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Quality evaluation of essential oils from Morocco fennel achenes

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1. INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) is a member of the ***Apiaceae* family**, closely related to the genera Anethum and *Ridolfia*. It is an annual, biennial, or perennial herb, ranging from 0.3 to 2.5 meters in height, completely glabrous. The plant is characterized by linear cotyledons, pinnatisect primary and sterile leaves.

Two subspecies have been described:

1/ Subsp. *vulgare*, whose leaves have longer and less rigid segments. Three varieties have been identified within this subspecies:

- **var. *vulgare*,** or bitter fennel, wild or cultivated for the production of (E)-anethole.
- **var. *dulce*,** or sweet fennel, is cultivated and has a more pleasant tasting fruit (used mainly as a culinary or aromatic variety).
- **var. *azoricum*,** or bulbous fennel, is cultivated for its swollen, fleshy leaf sheaths. Which are consumed as a vegetable (**Figure 1**).

2/ Subsp. *piperitum* (Ucria) Cout., commonly known wild fennel (is a non-cultivated form), whose leaves have very short, fleshy segments. The achenes are dark brown and the essential oil is characterized by the presence of two oxygenated compounds: piperitenone and piperitenone oxide (**Figure 2**).

Figure 1: variety *azoricum* or bulbous fennel.

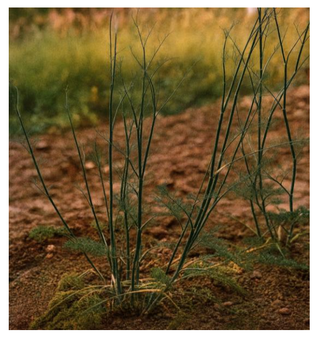


Figure 2: Subsp. *Piperitum.*

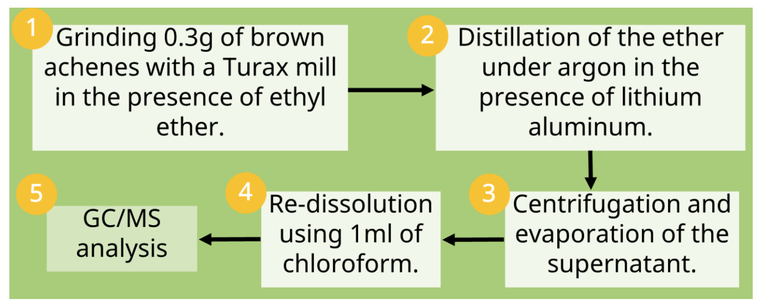
2. OBJECTIVES

- **For the first time,** the composition of the essential oil (EO) from each batch of fruits was **determined and compared** in order to characterize **possible chemotypes** of different fennel varieties (bitter sweet and bulbous) cultivated and marketed in **Morocco.**
- Some commercial culinary fennels often contain **little (E)-anethole** and a high content **of highly oxidized arylpropenes**, which led us **to propose a standardization.**

3. MATERIALS AND METHODS

Table 1: Origin and varieties of 14 fennel achenes batches cultivated and marketed in Morocco.

Batches	A B C D E F G H I J	K	M O P
Varieties	*dulce*	*azoricum*	*vulgare*
Origins (region)	Marrakech	Marrakech	Beni Mellal



4. RESULTS

Table 2: summarizes the average percentages of 25 compounds detected in the essential oil achenes from 14 samples of cultivated fennel. (tr= trace, ≤ 0.01%)

Compounds	Batches				
	Sweet fennel		Bulbous	Bitter	
	A, B, C and D	E, F, G, H, I and J	K	M	O and P
Monoterpene hydrocarbons					
α-thujene	tr	tr	tr	0.1	tr
α-pinene	4.57	2.75	1.3	14.5	8.3
camphene	0.075	0.36	0.2	0.5	0.3
β-phellandrene	0.85	0.38	0.3	0.5	0.3
β-pinene	0.1	0.06	Tr	0.9	0.45
Sabinene	0.57	1.5	1.2	2.5	1.75
α-phellandrene	0.1	0.26	0.2	0.3	0.25
p-cymene	Tr	tr	tr	tr	tr
Limonene	16.27	9.73	6.9	2.3	2.65
γ-terpinene	0.75	0.65	0.7	0.8	0.45
Terpinolene	0.05	0.08	tr	0.1	0.1
Oxygenated monoterpenes					
1,8-cineole	0.85	0.11	0.3	Tr	0.3
Sabinene hydrate	Tr	tr	tr	tr	tr
Fenchone	5.1	10.2	11.4	10.5	11.75
Camphre	0.05	0.02	0.3	0.3	0.45
Arylpropenes					
Estragole	67.5	3.9	4.2	42.9	28.4
(Z)-anethole	tr	0.016	0.2	tr	tr
anisaldehyde	0.52	0.55	0.9	0.3	0.8
(E)-anethole	0.42	67.5	70.3	20.5	10.6
p-butylanisole	tr	0.42	0.8	0.2	0.7
Methyleugenol	tr	tr	tr	0.2	7.8
Anisacetone	tr	tr	tr	tr	tr
Methyl isoeugenol	tr	0.03	tr	tr	tr
Elemicin	tr	tr	tr	tr	22.8
Alcane					
10-nonacosanone	0.6	0.03	0.5	0.2	0.3
Total	97.8	98.5	97.6	98.7	98.54

- The amount of (E)-anethole varies from 0.42 to 70.3% (**Table 2**), and the same observation is made for its allylic isomer estragole (3.9 to 67.5%).

- (E)-Anethole and estragole represent the slightly oxidized arylpropenes. Methyl eugenol, methyl isoeugenol and elemicin constitute the highly oxidized arylpropenes observed for the first time in the essential oil of Moroccan fennel fruits (**Figure 3**).

Table 3: Three varieties of Fennel have been clearly distinguished based on the characteristics of the achenes essential oil.

Varities	Batches	Chemotypes	α-pinene/ Limonene	Fenchone	Estragole	(E)-anethole
dulce	A, B, C and D	Estragole	0.28	5.1	67.5	0.4
	E, F, G, H, I and J	(E)-anethole	0.28	10.2	3.9	67.5
vulgare	M	Estragole+(E)-anethole	6.3	10.5	42.9	20.5
	O and P	Estragole+elemicin	3.13	11.75	28.4	10.6
azoricum	K	(E)-anethole	0.18	11.4	4.2	70.3

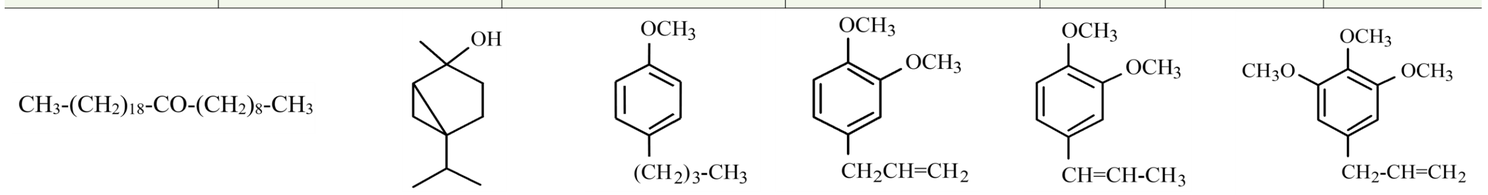


Figure 3: Chemical structures of compounds detected for the first time in bitter fennel achenes essential oil cultivated in Morocco.

- Six samples of sweet fennel and only one batch of bulb Fennel (K) are condiments (**Table 3**).
- Four batches of sweet fennel (A, B, C, and D) should not be marketed or consumed because they contain more than 60% estragole (**Table 3**).
- The three lots (M, O and P) of bitter fennel are not authorized to be marketed as a condiment. They contain on average **42.9% estragole (M), 22.8% elemicin** (O and P) and **very little (E)-anethole (10.6%)**. In addition, lot P contains anisaldehyde (1.3%) and p-butylanisole (1.2%).
- Elemicin accumulates in the body and causes psychotropic effects.

5. CONCLUSION

We propose certain standards to be met before marketing fennel fruits:

- Consumers have the right to expect under the names "sweet fennel", "bulb fennel" and "bitter fennel" a product with an aniseed flavor, with more than 50% (E)-anethole, less than 20% fenchone and less than 10% (E)-anethole oxidation compounds.
- Fennel containing more than 10% estragole or highly oxidized arylpropenes should be avoided.
- Expiration dates must be indicated because we have demonstrated that the essential oil of the fruits oxidizes easily in the container or bags intended for marketing.

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