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Session B : Nutritional and Functional Foods

Biochemical and Nutritional Profiling of Fig Seed Oils and Defatted Cakes by FTIR-ATR Spectroscopy

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Plan

1. Introduction
2. Background to the study
3. Problematic
4. Materials and methods
5. Resultats and discussion
6. Conclusion and perspectives

Background to the study

Favorable climate for fig cultivation

Socio-economic and ecological importance

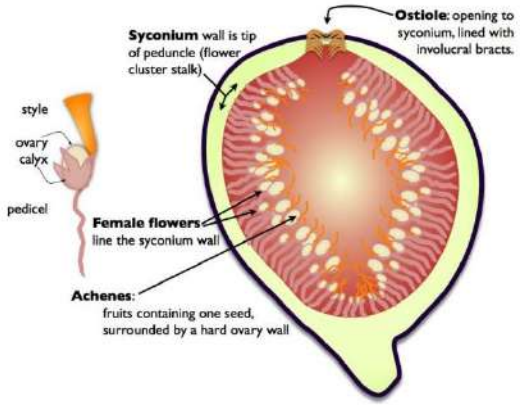
Green Generation 2020-2030

1. **Improved productivity and fig quality**
2. **Extension of the area to 80000 ha by 2030**
3. **Selection of high-performance varieties**

High phenotypic diversity within fig genetic material

Important component of the balanced Mediterranean diet due to their high nutritional value

Fruit Physiologies and Crop Types



Botanically considered a syconium

Flower cluster, semi-hollow and fleshy fruit

Type sanpedro

Type smyrn

Breba culture (parthenocarpics)

Growing on yearling cattle

Main crop (non-parthenocarpic)

Growing on the current year's wood

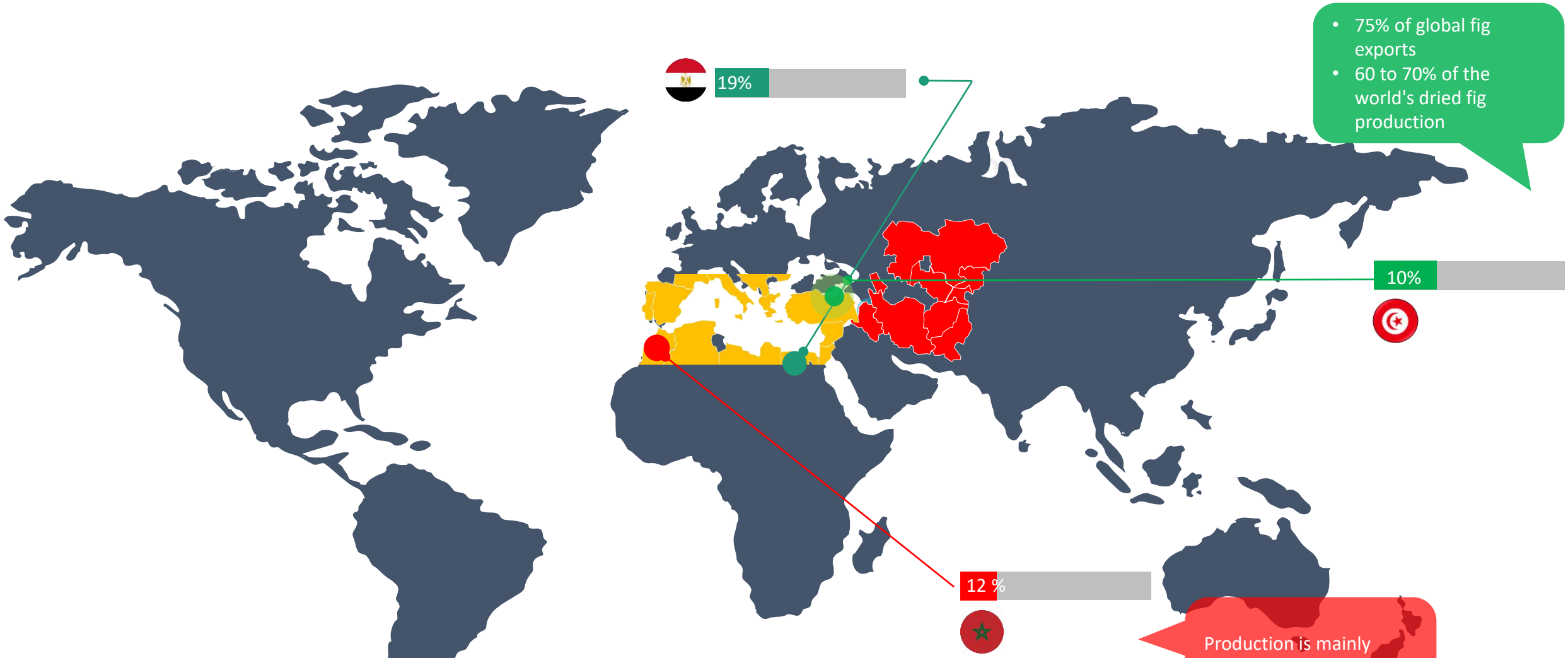
Taxonomy of the species

Scientific name	: *Plantae*
Superdivision	: *Embryophyta*
Division	: *Tracheophyta*
Class	: *Magnoliopsida*
Superorder	: *Rosanae*
Order	: *Rosales*
Gender	: *Ficus L. (includes (700–2000 spice)*
Cash	: *Ficus carica L. – Common fig. Edible fig*

Nomenclature

- Scientist: *Ficus carica* L.
- France : Fig tree
- English: Fig tree
- Arabic: karmousse/Bakur

ORIGIN OF THE FIG AND WORLD PRODUCTION (1million t)



- 75% of global fig exports
- 60 to 70% of the world's dried fig production

Production is mainly intended for local markets

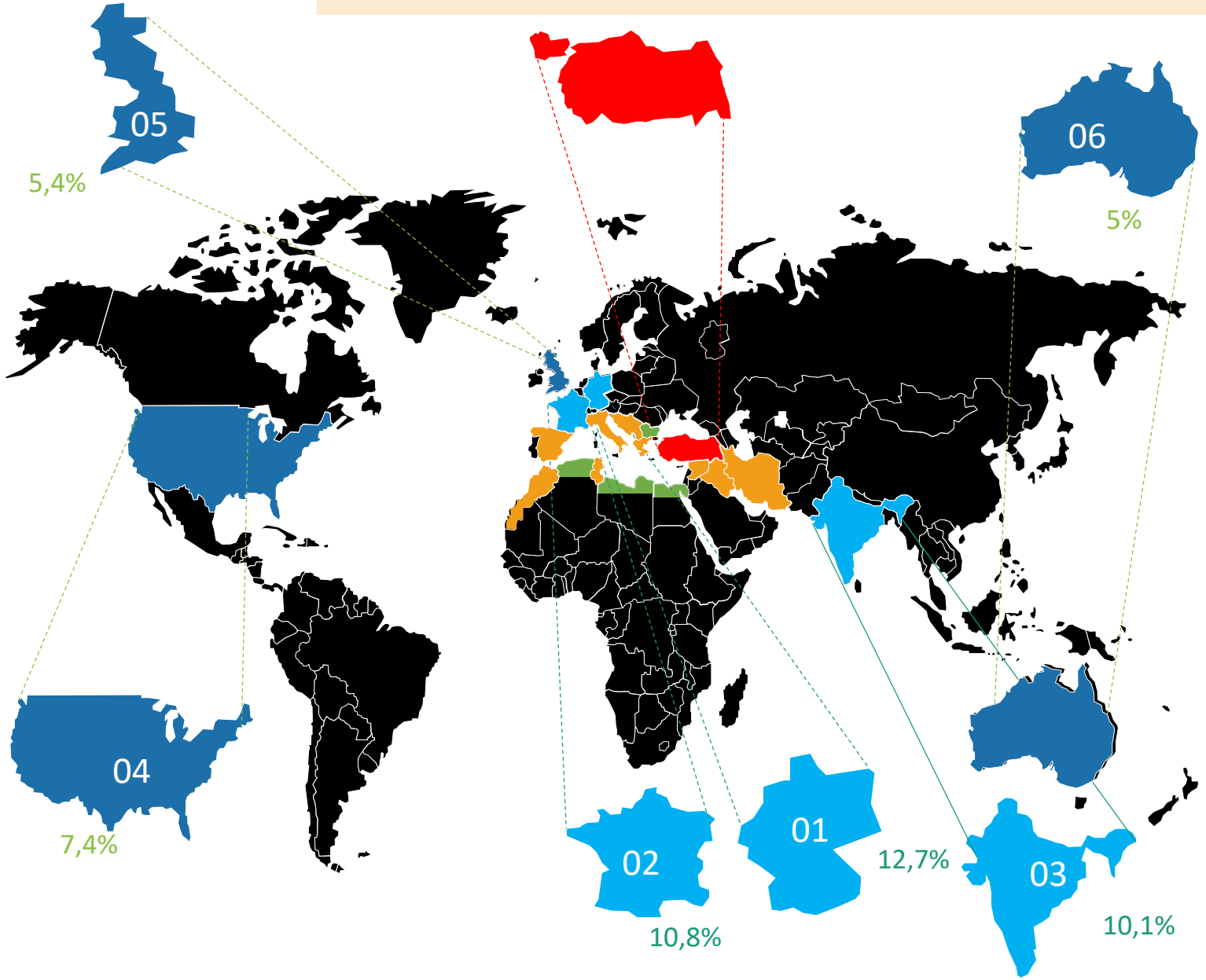
Average production = 91,500 t

Average yield = 1.2 t/ha

Total cultivated area = 60,000 ha

Source : FAOSTAT. 2024

FIG WORLDWIDE



>80% production

70 % exportations

33% importations

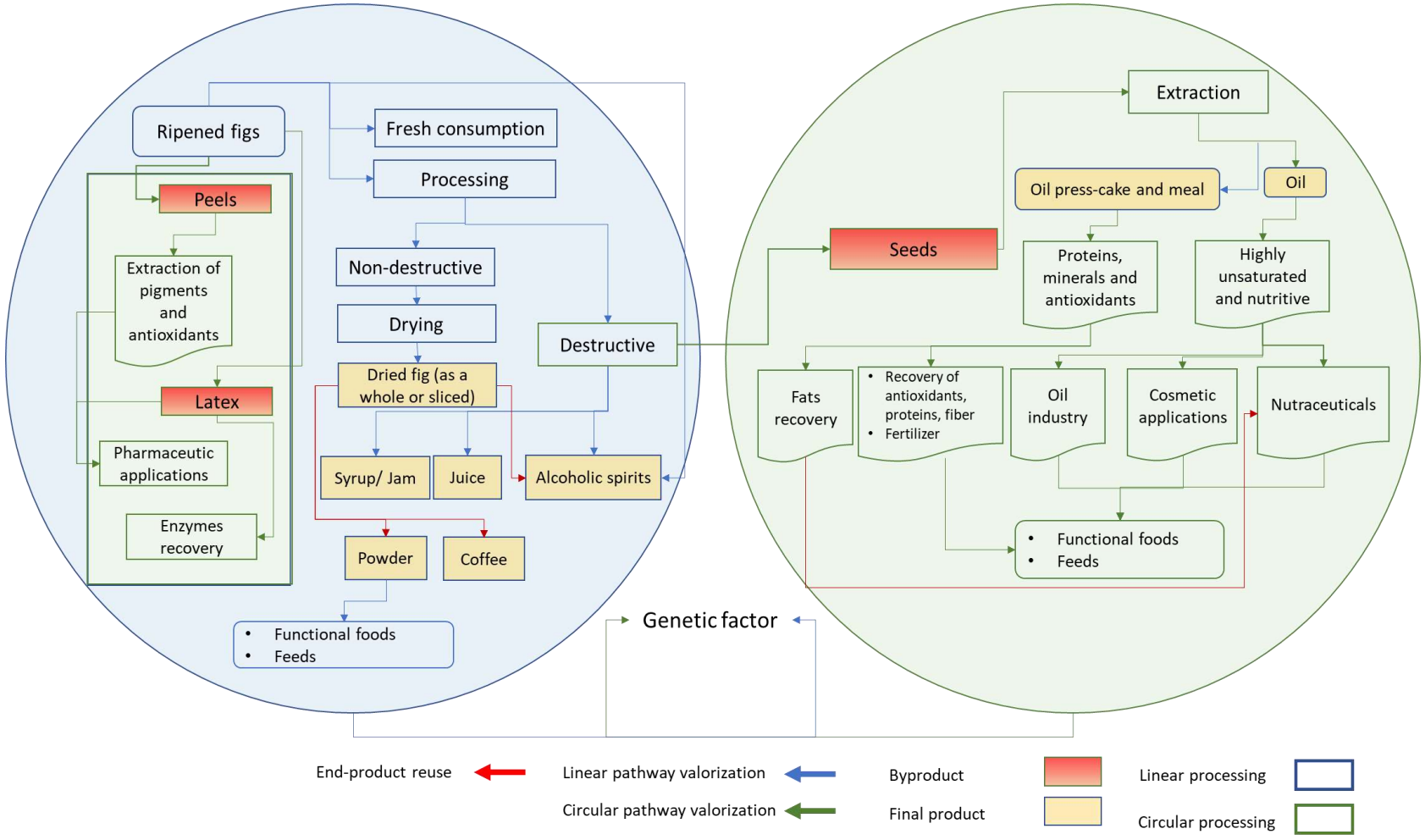
18% faible importation

Source : FAOSTAT. 2024

Valorization of Fig Seeds in the Context of the Circular Economy

Fig Seed

Valorization of fig seeds in the context of the circular economy



General information about Fig Tree Oil

Benefits of Fig Tree Oils

- Soothes skin inflammation
- Protection against free radicals Skin hydration
- Hair repair
- Anti-Aging Benefits



Nutritional Composition - Fig Oil

Saturated Fatty Acids
11 g for 100 g

Monounsaturated Fatty Acids
62 g for 100 g

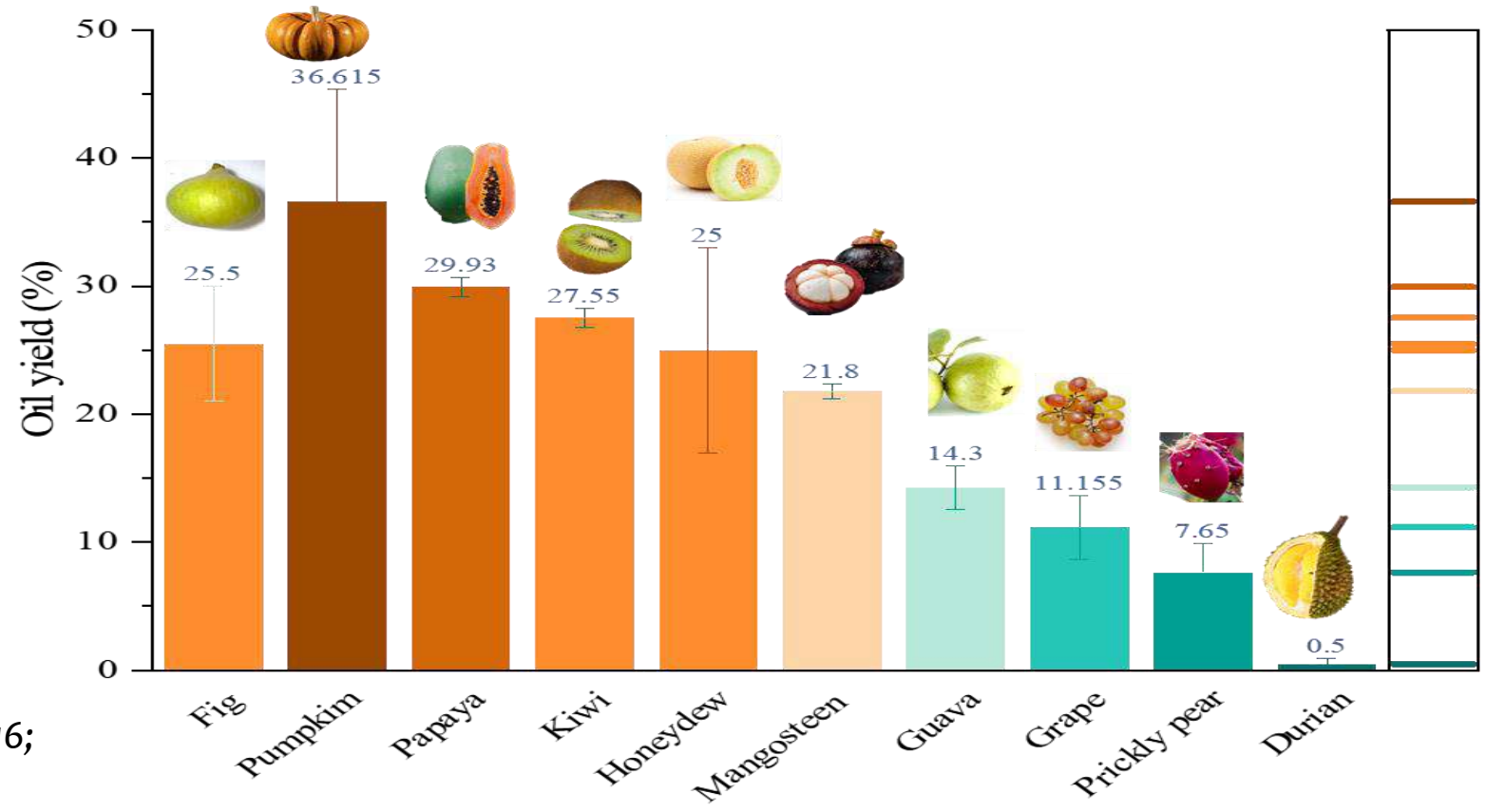
Polyunsaturated Fatty Acids
25g for 100 g

- Rich in phenolic compounds
- Rich in antioxidants

- Vitamin E
- Sterols

General Information about Fig Tree Oil

Oil yield (%) of several fruit seeds compared to figs



Górnaś & Rudzińska, 2016;
Hssaini et al., 2020a;
Piomboet al., 2006;
Raihana et al., 2015)

PLANT MATERIAL

135 cultivars (ex-situ collection) located at the INRA experimental station in Meknes

Randomized full block planting (RBC), with 3 replicates for each genotype

The fruits were randomly harvested around the canopy: full ripening period (June-October 2023-2024)

Biochemical screening of fig tree seed and meal

- *Location : (x=511600; y=370250; z=480m).*
- *Altitude : 500 m*
- *Soil type: Calcimagnesic.*
- *Precipitation: 460 mm.*
- *Temperature : max = 37°C (July) and min = 2.8°C (January).*
- *Average solar radiation: 238.28 W/m² (August)*

Source: Weather station installed next to the orchard.

Lipochemical analyses

Extraction of the seeds: soaking of the pulp in 10% technical ethanol (5 min), then stirring and decanting, then drying at 25°C.

Oil extraction by Soxhlet according to the ISO method (1999) 659:199

Evaluation of the Biochemical Properties of Fig Tree Oils

Plant material

- Randomized full block planting (RBC), with 3 replicates for each genotype.
- 21 genotypes studied.

Traits Assessed

Cake

- Ash Content (Chemists & Horwitz, 1975)
- Carboydrate Content (Chemists & Horwitz, 1975)
- Protein Content (Energy, 2003)
- Faty Acid Profil (Hssaini et al.,2020)
- FTIR-ATR Spectroscopy (Hssaini et al.,2021)
- Total Polyphénols Content (TPC) (Kao et Chen, 2006)
- Total Flavonoid Content (TFC) (Dravie et al., 2020)
- Antioxydant activity (AA) (DPPH, Dravie et al., 2020)

Biochemical and Nutritional Quality

Oil

Statistical Analysis

- **One-Way ANOVA** via **SPSS** was used to compare the means of the four quantitative parameters (TPC, TFC, DPPH, ABTS. Moisture, Fat content, Protein , NDF) across the 21 varieties. **Highly significant differences** were found ($p < 0.001$), followed by *post-hoc* tests (Tukey/Duncan) with a significance level of $p < 0.05$.

Oil Content Assessment

Genotypes	Seed Yield (g/Fruit)	Seed Yield (g/kg)	Oil Content (%)
Breval Blanca	2.04 ± 0.3	117.95 ± 2.89	31.24 ± 0.09
Melissosyki	1.97 ± 0.48	114.81 ± 3.17	30.89 ± 0.14
White Adriatic	2.27 ± 0.93	89.03 ± 1.48	22.49 ± 0.42
Kamalata	2.10 ± 0.14	112.02 ± 2.11	28.87 ± 0.40
Lerida	2.25 ± 0.38	92.07 ± 2.92	30.28 ± 0.12
Breba Blanca	2.30 ± 0.18	78.68 ± 2.85	23.75 ± 0.28
Hafer Jmel	2.23 ± 0.4	107.23 ± 2.19	31.50 ± 0.81
Embar El Khal	2.09 ± 0.75	107.17 ± 3.18	30.77 ± 0.26
Ahra 2870	2.24 ± 0.05	101.10 ± 2.48	30.75 ± 0.44
III 31 Roger	1.93 ± 0.40	120.52 ± 1.22	29.18 ± 0.30
Hayoul 2265	2.18 ± 0.87	104.54 ± 2.55	28.67 ± 0.40
Amtalaa Arch	2.08 ± 0.12	116.87 ± 1.86	30.20 ± 0.0
INRA 2603	1.99 ± 0.55	109.35 ± 1.70	23.29 ± 0.15
Aicha Moussa	**1.39 ± 0.89**	107.75 ± 1.81	31.08 ± 0.70
INRA 2802	1.79 ± 0.2	131.62 ± 1.37	16.68 ± 0.69
Rhoul 2216	2.07 ± 0.78	110.46 ± 3.75	31.86 ± 0.13
El Qoti Lezreq	**2.46 ± 0.02**	58.18 ± 1.00	28.97 ± 0.55
INRA 2105	1.96 ± 0.45	121.95 ± 2.41	**6.69 ± 0.14**
Bourqui	1.39 ± 0.54	111.23 ± 2.52	39.97 ± 0.01
Bourjassate Noire	1.99 ± 0.51	114.72 ± 3.50	30.89 ± 0.42
Adroulaniki	1.95 ± 0.48	128.23 ± 2.98	26.54 ± 0.91

Kassimi et al.,2025
Górnaś and Rudzińska, 2016
Taoufik et al., 2015
Ajayi et al., 2007
Alfawaz, 2004

Grape (8-20%)

Prekly pear (5-8%)

Date Kernel (7-9%)

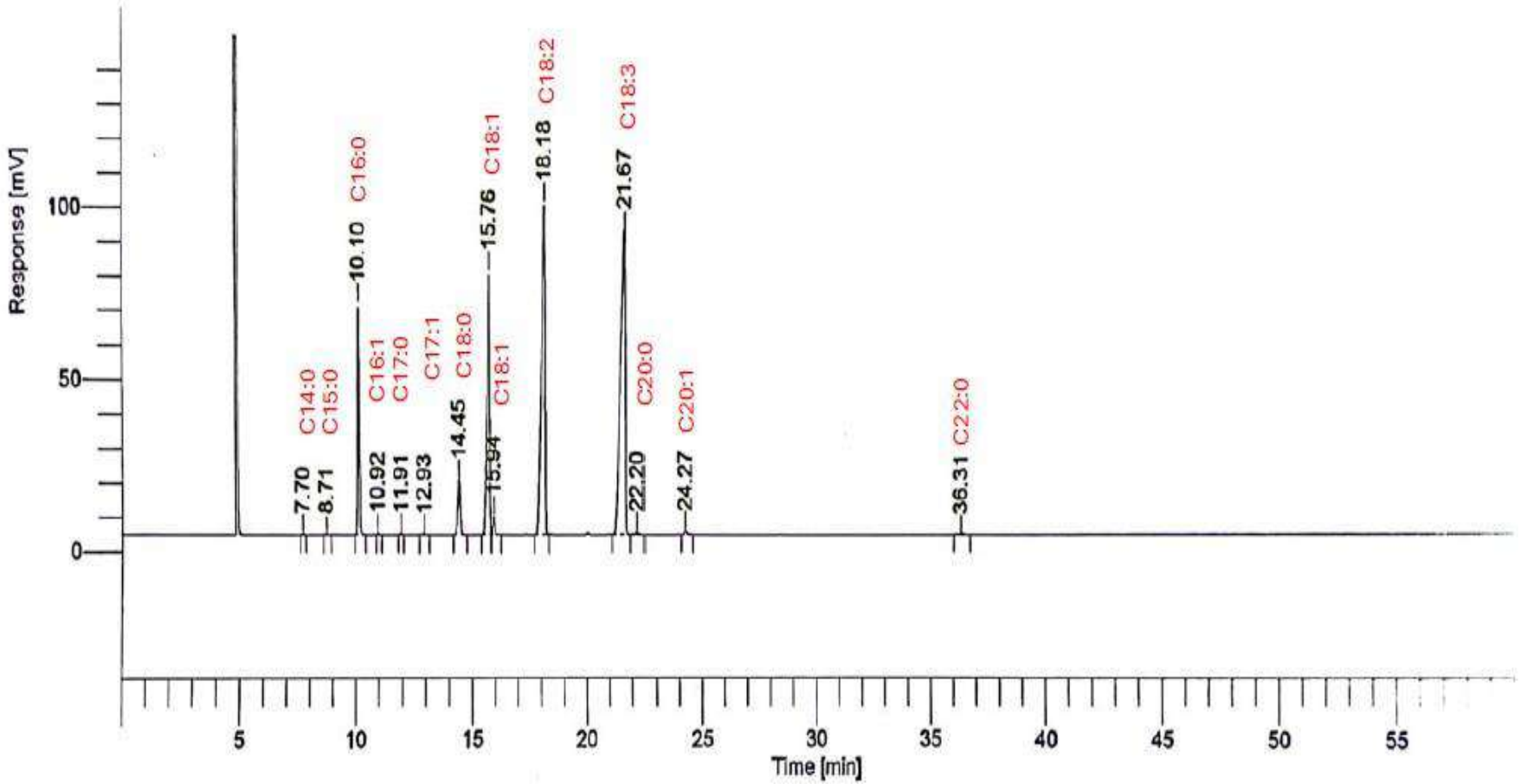
Guava (14-16%)

Melon (25-28%)

Kiwi (28-30%)

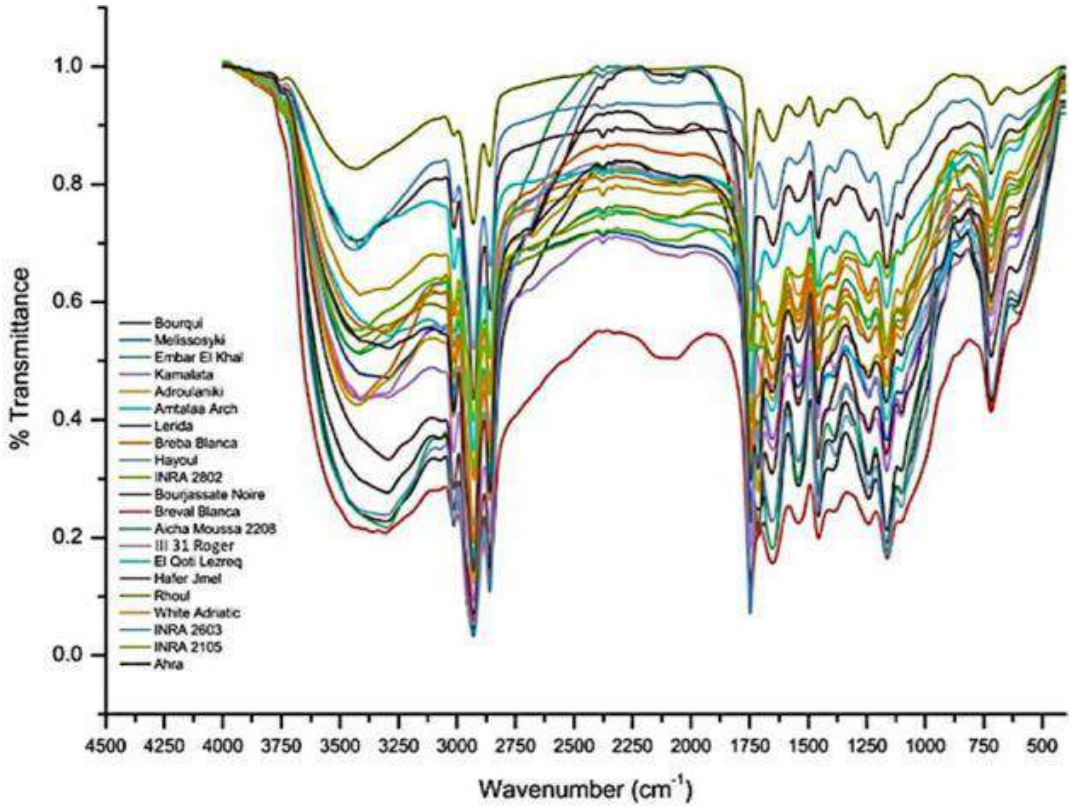
Fatty Acid Composition of Seed Oil

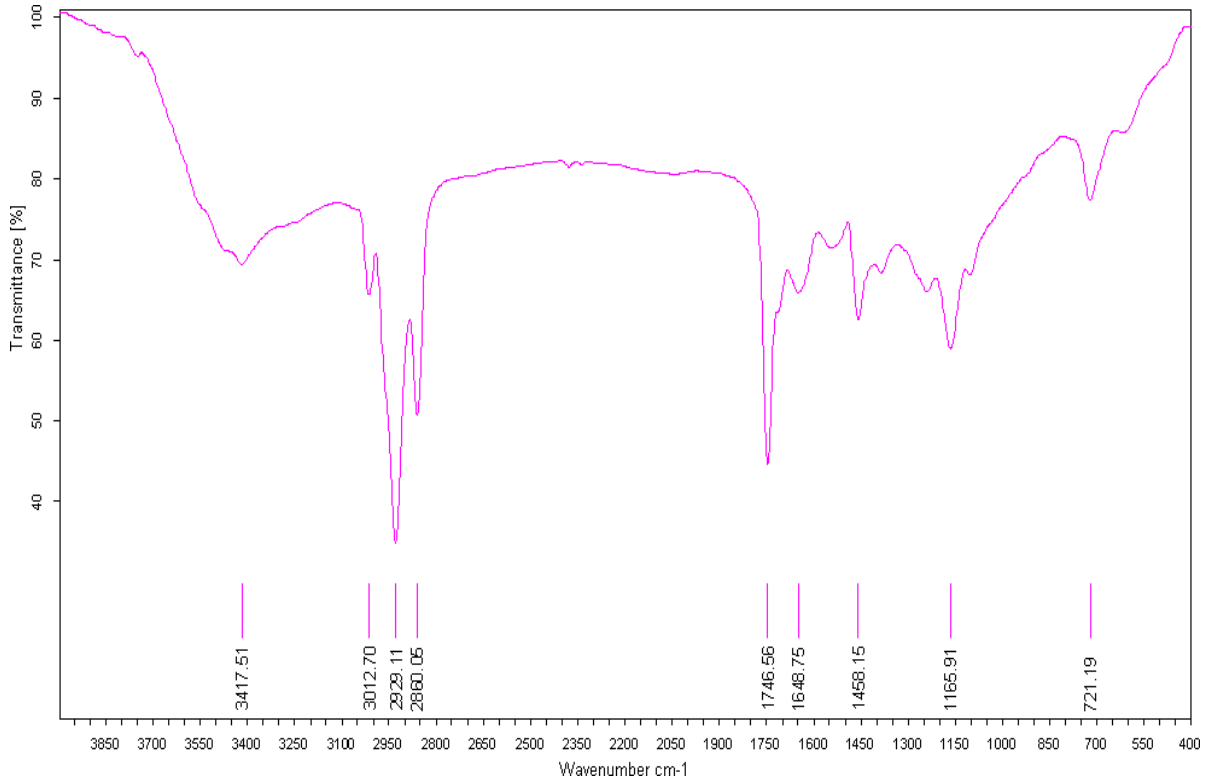
- Unsaturated fatty acids (IFAs) dominate, with high levels of omega-3 (C18:3) and omega-6 (C18:2), which are beneficial to health (heart, immunity).
- The variety 'Amtalaa Arch' stands out as the richest in linolenic acid (C18:3), reaching 42.76% → best nutritional quality.
- The SFA is in low proportion, reinforcing the nutritional interest of this vegetable oil.



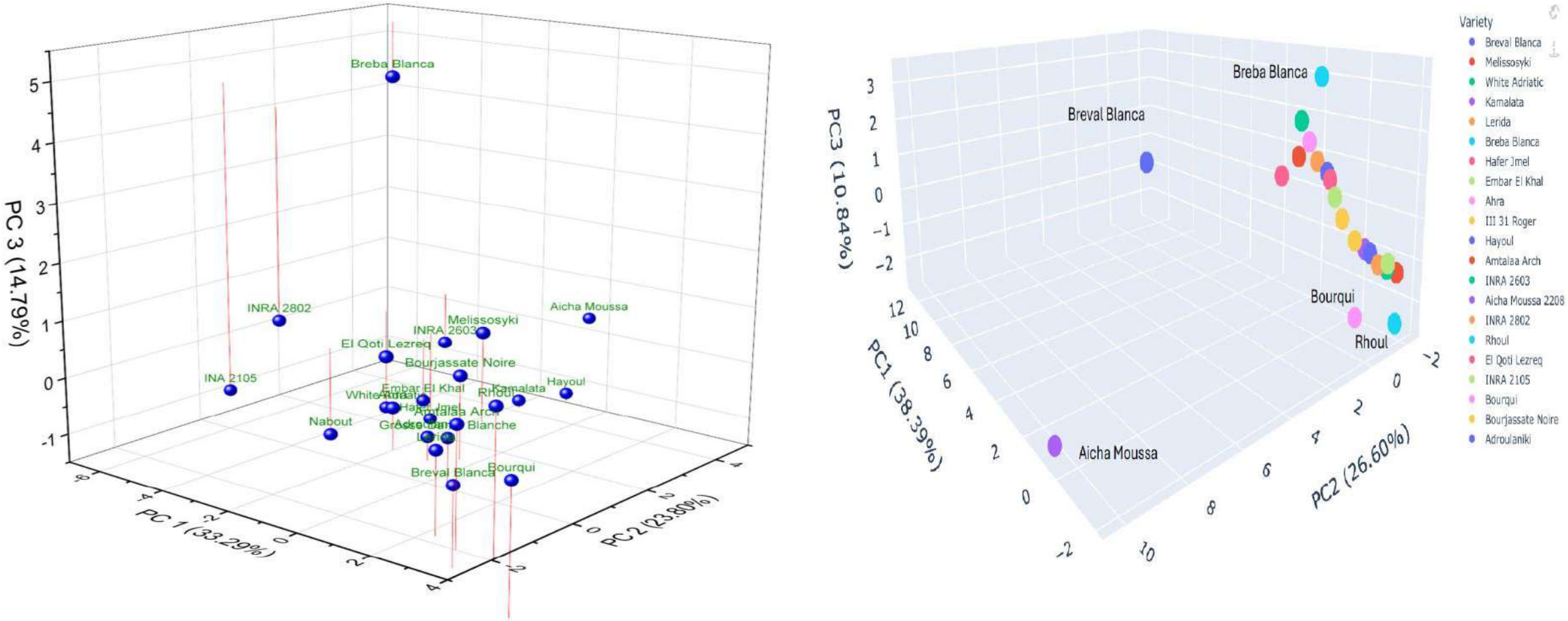
Typical GC chromatogram of the fatty acids of fig seed oil. Example of variety 'Amtala Arch ' (C14:0: myristic acid; C15:0: pentadecylic acid; C16:0: palmitic acid; C16:1: palmitoleic acid; C17:0: margaric acid; C17:1: heptadecenoic acid; C18:0: stearic acid; C18:1: oleic acid; C18:2: linoleic acid; C18:3: alpha-linolenic acid; C20:0: arachidic acid; C20:1: eicosenoic acid; C22:0: behenic acid

Characteristics of FTIR-ATR Fingerprints



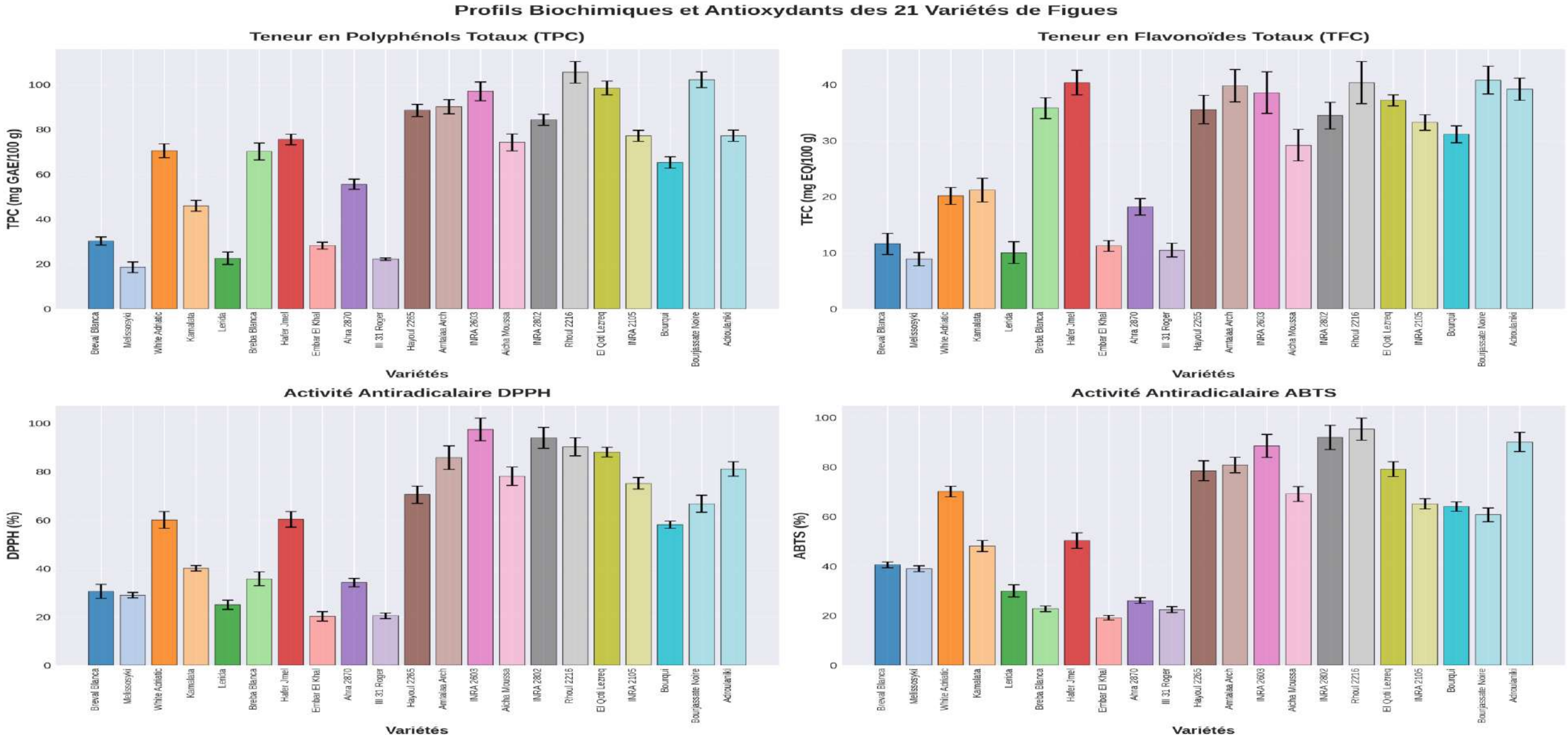


Principal Component Analysis (PCA)



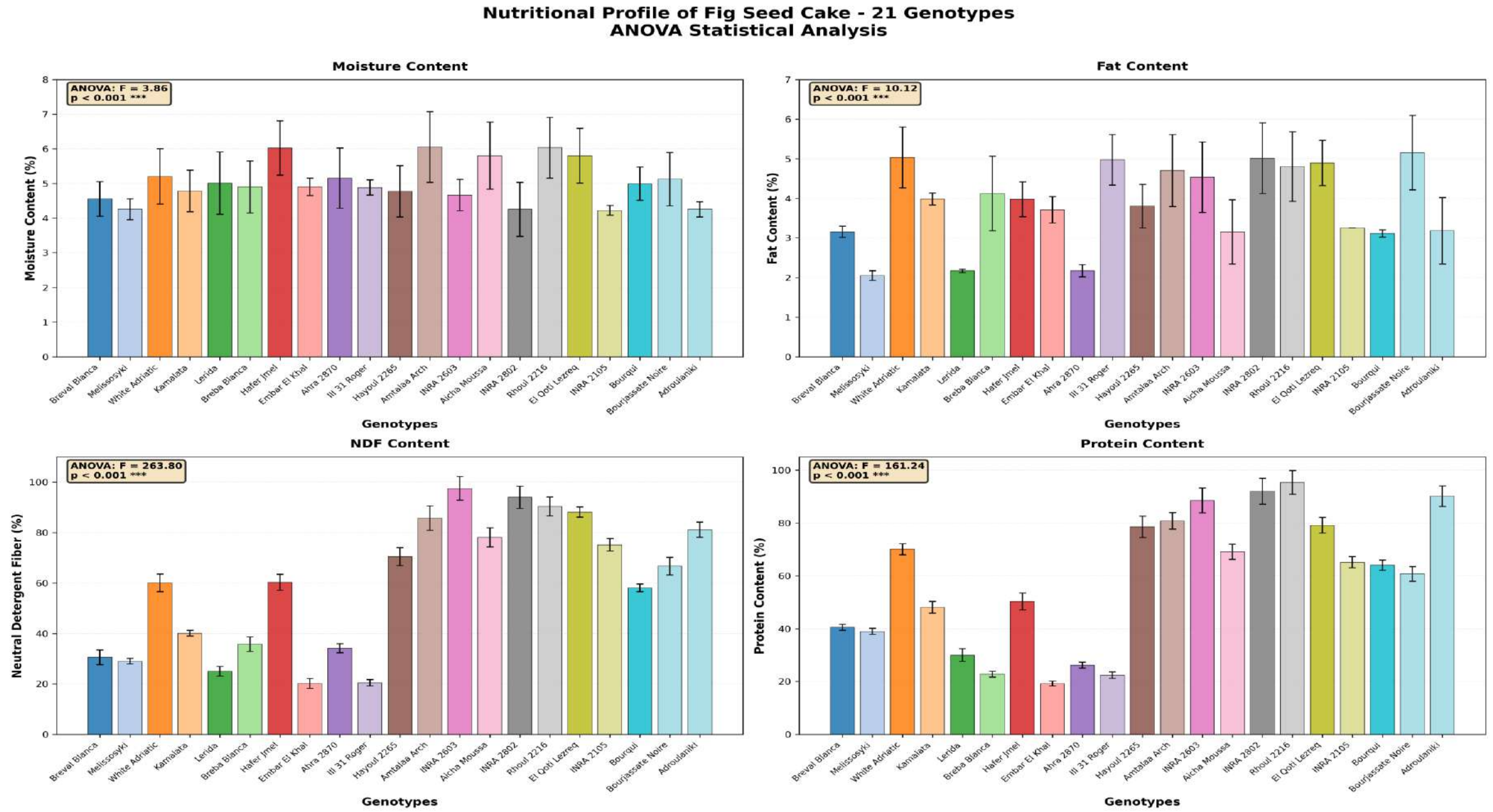
3D PCR visualization of FTIR fingerprints and lipid profiles of fig seeds: highlighting the biochemical and lipidochemical diversity of cultivars

Statistical Analysis of the Biochemical and Antioxidant Profiles



ANOVA tests revealed a highly statistically significant difference in the means of all biochemical and antioxidant parameters (TPC, TFC, DPPH, ABTS) among the 21 fig varieties ($p < 0.001$).

Statistical Analysis of the Nutritional Composition of Oil seed Cake



Conclusion and Perspectives

- Fig seeds: single source of oil with high yield (up to 40%)
- Rich in essential fatty acids: linolenic (42.7%) and linoleic (36.7%)
- Presence of saturated fatty acids: palmitic and stearic
- Genotypic variability of lipid profiles, including 'Amtala Arch' (omega-3 richness)
- FTIR-ATR + ACP: Effective tools for differentiating cultivars
- Possible applications: functional foods, cosmetics.
- Opportunities for the recovery of by-products and the creation of a circular economy

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Thank you for your attention