the highest alkaloid contents for cultivation and production systems.

Acknowledgments

This research was funded by the Brazilian Agricultural Research Corporation (EMBRAPA): grant number 11.15.02.002.08.05.013. The authors thank the technical staff of the Botany Laboratory of Embrapa Eastern Amazon for their contribution in confirming the identity of the species.

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