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Material review

Searching for the Real Ravensara (*Ravensara aromatica Sonn.*) Essential Oil

A case study for "NATIORA" — the Malagasy natural product label

Hector Juliani, Olivier Behra, Hisham Moharram, Lalasoa Ranarivelo, Béatrice Ralijerson, Marta Andriantsiferana, Noel Ranjatoson, Jean Rasoarahona, Panja Ramanoelina, Mingfu Wang and James Simon

Madagascar is endowed with a very rich and diverse indigenous aromatic flora that has great economic value. Some essential oils extracted from these indigenous and also from introduced plants, such as ylang-ylang and other oils, have been sold in the international market for many years.[1,2]

The essential oil of ravintsara is obtained from the leaves of a tree (*Cinnamomum camphora* (L.) J. Presl), which was introduced from Taiwan as an ornamental tree and now grows widely in Madagascar, with increased demand from the international market. This essential oil has often been misreported and traded as ravensara, or *Ravensara aromatica*.[3-7] The true ravensara (*R. aromatica*) essential oil is extracted from the leaves of an endemic species locally known as "havozo," or "hazomanitra," which means "aromatic tree" in the Malagasy language.[2,8] This species was also described under the botanical names of *R. anisata* Danguy[9] and *Agathophyllum aromaticum* Willd.[2,10] However, *R. aromatica* Sonn. is the correct botanical name and has precedence over these synonyms.[11-13]

The taxonomical confusion, translation similarities of the common names and the lack of regional, national and international quality standards continue to allow the misidentification of these oils in the marketplace.[2,8]

This study was a collaborative effort between the Agribusiness in Sustainable Natural African Plant Products (ASNAPP) program at Rutgers University, Landscape Development Interventions (LDI) and PRONABIO (Association of Malagasy Exporters of Natural Products) that reviewed and evaluated commercial and research samples of ravensara (*R. aromatica*) and ravintsara (*C. camphora*) as part of a joint program in developing grades and standards for "NATIORA," a new natural plant products label of Madagascar to ensure export product quality, consistency and traceability.

Experimental

Essential oil samples: Malagasy companies (Conservation Biodiversity and Development and Exhev) provided selected and botanically authenticated essential oil samples of ravensara (*R. aromatica*) and ravintsara (*C. camphora*). Commercial *R. aromatica* samples were obtained from the US marketplace from two different companies (Company I and II) and a sample of *R. anisata* was obtained from a Malagasy company. The physicochemical properties were assessed for each sample using methods described by the Food Chemical Codex (1996) (relative density, 25°C/25°C; refractive index, 20°C) and the aroma profile was evaluated by our internal taste panel.[14,15]

GC/MS: The volatile oils were analyzed by a gas chromatograph (GC) coupled to a mass spectrometer (MS) and FID detectors (Agilent GC System 6890 Series, Mass Selective Detector, Agilent 5973 Network, FID detector). Samples were injected with an autosampler (Agilent 7683 Series), the inlet temperature was 220°C, in an HP5-MS (30 m x 0.25 mm, 0.25 µm film thickness) column, temperature program, 60°C/min, 4°C/min, 200°C for 15 min. Helium constant flow was set at 1 mL/min. Individual identifications were made by matching their spectra with those from mass spectral libraries (Wiley 275.L) and the identity

Organoleptic and physicochemical properties of ravintsara (*C. camphora*), ravensara (*R. aromatica*) and havozo (*R. anisata*) essential oils **T-1**

Commercial name[1]	Ravintsara essential oil	Ravensare aromatique essential oil[3]	*Ravensara aromatica* essential oil	Ravensare essential oil	Havozo
Species[1]	*Cinnamoum camphora*	*Ravensara aromatica*	*Ravensara aromatica*	*Ravensare aromaticum*	*Ravensara anisata*
Origin[2]	Madagascar (Exhev)	Madagascar (CBD3)	Madagascar (US Co. I)	Madagascar (US Co. II)	Madagascar (Malagasy Co.)
Organoleptic evaluation					
Aroma	Fresh, cineole type, low spicy note	Spicy, liquorish	Fresh, cineole type, low spicy note	Fresh, cineole type, low spicy note	Anise-like
Color	Colorless	Slightly yellow	Colorless	Colorless	Colorless
Physicochemical properties					
Refractive index	1.4666 1.5178	1.4887	1.4654	1.468	
Density	0.908	0.896	0.909	0.912	0.9721
Optical rotation	-16.6	-36.5	-17.4	Not tested[4]	Not tested[4]
Solubility in ethanol 80 percent[5]	Soluble	Not soluble	Soluble	Soluble	Not tested

[1]we collected these commercial samples on the US retail market as part of our random screening program; the spelling of above-listed oils reflect exactly what was on the label regardless its inaccuracy (see text for correct names). [2]the essential oils from the US and Malagasy companies (Co.) have been kept anonymous; [3]Label Conservation Biodiversity and Development (Madagascar); [4]not tested due to the low amount of material for this analysis (less than 6 ml); [5]one volume of oil in one volume of ethanol 80 percent

of each component was confirmed by comparison of its Kovat's index[16] with those from literature.[17]

Results and Discussion

The essential oil of ravintsara (*C. camphora*) was typically colorless with fresh (1,8-cineole-type) and slightly spicy notes (T-1). The density was 0.908, the refractive index 1.4666 and optical rotation -16.6. The chemical profile of ravintsara oil was dominated by 1,8-cineole (63 percent) with lower amounts of sabinene (12 percent) and α-terpineol (7 percent) (T-2).

The true authenticated ravensara (*R. aromatica*) showed a distinct and markedly different aroma and physicochemical properties than those of ravintsara (*C. camphora*) (T-1). Ravensara (*R. aromatica*) oil was slightly yellow and the aroma was spicy and liquorish. The physicochemical properties (density 0.896, refractive index 1.4887 and optical rotation -36.5) were clearly different from the ravintsara oil (T-1). The ravensara (*R. aromatica*) oil was dominated by sabinene (15 percent), limonene (21.5 percent) and methyleugenol (19 percent), and showed lower levels of α-pinene (5 percent), α-terpinene (5 percent) and methylchavicol (7 percent) (T-2).

The *R. aromatica* essential oils as traded and commercially available by US companies (I and II) were also colorless essential oils with fresh (1,8-cineole-type) and spicy notes (T-1). These ravensara oils also exhibited the physicochemical properties resembling those observed for ravintsara (*C. camphora*) essential oil (refractive index, 1.4666, 1.4654; density, 0.908, 0.909; and the optical rotation -16.6, -17.4, for ravintsara and US ravensara oils, respectively) (T-1).

The essential oil composition from both of these US ravensara oils (Company I and II) were almost the same (T-2), being dominated by 1,8-cineole (63 percent and 66 percent, respectively), with minor amounts of sabinene (11 percent and 14 percent), α-terpineol (7 percent and 8 percent) and β-pinene (3 percent) (T-2).

The solubility in ethanol can also be used as an additional tool in the authentication of an oil. The authenticated oil of ravintsara (*C. camphora*) was soluble in ethanol (80 percent) in contrast to the oil of ravensara (*R. aromatica*), which was not soluble in ethanol (80 percent) (T-1 – T-3). As the essential oils from Companies I and II were also soluble in ethanol (80 percent), this suggests that both commercial oils were actually ravintsara. Our results showed that

Chemical composition (GC area percent) of ravintsara and ravensara essential oils **T-2**

Commercial name[1]	Ravintsara essential oil	Ravensare aromatique essential oil	*Ravensara aromatica* essentia oil	Ravensare *(Ravensare aromaticum)*	Havozo
Species[1]	*Cinnamoum camphora*	*Ravensara aromatica*	*Ravensara aromatica*	*Ravensara aromatica*	*Ravensara anisata*
Origin[2]	Madagascar (Exhev)	Madagascar (CBD)	Madagascar (US Co. I)	Madagascar (US Co. II)	Madagascar (Malagasy Co.)
α-thujene	0.8	0.9	0.8	0.7	t
α-pinene	5.0	4.9	5.0	4.7	0.2
camphene	0.1	0.4	0.1	0.2	0.1
sabinene	**12.2**	**14.7**	**14.3**	**10.8**	**0.1**
β-pinene	3.3	2.5	3.4	3.0	0.2
myrcene	1.2	2.5	1.2	0.5	0.1
α-phellandrene	0.1	1.3		0.0	
δ-3-carene		4.1			t
α-terpinene	1.3	5.0	0.7	0.0	
p-cymene	0.1	1.7	0.5	2.8	0.4
limonene		**21.5**			1.6
1,8-cineole	**62.6**	1.2	**62.6**	**66.0**	**0.6**
(Z)-β-ocimene		1.1			
(E)-β-ocimene	0.4	0.1	0.4	0.0	
γ-terpinene	2.0	1.7	1.1	0.0	
terpinolene	0.3	0.3	0.2	0.0	
linalool		3.5			2.8
para menthadienol	0.3		0.4		
terpin-4-ol	2.5	2.0	1.7	2.4	0.3
α-terpineol	**7.3**	0.2	**6.7**	**8.2**	
methyl chavicol		6.5			89.7
α-copaene		0.4			
β-cubebene		0.2			
methyleugenol		**18.7**			**0.9**
(E)-caryophyllene	0.1	1.7	0.3	0.0	t
α-humulene	0.4	0.2	0.4	0.2	t
germacrene D		2.3			t
δ-cadinene		0.1			
Total	**99.8**	**99.7**	**99.8**	**99.5**	**98.2**

[1]we collected these commercial samples on the US retail market as part of our random screening program; the spelling of above listed oils reflect exactly what was on the label regardless its inaccuracy (see text for correct names); [2]the essential oils from the US and Malagasy companies (Co.) have been kept anonymous

the oil of ravensara is more apolar as evidenced by the higher amounts of non-oxygenated terpenes in this oil (T-2, T-4).

Based on these characteristics, the essential oils of the US Companies I and II were labeled and sold incorrectly as *R. aromatica*, when both essential oils were actually ravintsara (*C. camphora*) (T-1, T-2). This observation reflects the misidentification of ravensara commercial oil samples in the US marketplace, which has caused confusion in

Quality standards for the essential oil of ravintsara (*Cinnamomum camphora* (L.) J. Presl)[1] **T-3**

Commercial name	Ravintsara essential oil	
Botanical name	*Cinnamomum camphora* (L.) J. Presl	
Specifications	**Requirements**	
Appearance	Clear, low viscosity liquid	
Color	Colorless	
Aroma	Fresh, cineole type, low spicy note	
Physicochemical properties	**Minimum**	**Maximum**
Refractive index	1.4620	1.4685
Density	0.900	0.9200
Optical rotation	-11°	-22°
Essential oil solubility in ethanol	Soluble in ethanol 80 percent[2]	
Chemical composition	**Minimum percent**	**Maximum percent**
α-pinene	3	8
sabinene	7	18
β-pinene	2	5
myrcene	0.5	3
α-terpipene	0	2
1,8-cineole	50	68
γ-terpinene	0.2	3
terpin-4-ol	0.5	5
α-terpineol	3	13

[1]these standards grew-out of the laboratory tests compiled by the pool of Malagasy labs and the suggestions made by the PRONABIO and scientific advisory committee in Madagascar in concert with Rutgers quality control team; [2]one volume of oil in one volume of ethanol 80 percent

the past. Many reports have described the *R. aromatica* essential oil as having similar physicochemical properties as our true ravintsara (*C. camphora*) essential oil with 1,8-cineole as the main component with minor amounts of sabinene and α-terpineol.[3-7]

The results of our study are also supported by the fact that in Taiwan, the origin place of the trees that were introduced to Madagascar, the essential oil of the cineole tree (*C. camphora* ssp. *formosana* Hirota) was also described as having high levels of 1,8-cineole (50 percent) with minor amounts of α-terpineol.[18] In Madagascar, *C. camphora* was also correctly described as being dominated by 1,8-cineole with minor amounts of sabinene and α-terpineol.[19-20] However, the Taiwanese oils were reported to contain camphor, which are found only in trace amounts in the Malagasy essential oils.

Another source of confusion with *Ravensara* species is that *R. aromatica* and *R. anisata* (a synonym for *R. aromatica*) were considered different species producing different essential oils, whereas the plants were one and the same. Both essential oils come from the same plant, but the oil of *R. anisata* usually refers to the bark oil of *R. aromatica* (rich in methylchavicol), while the essential oil of the true *R. aromatica* is extracted from the leaves.[2,3] The species that was first described by Sonnerat was further renamed as *R. anisata* by Danguy.[9,11] Although botanical taxonomists solved this taxonomic confusion, the older Latin name remained and thus has not changed in the oil trade.[12,13] This misidentification was also observed in an essential oil sample we received from a Malagasy private company.

This essential oil, commonly known as havozo, was a colorless mobile liquid with anise seed-like aroma, with physicochemical properties (n20/D = 1.5178, $d^{20}/_{20}$ = 0.9721) (T-1) similar to those of pure methylchavicol (n20/D = 1.521, $d^{20}/_{20}$ = 0.965). The oil was dominated by methylchavicol (90 percent) with minor amounts of linalool (3 percent), limonene (2 percent),

Quality standards for the essential oil of ravensara (*Ravensara aromatica* Sonn.)[1] **T-4**

Commercial name	Aromatic ravensara essential oil	
Botanical name	*Ravensara aromatica* Sonn.	
Specifications	**Requirements**	
Appearance	Clear, low viscosity liquid	
Color	Slightly yellow	
Aroma	Liquorice and spicy	
Physicochemical properties	**Minimum**	**Maximum**
Refractive index	1.4836	1.4924
Density	0.8834	0.9048
Optical rotation	-34.3°	-36.5°
Essential oil solubility in ethanol	Soluble in ethanol 90 percent[2]	
Chemical composition	**Minimum percent**	**Maximum percent**
α-pinene	3	5
sabinene	8	16
β-pinene	2	5
myrcene	2	3
limonene	14	21
linalool	4	9
methylchavicol	3	17
methyleugenol	9	17
(E)-caryophyllene	2	7

[1]these preliminary standards came from five authenticated ravensara (*R. aromatica* Sonn.) essential oils; [2]one volume of oil in one volume of ethanol 90 percent

methyleugenol and 1,8 cineol (1 percent) (T-2). Our results are supported by others that described the oil of *R. aromatica* bark oil as also dominated by methylchavicol (estragol).[19,21] Another study reported the oil of *R. anisata* as also dominated by methylchavicol.[6]

The essential oil of the bark of *R. aromatica* has not been recommended for trade since its production is highly unsustainable.[8]

The essential oil extracted from the botanically authenticated *R. aromatica* leaves showed similar levels of limonene and methyleugenol (T-2). However, *R. aromatica* leaf oil was described as being dominated by methyleugenol (87 percent).[20]

This high level of methyleugenol may be partially explained because the oils extracted from the leaves also include stems, which usually yield higher levels of methyleugenol (> 20 percent).[22]

In contrast, another study reported that the oil of *R. aromatica* leaves was composed of β-myrcene (5 percent), 1,8-cineole (6 percent), linalool (13 percent) and carotol (6 percent).[2] This was probably another chemotype. Therefore, further research is needed to better define the quality standards of *R. aromatica* oil as well as understand the full natural genetic diversity and potential chemotypes within the species.

This misidentification and confusion in the marketplace is also likely due to the similarity of both common names (ravensara/ravintsara) among US customers. The ravensara (*R. aromatica*) essential oil is distinct and a unique natural product from Madagascar, for which exportation has not increased in international trade, due in part to this product confusion.

Taxonomists continue to examine the genetic diversity and population differences within and between ravensara species. In concert with PRONABIO, we propose the following standards that can reflect the true ravintsara (*C. camphora*) thus providing to the users and international community a consistent and defined essential oil (T-3). Further studies are needed

with ravensara (*R. aromatica*) to identify additional and distinct chemotypes. However, we believe that these preliminary standards can provide the basis for proper identification of this Malagasy essential oil (T-4).

The development of clear grades and standards for ravensara and ravintsara are needed. Toward this end, a new natural certification program "NATIORA" is being implemented in Madagascar under which grades and standards for essential oils are defined.

Our study should help avoid future market confusion and misidentification of these essential oils, and should provide a foundation upon which processors, producers as well as buyers and users can objectively define each of these three essential oil products.

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Address correspondence to James E. Simon, Dept. of Plant Biology and Pathology (Foran Hall), Cook College, Rutgers, the State University of New Jersey, 59 Dudley Rd, New Brunswick, NJ 08901-8520; e-mail: jesimon@aesop.rutgers.edu.

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