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Chemical composition and mineralogical residence of sesame oil from plants grown in different Yemeni environments

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ABSTRACT

Sesame seeds collected in eight provinces of Yemen were used to prepare cold-pressed sesame oil over three consecutive years. After ascertaining the nutritional quality and compliance with official norm of each batch of oil, mineral composition was determined by ICP-OES. No major and significant variations were detected over three years indicating the high reproducibility of Yemeni sesame oil composition as a function of its geographic origin. Three physico-chemically distinct sub-groups were identified. A subgroup includes sesame oil from Al Bayda, Marib, Ibb, and Taiz; a second is constituted by sesame oil from Abyan, Shabwa, and Hadhramount while sesame oil from Hodeida presents its own specificity. Calcium content was between 3.02 and 9.66 mg/kg, this cation making up 50% of the total mineral content. The two other most abundant minerals were potassium (0.824–4.251 mg/kg) and magnesium (0.811–4.742 mg/kg). Potentially toxic metal (Cd, Pb, Cu, Sn and Zn) content was very low in all samples. Principal component analysis showed that Abyan oil presents a unique metal-content profile. The precise geographic origin of Yemeni sesame oil can be determined by element content analysis.

1. Introduction

Sesame (*Sesamum indicum* L.) oil is probably the most ancient oil seed crop known to human kind, it has been cultivated in Asia and Africa for 2000 years [1]. It is still highly valued as a traditional healthy food ingredient [2,3]. Several other outputs have also recently been envisioned for this oil [4]. The quantity and the quality of the oil contained in sesame seeds have been shown to depend on ecological factors such as climate, soil type and on cultivars and maturity of plant [5]. Oxidative stability of sesame oil is superior to that of other vegetable oils although it contains nearly 85% unsaturated fatty acids [6–8]. Bioactive components, such as lignans, pinoresinol, tocopherols, lecithin, myristic acid, and linoleate have been identified as the major antioxidants responsible for the reduction of oxidative rancidity and deterioration of sesame oil [9,10]. A group of phenolic compounds has also been correlated with the oil nutritional and organoleptic properties, as well as its remarkable oxidative stability [11,12].

Sesame oil consists majoritarily of fatty acids whose distribution varies with the species of sesame seed [13,14]. Main fatty acids are palmitic acid (16:0; 7.0–12.0%), stearic acid (18:0; 3.5–6.0%), oleic acid (18:1; 35–50%), linoleic acid (18:2; 35–50%).

Vegetable oil quality is generally assessed by the determination of physico-chemical parameters [15–17]. Another important quality criterium of vegetable oils is its metal content [18–20], which can be analyzed by ICP-OES [21,22], and whose presence results from endogenous factors connected with the plant metabolism, and exogenous factors due to contamination during the agronomic techniques of production, as well as systems and materials of packaging and storage [23,24].

Recent studies have focused on the composition of locally produced

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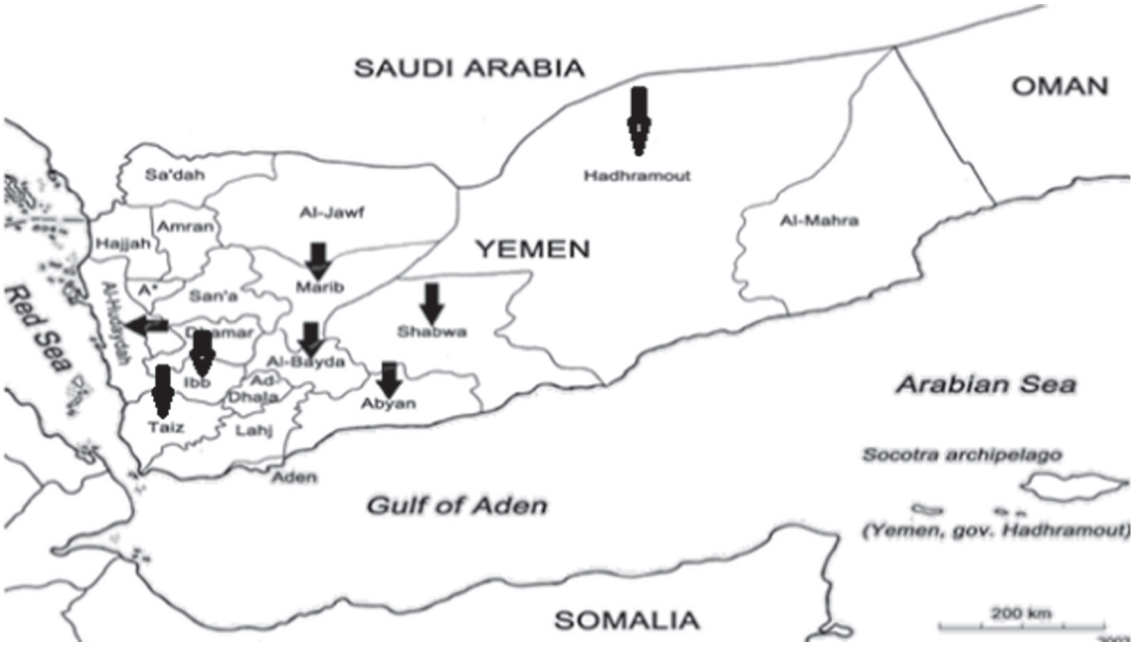

	Al Bayda	Hodeida	Marib	Abyan	Shabwa	Hadhramout	Ibb	Taiz
Altitude (m)	2250	800	1400	1030	1030	1060	3150	2700
Climate	Cold	Hot-humid	Hot	Hot-dry	Hot-dry	Hot-dry	Cold-humid	Mild

Fig. 1. Location and climatic information on the areas from which sesame seeds were harvested.

sesame oils [25]. Sesame seed is nutritionally important in Yemen. However, very limited scientific research has been carried out on the locally produced oil. Therefore, we decided to evaluate of chemical composition and mineralogical residence of Yemeni sesame oil grown in eight different environments over three consecutive years.

2. Materials and methods

2.1. Sampling

White sesame seeds (20 kg for each collect) were harvested in May 2015, 2016, and 2017 from eight geographic origins of Yemen (Al Bayda, Hodeida (also named Al Hudaydah), Marib, Abyan, Shabwa, Hadhramout, Ibb, and Taiz (Fig. 1).

Sample collection was performed after physiological maturity, the moment when 75% of the capsules on the main stem have mature seeds, 100 ± 5 days after seedling. Harvested sesame seeds were stored at 4 °C and oil was extracted prior analysis by mechanical pressing. Altitude and climate of the regions of collect are presented Fig. 1.

2.2. Analytical methods

2.2.1. Chemical composition

Proximate composition: Seed moisture content, expressed as percentage by mass, was determined using 5 g of seeds by adapting the AOAC method 934.06 [26]. A Jouan Quality Systems oven regulated at 105 °C was used. The difference between the results of the two last determinations was 0.1 g of moisture per 100 g of sample. Oil yield was calculated following the DIN EN ISO 659 recommendation. Nutritional composition of sesame seed oil cake was determined using the methods of the Association of Official Analytical Chemists [27]. Ash content was determined by incinerating 5 g of oil seed at 550 °C in a muffle furnace. Crude protein content was calculated from the nitrogen content measured by the Kjeldah procedure with Gerhardt model Vapodest 20 instrument, using a factor 6.25. Crude fiber was determined according to the gravimetric procedure on defatted samples.

Physical and chemical oil parameters: Samples, stored at 4 °C and protected from sunlight prior analysis, were analytically studied. Acid value (AV), peroxide value (PV), and UV-light (K_{270} and K_{232}) absorption were determined as previously described [28]. AV is expressed as percent of oleic acid, PV as milliequivalent of active oxygen per kilogram of oil (meq O_2/kg oil). Extinction coefficients (K_{232} and K_{270}) are expressed as the specific extinction of a 1% (w/v) solution of oil in cyclohexane in 1 cm cell path length, using a CARY 100 Varian UV spectrometer, and refractive index, was determined according to AOCS recommended practices Ca 5a-40, Cd 8b-90, Ch 5–91, Cc 7–25; respectively [29].

Fatty acid (FA) composition was determined using method ISO 5508–1990. FAs were first converted into fatty acid methyl esters by shaking a solution of 60 mg oil and 3 mL of hexane with 0.3 mL of 2 N methanolic KOH, then analyzed by gas chromatography using a Varian CP-3800 (Varian Inc.) chromatograph equipped with a FID. The column used was a CP-Wax 52CB column (30 m × 0.25 mm i.d.; Varian Inc., Middelburg, The Netherlands). The carrier gas was helium and the total gas flow rate was 1 mL/min. The initial and final column temperature was 170 °C and 230 °C, respectively, and the temperature was increased by steps of 4 °C/min. The injector and detector temperature was 230 °C. Data were processed using a Varian Star Workstation v 6.30 (Varian Inc., Walnut Creek, CA, USA). Results are expressed as the relative percentage of each individual FA present in the sample. Sterol composition was determined using method ISO 6799–1991, after trimethylsilylation of the crude sterol fraction, using a Varian 3800 instrument equipped with a VF-1 ms column (30 m × 0.25 mm i.d.) and helium (flow rate 1.6 mL/mn) as carrier gas, column temperature was