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Quality Attributes of Ginger and Cinnamon Essential Oils from Madagascar

Adolfina Koroch*, Lalasoa Ranarivelo, Olivier Behra, H. Rodolfo Juliani, and James E. Simon

Over 28,200 tonnes (t) of essential oils are produced worldwide every year at an estimated value of $18 billion, of which China contributes about 16,600 t. African countries collectively contribute less than 1% of global production. One of the major factors limiting increased trade and market penetration of African essential oils has been the lack of quality standards, inability to consistently produce the critical mass of essential oil quantities, high shipping costs, lack of familiarity with market requirements, and the challenge of meeting product specifications of the international marketplace. The natural products sector of Madagascar is dependent on international trade for its commercial success.

Ginger (*Zingiber officinale* Roscoe, Zingiberaceae) and cinnamon (*Cinnamomum zeylanicum* Garc. ex Blume, Lauraceae) are among the most important essential oils from Madagascar and are used by the food and fragrance industries. This study sought to evaluate the quality of these Malagasy essential oils and compare them with commercial available products and standards from the US (Food Chemical Codex 1996) and international organizations (ISO), to determine their market competitiveness.

MATERIALS AND METHODS

Essential oils extracted from fresh ginger rhizomes (*Z. officinale*) and cinnamon barks (*C. zelyanicum*) from Madagascar were analyzed. Organoleptic (color, aroma), physicochemical (refractive index, density, optical rotation, ethanol solubility) and chemical composition (Juliani et al. 2004) profiles were evaluated.

A cluster analysis was performed to find associations between the different essential oils of ginger. The distances based on similarity (or dissimilarity) were illustrated as a Similarity Index which was used as a criteria for grouping or separating essential oils. The cluster analysis of the oils was performed using the program NTSYSpc (ver. 2.02, Applied Biostatistics Inc.).

RESULTS AND DISCUSSION

Ginger

Rhizomes of ginger (*Zingiber officinale*) are one of the most important and oldest spices (Fig. 1). The commercial ginger essential oil was characterized by warm, spicy, and woody notes, with slight lemony notes. The oils were pale yellow, low viscosity liquids, with refractive indices of 1.4884 to 1.4918, the densities of 0.883 to 0.877, and optical rotations of –33.9 to –39 (Table 1). These essential oils were dominated by α-zingiberene with low AR-cucurmene content and trace amounts of neral and geranial (Table 2).

Two samples of Malagasy ginger oils had a different aroma from the commercial oils. While the commercial oil could be characterized as imparting light lemony notes, the Madagascan ginger oil sample was characterized by a distinctly stronger and intense lemon character with rose/floral notes. Sample 1 exhibited properties including aroma, physicochemical properties and organoleptic characteristics that were distinctly different from sample 2.

Fig. 1. Commercial ginger rhizomes.

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A cluster analysis, performed to evaluate the chemical diversity of the essential oils, showed that Malagasy sample 1 did not belong to the typical commercial cluster (Fig. 2) as this oil contained high levels of camphene and AR-cucurmene and lower amounts of α-zingiberene (Table 2). Malagasy sample 2 showed lower levels of camphene and higher amounts of citral (geranial + neral), and α-zingiberene. Geranyl acetate (8%) of sample 2, an uncommon component in ginger oil, appeared to be responsible for the pleasant floral notes. Citral provided the lemony notes. For comparison purposes, we included a sample form Ghana, which was similar to the Malagasy sample, though lacking geranyl acetate. The moisture content of the ginger at the time of distillation appeared to be related to the intensity of the lemony notes in the distilled oil. The fresher ginger produced higher lemony notes and aroma in the distilled essential oil.

Cinnamon

Essential oils extracted from commercial cinnamon barks (Fig. 3) were yellow, with warm-spicy notes characterized simply as "cinnamon notes" (Table 3). The refractive index (1.5817–1.5909) and density (1.019–1.026) of the commercial samples were closer to pure cinnamic aldehyde, reflecting the higher levels of cinnamic aldehyde (Table 4). Essential oil of *Cinnamomum cassia* was included for comparison purposes. The oils were

Table 1. Appearance profile and physicochemical properties of ginger essential oils from different origins.

	Organoleptic profile		Physicochemical properties		
Origin	Aroma	Color	Refractive index	Density	Optical rotation (°)
Malagasy 1	Less characteristic	Yellow	1.4927	0.936	11.4
Malagasy 2	Characteristic of ginger, but with floral character	Pale yellow	--	--	--
Commercial 1	Characteristic of ginger	Pale yellow	1.4884	0.8803	–33.9
Commercial 2	Characteristic of ginger	Yellow-orange	1.4918	0.883	–39.3
Commercial 3	Characteristic of ginger	Pale yellow	1.4894	0.877	–39.3
Guenther (1985)	Characteristic of ginger	Green to yellow	1.489–1.494	0.877–0.886	–26 to –50
FCC[z]	Aromatic odor characteristic of ginger	Yellow to pale yellow	1.488–1.494	0.870–0.882	–28 to –47

[z]Food Chemical Codex standards.

Table 2. Chemical composition of ginger essential oils from different origins.

	Composition (rel. % of total EO)					
	Madagascar		Commercial			
Component	1	2	1	2	3	Ghana
α-pinene	7.4	0.1	3.1	1.7	2.6	
Camphene	22.8	1.0	10.4	5.7	8.1	0.2
β-phellandrene	8.2	0.9	9.1	5.4	7.3	0.4
1,8-cineole	8.7	2.0	4.1	2.2	3.2	0.9
Neral	2.4	6.4		0.1	0	11.2
Geranial	4.2	14.6		0.2	0.1	17.8
Geranyl acetate		8.3				
AR-curcumene	15.3	7.7	8.8	8.2	9.1	4.5
α-zingiberene	5.2	22.9	36.2	42.2	39.7	18.1
β-bisabolene	7.4	8.5	10.1	11.5	11.3	6.4
β-sesquiphellandrene	6.3	6.5	9.6	13.5	10.9	6.8
Total analyzed	94.1	90.6	96.4	96.6	96.0	80.7

dark orange, with refractive index (1.6119) and density (1.058) closest to pure cinnamic aldehyde, due to the highest amount (92%) of this component (Table 4). The optical rotation of the commercial essential oils were also similar ranging from –0.3 to –0.83 (Table 3).

Madagascar essential oil was pale yellow, with weaker spicy or "cinnamon" notes. It exhibited lower refractive indexes and density, showing that this oil contained low levels of cinnamic aldehyde (29%), with higher amounts of monoterpene hydrocarbons, of which β-phellandrene was the main component (Table 4). This essential oil was insoluble in ethanol 70%, supporting the fact that the oil was richer in non-polar components, such as monoterpene hydrocarbons (Table 3).

Although, the Malagasy essential oils showed different properties when compared with commercially available oils, they received positive feedback from the private sector, and are now entering international markets for niche applications. The "lemon ginger" essential oils are thus now beginning to contribute to economic development in Madagascar though they will likely find their niche as a specialty item. We suggest such a new oil be accompanied with a specific international product specification sheet highlighting the high amounts of citral (geranial + neral), α-zingiberene and geranyl acetate as well as all other physicochemical attributes which illustrate the oils uniqueness from traditional ginger oil.. We also suggest that such an oil can be introduced into the market with a unique name so that it will not be confused with the essential oil of ginger now produced in several other countries.

Despite the lower amount of cinnamic aldehyde, the organoleptic profile was desirable for some buyers seeking a milder less intense cinnamon, demonstrating that it is not always important to have high amounts of the main component as long as the essential oil has the desired or complex aroma profile of interest to specialized market niches. Yet there is a significant challenge in marketing such a cinnamon when the cinnamic aldehyde content does not meet the minimum levels set forth for this product in the ISO specifications. Cinnamomum cassia oil included in this study, had the highest levels of cinnamic aldehyde but also produced a hot, burning sensation.

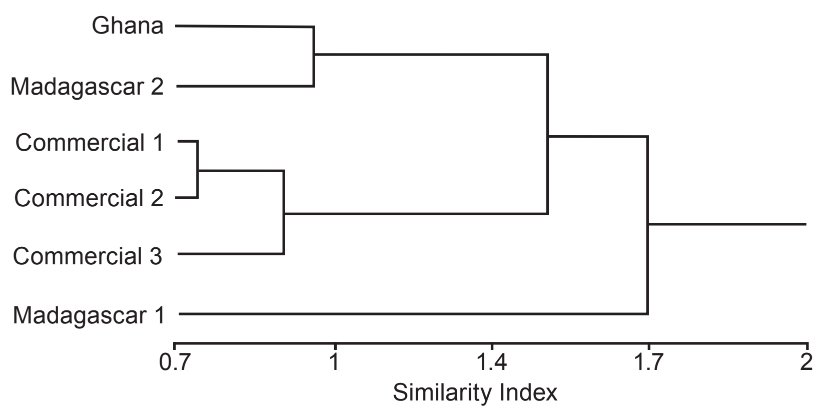

Fig. 2. Cluster analysis of the ginger essential oils.

Fig. 3. Commercial cinnamon barks.

Table 3. Appearance profile and physicochemical properties of cinnamon bark oil from Madagascar with cinnamon bark oils (*Cinnamomum zeylanicum)* and cassia (*Cinnamomum cassia*) in the US Market.

	Appearance profile		Physicochemical properties			
Origin	Aroma	Color	Refractive index	Density	Optical rotation	Ethanol solubility (ml EtOH)
Malagasy	Mildly sweet, weak and less rich aroma	Pale yellow	1.5301	0.949	–3.9	Not soluble[z]
Commercial 1	Sweet, characteristic of cinnamon, strong, rich and pleasant aroma	Yellow	1.5817	1.019	–0.3	1.7
Commercial 2	Sweet, characteristic of cinnamon, strong, rich and pleasant aroma	Yellow	1.5909	1.026	–0.83	1.7
FCC[y]	Odor of cinnamon	Yellow	1.573–1.591	1.010–1.03	2 to 0	3.0
Cassia commercial 3	Cinnamon like, burning sensation	Dark orange	1.6119	1.058	–0.83	1.4

[z]1 mL of oil in 1 mL of EtOH (70%)
[y]Food Chemical Codex standards.

Table 4. Chemical composition of cinnamon bark oil from Madagascar with cinnamon bark oils (*C. zeylanicum*) and Cassia (*C. cassia*) in the US market.

	Composition (%)			
	Cinnamon			Cassia
Component	Malagasy	Commercial 4	Commercial 5	Commercial 6
α-pinene	5.68	0.29	2.8	0.15
α-phellandrene	5.24	1.0	0.11	
β-phellandrene	18.37	2.43		
cinnamic aldehyde[z]	29.22	73.06	79.38	92.31
(E)-caryophyllene	5.75	4.04	0.43	
(E)-cinnamyl acetate	12.86	5.58	0.66	1.05

[z]Food Chemical Codex standards for cinnamic aldehyde 55% to 78%

REFERENCES

Food Chemical Codex. 1996. Food chemical codex. National Academy Press: Washington, DC.

Guenther, E. 1949. The essential oils. Vol. 5. Van Nostrand Reinhold, New York. p. 104.

Juliani, H.R., J.A. Zygadlo, R. Scrivanti, E. de La Sota, and J.E. Simon. 2004. The essential oil of *Anemia tomentosa* (Savigny) Sw. var. *anthriscifolia* (Schrad.) Mickel. Flavour Fragr. J. 19:541–543.