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Cross-Cultural Evaluation of Virgin Olive Oil, Cold-Pressed Rapeseed Oil, and Cold-Pressed Hemp Seed Oil in Greece and Türkiye: Consumer Acceptance and Nutritional Composition

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Abstract

In Mediterranean dietary cultures, culinary oils constitute an important component of dietary fat intake. However, nutritional composition does not necessarily predict consumer acceptance, which may differ according to dietary habits and cultural context. This study compared consumer acceptance of virgin olive oil (VOO), cold-pressed rapeseed oil (RO), and cold-pressed hemp seed oil (HSO) in Greece and Türkiye and characterized the nutritional composition of the oils. A randomized repeated-measures sensory study included 100 participants (50 per country), who evaluated all three oils using a nine-point hedonic scale and ranked their preferences. Mediterranean-diet adherence was assessed using the 14-item Mediterranean Diet Adherence Screener (MEDAS). Greek participants gave the highest hedonic score to VOO (5.62), followed by RO (4.84) and HSO (4.26), whereas Turkish participants preferred HSO (6.24), followed by VOO (5.24) and RO (3.72). VOO was the first choice of 64% of Greek participants, while HSO was the first choice of 52% of Turkish participants. Nutritional characterization demonstrated distinct compositional profiles among the oils. VOO contained the highest α-tocopherol concentration (628.63 ± 14.67 μg/g), whereas HSO had the highest γ-tocopherol (2967.58 ± 65.26 μg/g) and δ-tocopherol (106.59 ± 8.49 μg/g) concentrations. RO contained 1014.79 ± 18.65 μg/g γ-tocopherol and the highest β-carotene concentration (3.82 ± 0.04 μg/g), followed by VOO (3.07 ± 0.05 μg/g) and HSO (0.94 ± 0.05 μg/g). These findings demonstrate cross-cultural differences in consumer acceptance of the evaluated oils and indicate that consumer preference cannot be inferred solely from nutritional composition.

Keywords: virgin olive oil; hemp seed oil; rapeseed oil; consumer acceptance; sensory evaluation; Mediterranean diet; cross-cultural study

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1. Introduction

Vegetable oils constitute an essential component of the human diet, providing energy, essential fatty acids, fat-soluble vitamins, and numerous bioactive compounds that contribute to human health [1–3]. Beyond their nutritional value, edible oils influence

the sensory characteristics of foods and play a central role in culinary traditions, dietary patterns, and consumer food choices [1,4]. Growing scientific evidence supports replacing saturated fats with unsaturated plant oils to reduce cardiovascular disease risk and improve metabolic health [5,6]. Consequently, consumer interest has expanded beyond traditional cooking oils toward plant oils with enhanced nutritional and functional properties [1,7].

Olive oil remains the cornerstone of the Mediterranean diet and is recognized as an important source of health-promoting lipids and minor bioactive compounds [8,9]. Its high concentration of monounsaturated fatty acids, particularly oleic acid, together with phenolic compounds, tocopherols, phytosterols, and squalene, contributes to its antioxidant capacity, oxidative stability, and potential cardiovascular benefits [10–12]. These characteristics distinguish olive oil from many refined vegetable oils and help explain its prominent role in Mediterranean dietary patterns [5,8,10].

Cold-pressed rapeseed oil has emerged as an attractive alternative because of its favorable fatty-acid composition, characterized by low saturated fat content, high monounsaturated fatty acids, appreciable concentrations of α-linolenic acid (omega-3), and naturally occurring tocopherols [7,13]. Clinical evidence indicates that rapeseed oil consumption can improve blood lipid profiles and may provide cardiovascular benefits [14]. Nevertheless, its compositional and sensory characteristics differ from those of olive oil [7,13].

Cold-pressed hemp seed oil has attracted considerable scientific and commercial interest as a functional edible oil. It is characterized by a high proportion of polyunsaturated fatty acids, particularly linoleic acid and α-linolenic acid, with an omega-6/omega-3 ratio considered nutritionally favorable [15,16]. Hemp seed oil also contains γ-linolenic acid, tocopherols, phytosterols, and other minor bioactive compounds [15,17]. However, its high degree of unsaturation makes it more susceptible to oxidation than oils rich in monounsaturated fatty acids, which may influence shelf life and sensory quality [17,18]. Recent research is particularly relevant to the present study because Scottish cold-pressed hemp oils have been shown to contain approximately 74.93–76.92% PUFA, 53.8–55.3% omega-6 fatty acids, and 19.4–20.5% omega-3 fatty acids, with omega-6/omega-3 ratios of approximately 2.67–2.82 [18]. The same work reported relatively low oxidative induction times for Scottish hemp oils, illustrating the nutritional–technological trade-off associated with highly unsaturated oils [18].

Hemp seed oil (HSO) was included in the present study because of its distinctive nutritional composition and growing recognition as a sustainable alternative edible oil. Rich in essential polyunsaturated fatty acids, particularly linoleic acid and α-linolenic acid, and containing γ-linolenic acid, tocopherols, phytosterols, and other bioactive compounds, HSO differs from the predominantly monounsaturated fatty-acid profile of olive oil [15–17]. Despite these nutritional characteristics, HSO remains less familiar to consumers and less established in traditional Mediterranean dietary practices than olive oil and rapeseed oil. Its inclusion was therefore motivated by its nutritional relevance rather than its prevalence in habitual consumption. Furthermore, comparing HSO acceptance among Greek and Turkish consumers provides an opportunity to investigate preferences for an alternative oil with a distinct nutritional profile across populations with different dietary backgrounds and potentially varying levels of familiarity, supporting the broader objective of examining consumer acceptance in different cultural contexts.

Virgin and unrefined oils were selected to compare consumer acceptance and nutritional characteristics of oils with distinct fatty-acid compositions and naturally occurring minor components. Although the present study evaluated the oils individually rather than as blends, vegetable oil blending represents a potential approach to modifying

fatty-acid composition, nutritional characteristics, and oxidative stability according to the intended application [19]. However, the effects of blending were beyond the scope of the present study.

Although the nutritional composition of olive, rapeseed, and hemp seed oils has been extensively investigated individually, direct comparative studies evaluating these oils within the same experimental framework remain limited [1,13,17]. Moreover, objective nutritional quality does not necessarily translate into consumer preference. Acceptance of edible oils is influenced by sensory characteristics, familiarity, perceived healthiness, cultural background, and previous dietary habits [11,12]. Cross-cultural research has demonstrated that consumer preferences for olive oil and other edible oils can differ according to prior experience, origin, and cultural context [12,18].

Consumption patterns provide an important context for interpreting consumer acceptance of edible oils. Olive oil is particularly relevant within Mediterranean dietary practices, and Greece is characterized by high per capita olive oil consumption. According to the International Olive Council, estimated olive oil consumption in Greece reached 9.3 kg per capita in the 2022/23 crop year [20]. In contrast, directly comparable country-specific consumption estimates for rapeseed oil and hemp seed oil are less readily available, particularly for hemp seed oil, which is less established in habitual dietary practices.

Greece and Türkiye share geographical proximity and important elements of Mediterranean culinary heritage, but differences in dietary practices, exposure to alternative vegetable oils, market availability, and consumer knowledge may influence attitudes toward emerging oils such as rapeseed and hemp seed oil [12,18]. The aim of this study was to evaluate and compare consumer acceptance of olive oil, cold-pressed rapeseed oil, and cold-pressed hemp seed oil in Greece and Türkiye, and to assess differences in their nutritional composition, including fatty acid profiles and fat-soluble vitamin content. In this context, the present study focused on consumer acceptance and preference for VOO, RO, and HSO among Greek and Turkish participants, rather than on estimating habitual consumption or market demand. The inclusion of HSO allowed the evaluation of consumer responses to an alternative oil with a distinctive nutritional composition and potentially different levels of familiarity across the two populations.

2. Materials and Methods

2.1. Materials—Oil Samples

Three commercially available cold-pressed edible oils were evaluated: VOO, cold-pressed RO, and cold-pressed HSO. VOO was obtained from olives (*Olea europaea* L.) cultivated in an olive grove located in Piskokefalo, Lasithi, Crete, Greece. The olives were harvested at the end of November 2025 and processed immediately by mechanical extraction to obtain olive oil.

Cold-pressed RO was obtained from rapeseed (*Brassica napus* L.) cultivated in Fyvie, Aberdeenshire, Scotland. The crop was harvested in late July 2025, and the seeds were mechanically cold-pressed at Oldmeldrum, Aberdeenshire, in January 2026. The oil used in the present study was produced on 2 February 2026 and subsequently filtered to 1 μm to remove suspended particles while preserving its native composition.

Cold-pressed HSO was obtained from a commercial producer located in Angus, Scotland. The oil was produced in Aberdeenshire, Scotland, from hemp (*Cannabis sativa* L.) seeds harvested during the September–October 2025 growing season. Following mechanical cold pressing, the oil was supplied without further refining. All oils were obtained directly from the producers in unopened commercial containers and stored in dark glass bottles at 15–18 °C until analysis and sensory evaluation. Before sensory test-

ing, oils were equilibrated to 22 ± 2 °C.

2.2. Nutritional Characterization of Edible Oils

2.2.1. Analysis of Total Fat

Total fat content of the oil samples was determined using the Soxtec method, following the previously described procedure [21]. Analyses were carried out using a Soxtec™ 2050 Auto Fat Extraction System (FOSS A/S, Hillerød, Denmark).

2.2.2. GC-FID Analysis of Fatty Acids in Food Samples

Fatty acid methyl esters (FAMEs) were analysed following lipid extraction based on the method described by Bligh and Dyer (1959) [22]. Samples (50–200 mg) were dispersed in 2 mL methanol and homogenised using an Ultra-Turrax homogeniser (IKA T10, IKA, Staufen, Germany) at setting 4 (2800 × g) for 30 s at 5 °C. Chloroform (4 mL) was added, and homogenisation continued for 2 min. Following centrifugation, the supernatant was collected, and the residue was re-extracted with 5 mL chloroform (2:1, *v*/*v*). The combined extracts were mixed with 6 mL deionised water and centrifuged at 1800× *g* for 5 min at 5 °C. The lower chloroform phase was recovered and evaporated under nitrogen.

For derivatisation, 20 mg of extracted lipids was mixed with 0.5 mL hexane, methanolic HCl prepared from methanol (20 mL) and acetyl chloride (2 mL), and heptadecanoic acid (0.01 mL, 2 mg mL^{-1} in methanol) as an internal standard. Samples were heated at 105 °C for 2 h using a dry-block heater. After cooling, 2.5 mL distilled water and 2.5 mL hexane were added, followed by centrifugation at 1800 × g for 5 min at 5 °C. The organic phase was further extracted twice with 2.5 mL diethyl ether. Combined extracts were washed with 4 mL distilled water, followed by an additional 5 mL water wash. The organic phase was dried over 1–2 cm anhydrous sodium sulphate, evaporated under nitrogen at 40 °C, and reconstituted in 0.1 mL butylated hydroxytoluene (BHT; 0.02% in hexane) before GC analysis.

FAMEs were separated using an Agilent 6890N gas chromatograph (Agilent Technologies, Stockport, UK) equipped with a CP-SIL 88 capillary column (50 m × 0.25 mm). Helium was used as carrier gas at approximately 0.8 mL min^{-1} and 16 psi. Injector and detector temperatures were 250 °C and 270 °C, respectively. The oven programme started at 80 °C, increased to 160 °C (3 min hold), followed by 190 °C and a final temperature of 230 °C, maintained for 18 min to ensure complete FAME elution.

Fatty acid composition was determined following extraction of the lipid fraction and subsequent transesterification to produce fatty acid methyl esters (FAMEs), which were extracted in methanolic HCl according to the method described by Bligh and Dyer [22]. FAMEs were separated by gas chromatography using a Hewlett Packard HP7890N system (Agilent Technologies, Santa Clara, CA, USA) fitted with a CP-SIL 88 (50 m × 0.25 mm) column and equipped with a flame ionization detector (FID).

2.2.3. HPLC Determination of Retinol, Carotenoids and Tocopherols in Food Samples

Retinol, carotenoids and tocopherols were quantified using reverse-phase HPLC based on the method documented by Hess et al. (1991) [23]. Analyses were performed using a Waters Alliance HPLC system (Waters Corporation, Milford, MA, USA) equipped with a 2487 dual-wavelength UV detector and a 2475 multi-wavelength fluorescence detector, controlled by Empower 3 software. Separation was achieved using a Phenomenex Luna C18(2) column (250 × 4.6 mm, 5 µm) at 29 °C. The mobile phase comprised acetonitrile (67.4%), tetrahydrofuran (22.0%), methanol containing BHT (6.8%) and ammonium acetate solution (3.8%), delivered at 1.23 mL min^{-1}. Samples (100 µL)

were injected with a 25 min run time. Carotenoids were detected at 450 nm, while tocopherols and retinol were detected by fluorescence at excitation/emission wavelengths of 298/330 nm and 328/470 nm, respectively. The method quantified α-carotene, β-carotene, lycopene, β-cryptoxanthin, xanthophylls, retinol, and α-, γ- and δ-tocopherol.

Samples were homogenised, and approximately 200 µL of homogenate was mixed with ascorbic acid and ethanol, followed by alkaline saponification with potassium hydroxide at 60 °C. After cooling, echinenone was added as an internal standard, and analytes were extracted using hexane containing BHT. Following centrifugation, the hexane extract was evaporated to dryness, and residues were reconstituted in DEA solvent (dioxane, ethanol and acetonitrile) and transferred into amber autosampler vials.

Reference standards included α-carotene, β-carotene, lycopene and β-cryptoxanthin in hexane, and xanthophylls, retinol, and α-, γ- and δ-tocopherol in ethanol. NIST-supplied extinction coefficients were used to calculate and verify analyte concentrations. A mixed calibration standard containing all analytes was prepared at defined concentrations and serially diluted to generate five calibration levels. The highest standard contained α-carotene (1.0 µg mL^{-1}), β-carotene (0.6 µg mL^{-1}), lycopene (1.0 µg mL^{-1}), β-cryptoxanthin (0.2 µg mL^{-1}), xanthophylls (0.5 µg mL^{-1}), retinol (1.5 µg mL^{-1}), δ-tocopherol (1 µg mL^{-1}), γ-tocopherol (32 µg mL^{-1}) and α-tocopherol (20 µg mL^{-1}). Subsequent calibration levels were prepared by serial 1:2 dilution in hexane. Standards underwent the same extraction and analytical procedures as samples. Quality control included echinenone as an internal standard, triplicate sample analysis, and food quality-control materials analysed after every ten samples to monitor batch-to-batch and day-to-day variation. Fresh calibration curves were prepared for each sample set to account for detector response and analyte stability.

The analytical limits of detection (LOD) and quantification (LOQ) were established for each target analyte. The LOD values ranged from 2 to 100 ng/mL, while the LOQ values ranged from 6 to 160 ng/mL. Specifically, the LOD/LOQ values (ng/mL) were as follows: xanthophylls, 3/6; β-cryptoxanthin, 5/6; lycopene, 7–8/10; α-carotene, 2/8; β-carotene, 5–6/9; δ-tocopherol, 10/16; γ-tocopherol, 100/160; α-tocopherol, 50/80; and retinol, 25/30.

2.2.4. Peroxide Value Determination

Peroxide value (PV) was determined according to the iodometric visual endpoint method described in ISO 3960:2017 [24], with minor laboratory adaptations. Briefly, approximately 5.0 g of oil was dissolved in 50 mL of glacial acetic acid–isooctane solution (60:40, *v*/*v*). Subsequently, 0.5 mL of saturated potassium iodide solution was added, and the mixture was allowed to react for 1 min with gentle mixing. After the addition of 30 mL of distilled water, the liberated iodine was titrated with 0.01 N sodium thiosulfate solution. A freshly prepared 1% soluble starch solution was used as the indicator near the endpoint, and titration was conducted until disappearance of the blue-violet color. A reagent blank was analyzed under identical conditions. Peroxide value was expressed as milliequivalents of active oxygen per kilogram of oil (meq O_2/kg oil) and calculated as follows:

$$PV = [(Vsample–Vblank) \times N \times 1000] / m$$

where Vsample and Vblank represent the values of sodium thiosulfate consumed by the sample and blank, respectively (mL), N is the normality of sodium thiosulfate, and m is the sample mass (g).

2.2.5. Colour Measurement

The colour of the vegetable oil samples was determined using a JCS-200 portable colorimeter (KERN, Balingen, Germany) operating with diffuse illumination/8° viewing geometry (d/8). Before analysis, the instrument was calibrated using the manufacturer's standard white calibration plate. Oil samples were transferred into optically clear glass cells and measured at 22 ± 2 °C. Colour was recorded in the CIELAB colour space as L* (lightness), a* (redness/greenness), and b* (yellowness/blueness). Three independent measurements were performed for each sample, and results were expressed as mean ± standard deviation.

Fatty acid composition, fat-soluble vitamin content and colour were determined using the analytical procedures described above. Each commercial oil sample was analysed in triplicate by repeated analytical measurements of the same preparation. Therefore, the three replicates represent analytical replicates rather than independent commercial samples or production batches.

2.3. Consumer Sensory Evaluation

2.3.1. Study Design

This study was designed as a randomized, cross-cultural consumer sensory evaluation involving 100 participants, comprising 50 participants from Greece and 50 from Türkiye. Consumer sensory evaluation was conducted using a randomized repeated-measures design, in which each participant evaluated all three oil samples under identical experimental conditions. Overall consumer acceptance, assessed using a 9-point hedonic scale, was defined as the primary outcome.

The study was conducted in accordance with the Declaration of Helsinki and received ethical approval from the Research Ethics Committee of the Hellenic Mediterranean University (Approval No. 165844/16-03-2026) and the Research Ethics Committee of Acibadem Mehmet Ali Aydinlar University (Approval No. 2026-10/113). All participants provided written informed consent before participation.

2.3.2. Experimental Procedure

Participants were instructed to refrain from eating, consuming beverages other than water, chewing gum, or smoking for at least one hour before testing, following procedures reported in a previous consumer sensory study of olive oil [25,26]. Each participant evaluated the three oil samples during a single session, with serving order determined using a Williams Latin Square design to balance presentation sequences and minimize first-order carry-over effects [27]. Samples were served in identical opaque plastic cups labelled with randomly generated three-digit codes to conceal product identity and minimize visual and expectation-related bias [25,26]. A standardized volume of 5 mL was served for each oil sample to all participants in both countries. Water and unsalted crackers were provided for palate cleansing between samples. The oils were stored in a dark, dry place until sensory evaluation and were served at room temperature (approximately 22 °C). The study was conducted between March and August 2026.

2.3.3. Consumer Questionnaire

Participants completed a structured questionnaire before sensory evaluation. Information collected included age, sex, educational level, smoking status, frequency of edible oil consumption, familiarity with rapeseed and hemp seed oils, and previous consumption habits. Adherence to the Mediterranean diet was assessed using the validated 14-item Mediterranean Diet Adherence Screener (MEDAS), with scores ranging from 0 to 14 and higher scores indicating greater adherence [28].

Consumer acceptance was assessed using a nine-point hedonic scale (1 = 'Dislike extremely' to 9 = 'Like extremely') [29]. Following completion of the hedonic evaluation, participants ranked the three oils from the most preferred to the least preferred.

2.4. Statistical Analysis

Descriptive statistics were calculated for participant characteristics, MEDAS scores, hedonic ratings, preference rankings, colour measurements, and fat-soluble vitamin concentrations. Differences in hedonic ratings among the three oils were assessed separately for each country using one-factor repeated-measures ANOVA, with oil type as the within-subject factor. Mauchly's test was used to assess sphericity, and the Greenhouse–Geisser correction was applied when this assumption was violated. Bonferroni-adjusted pairwise comparisons were performed following significant repeated-measures ANOVA results. Differences in VOO acceptance across MEDAS adherence categories were assessed using one-way ANOVA, followed by Bonferroni-adjusted post hoc comparisons where appropriate. Fat-soluble vitamin and fatty acid results were expressed as mean ± standard deviation (SD; n = 3 analytical replicates). Fat-soluble vitamin and fatty acid data, including n-3 PUFA, n-6 PUFA, and the n-6/n-3 ratio, were compared among olive, hemp, and rapeseed oils using one-way analysis of variance (ANOVA). When significant differences were detected, Tukey's HSD post hoc test was applied for pairwise comparisons. Statistical significance was set at $p < 0.05$. Statistical analyses were performed using IBM SPSS Statistics **(**Version 32.0.0**)**.

3. Results

3.1. Consumer Characteristics and Mediterranean Diet Adherence

The study included 100 participants, with 50 participants recruited from each cohort. The demographic characteristics and MEDAS adherence categories of the Greek and Turkish participants are presented in Table 1. Each participant evaluated VOO, cold-pressed RO, and cold-pressed HSO in a randomized repeated-measures design.

Table 1. Sociodemographic characteristics and Mediterranean Diet Adherence Score (MEDAS) of participants in the Greek and Turkish cohorts.

Variables	**Greek Cohort—MEDAS Score**				**Turkish Cohort—MEDAS Score**			
	TOTAL	≤5	6–9	≥10	TOTAL	≤5	6–9	≥10
n (%)	50 (100)	10 (20)	36 (72)	4 (8)	50 (100)	23 (46)	27 (54)	
AGE mean (SD)	23.44 (8.89)	23.4 (7.39)	22.78 (8.41)	29.5 (13.22)	30.7 (10.26)	27.65 (8.47)	33.29 (11.07)	
				Sex (n%)				
Male	13 (26)	5 (50)	6 (17)	2 (50)	11 (22)	6 (12)	5 (10)	
Female	37 (74)	5 (50)	30 (83)	2 (50)	39 (78)	17 (34)	22 (44)	
Other	0 (0)	0	0	0	0 (0)	0	0	
Prefer not to answer	0 (0)	0	0	0	0 (0)	0	0	
				Marital status				
Single	41 (82)	9 (90)	30 (83)	2 (50)	27 (54)	15 (30)	12 (24)	
Married/Civil Partnership	3 (6)	0	2 (6)	1 (25)	23 (46)	8 (16)	15 (30)	
Other	6 (12)	1 (10)	4 (11)	1 (25)	0 (0)	0	0	
Prefer not to answer	0 (0)	0	0	0	0 (0)	0	0	
				Do you have children?				
YES	3 (6)	0	2 (6)	1 (25)	12 (24)	3 (6)	9 (18)	
NO	47 (94)	10 (100)	34 (94)	3 (75)	38 (76)	20 (40)	18 (36)	
				What is your level of education?				
Primary education (Elementary school)	0 (0)	0	0	0	0 (0)	0	0	
Lower secondary education (Junior high school)	0 (0)	0	0	0	0 (0)	0	0	
Upper	45 (90)	8 (80)	33 (92)	4 (100)	11 (22)	6 (12)	5 (10)	

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Variables	Greek Cohort—MEDAS Score				Turkish Cohort—MEDAS Score		
secondary/post-secondary (High school/Vocational training)							
Higher education (University/Technological institute)	3 (6)	1 (10)	2 (5)	0	39 (78)	17 (34)	22 (44)
Other	2 (4)	1 (10)	1 (3)	0	0 (0)	0	
Employment status							
Public sector employee	7 (14)	2 (20)	4 (11)	1 (25)	0 (0)	0	0
Private sector employee	1 (2)	0	1 (3)	0	29 (58)	12 (24)	17 (34)
Self-employed	0	0	0	0	1 (2)	0	1 (2)
Unemployed (seeking work)	0	0	0	0	0 (0)	0	0
Student	42 (84)	8 (80)	31 (86)	3 (75)	20 (40)	11 (22)	9 (18)
Other	0	0	0	0	0 (0)	0	
Working hours per day							
Not working/Other	41 (82)	7 (70)	31 (86)	3 (75)	17 (34)	10 (20)	7 (14)
4–6 h/day	2 (4)	1 (10)	1 (2)	0	1 (2)	0	1 (2)
8 h/day	5 (10)	2 (20)	2 (6)	1 (25)	28 (56)	11 (22)	17 (34)
>10 h/day	2 (4)	0	2 (6)	0	4 (8)	2 (4)	2 (4)
Do you consume vegetable oils?							
YES	43 (86)	7 (70)	32 (89)	4 (100)	50 (100)	23 (46)	27 (54)
NO	7 (14)	3 (30)	4 (11)	0	0 (0)	0	0
If yes, how often?							
Daily	32 (74)	4 (57)	24 (75)	4 (100)	43 (86)	19 (38)	24 (48)
Twice a week	7 (16)	2 (29)	5 (16)	0	6 (12)	3 (6)	3 (6)

Variables	Greek Cohort—MEDAS Score				Turkish Cohort—MEDAS Score		
Once a week	3 (7)	0	3 (9)	0	1 (2)	1 (2)	0
Once a month	1 (3)	1 (14)	0	0	0 (0)	0	0
MEDITERRANEAN DIET ADHERRENCE							
MEDAS, mean (SD)	7.16 (1.84)	4.3 (1.0)	7.61 (0.92)	10.25 (0.43)	5.84 (1.87)	4.08 (1.04)	7.33 (1.03)
MEDAS (minimum, maximum)	2, 11	2, 5	6, 9	10, 11	2, 9	2, 5	6, 9
Do you use olive oil as the main source of fat for cooking?							
YES	47 (94)	9 (90)	34 (94)	4 (100)	49 (98)	22 (44)	27 (54)
NO	3 (6)	1 (10)	2 (6)	0	1 (2)	1 (2)	0
How much olive oil do you consume per day (including frying, salads, eating out, etc.)?							
≥4 Tablespoon	13 (26)	0	11 (31)	2 (50)	23 (46)	11 (22)	12 (24)
≤3 Tablespoon	37 (74)	10 (100)	25 (69)	2 (50)	27 (54)	12 (24)	15 (30)
How many servings of vegetables do you consume per day? (1 serving = 200 g; side dishes = ½ serving)							
≥2	30 (60)	4 (40)	22 (61)	4 (100)	13 (26)	2 (4)	11 (22)
≤1	20 (40)	6 (60)	14 (39)	0	37 (74)	21 (42)	16 (32)
How many servings of fruit (including fresh juices) do you consume per day?							
≥3	12 (24)	0	12 (33)	0	10 (20)	2 (4)	8 (16)
≤2	38 (76)	10 (100)	24 (67)	4 (100)	40 (80)	21 (42)	19 (38)
How many servings of red meat, hamburgers, or sausages do you consume per day? (1 serving = 100–150 g)							
<1	35 (70)	4 (40)	27 (75)	4 (100)	16 (32)	2 (4)	14 (28)
≥1	15 (30)	6 (60)	9 (25)	0	34 (68)	**21 (42)**	13 (26)
How many servings of butter, margarine, or other fats do you consume per day? (1 serving = 12 g)							
<1	45 (90)	7 (70)	34 (94)	4 (100)	28 (56)	8 (16)	20 (40)
≥1	5 (10)	3 (30)	2 (6)	0	22 (44)	15 (30)	7 (14)
How many carbonated and/or sugary drinks do you consume per day?							
<1	39 (78)	4 (40)	32 (89)	3 (75)	33 (66)	10 (20)	23 (46)
≥1	11 (22)	6 (60)	4 (11)	1 (25)	17 (34)	13 (26)	4 (8)

Variables	Greek Cohort—MEDAS Score				Turkish Cohort—MEDAS Score		
Do you drink wine? How much do you consume per week?							
≥7	2 (4)	0	2 (6)	0	0 (0)	0 (0)	0 (0)
≤6	48 (96)	10 (100)	34 (94)	4 (100)	50 (100)	23 (46)	27 (54)
How many servings of legumes do you consume per week? (1 serving = 150 g)							
≥3	11 (22)	0	7 (19)	4 (100)	14 (28)	2 (4)	12 (24)
≤2	39 (78)	10 (100)	29 (81)	0	36 (72)	21 (42)	15 (30)
How many servings of fish/seafood do you consume per week? (1 serving = 100–150 g fish or ~200 g seafood)							
≥3	0	0	0	0	2 (4)	0 (0)	2 (4)
≤2	50 (100)	10 (100)	36 (100)	4 (100)	48 (96)	23 (46)	25 (50)
How many times per week do you consume commercial (non-homemade) sweets (e.g., biscuits, cakes)?							
<2	26 (52)	3 (30)	19 (53)	4 (100)	28 (56)	10 (20)	18 (36)
≥2	24 (48)	7 (70)	17 (47)	0	22 (44)	13 (26)	9 (18)
How many times per week do you consume nuts? (1 serving = 30 g)							
≥3	16 (32)	1 (10)	11 (31)	4 (100)	14 (28)	3 (6)	11 (22)
≤2	34 (68)	9 (90)	25 (69)	0	36 (72)	20 (40)	16 (32)
Do you prefer chicken, turkey or rabbit instead of beef, pork, hamburgers or sausages?							
Yes	37 (74)	5 (50)	28 (78)	4 (100)	24 (48)	7 (14)	17 (34)
No	13 (26)	5 (50)	8 (22)	0	26 (52)	16 (32)	10 (20)
How many times per week do you consume dishes with tomato, onion, garlic, or leek sauce cooked in olive oil (e.g., vegetables, pasta, rice)?							
≥2	45 (90)	6 (60)	35 (97)	4 (100)	38 (76)	16 (32)	22 (44)
≤1	5 (10)	4 (40)	1 (3)	0	12 (24)	7 (14)	5 (10)

Values are presented as n (%) unless otherwise indicated. Age and MEDAS are presented as mean (SD). MEDAS categories: low adherence ≤5, moderate adherence 6–9, and high adherence ≥10. The Turkish cohort had no participants in the ≥10 category.

The Greek cohort had a higher mean MEDAS score than the Turkish cohort (7.16 ± 1.84 vs. 5.84 ± 1.87, respectively). In Greece, 10 participants were classified as having low adherence (≤5), 36 as moderate adherence (6–9), and 4 as high adherence (≥10). In Türkiye, 23 participants were classified as having low adherence and 27 as moderate adherence, while no participants were classified in the high-adherence category.

3.2. Hedonic Acceptance of the Oils

Clear differences in consumer acceptance were observed between the two cohorts (Figure 1). Panel A represents the Greek cohort and Panel B the Turkish cohort. In the Greek cohort, VOO received the highest mean hedonic score (5.62), followed by RO (4.84) and HSO (4.26). In contrast, the Turkish cohort showed the highest acceptance for HSO (6.24), followed by VOO (5.24), whereas RO received the lowest mean score (3.72). A significant effect of oil type on hedonic acceptance was observed in both cohorts. In the Greek cohort, the Greenhouse–Geisser-corrected repeated-measures ANOVA showed a significant effect of oil type ($p = 0.0148$). In the Turkish cohort, the corresponding effect was considerably stronger ($p < 0.001$). The most pronounced cross-cultural difference concerned HSO, which increased from a mean score of 4.26 in Greece to 6.24 in Türkiye. VOO was more highly accepted by Greek consumers (5.62) than Turkish consumers (5.24), whereas RO was particularly poorly rated by Turkish consumers (3.72).

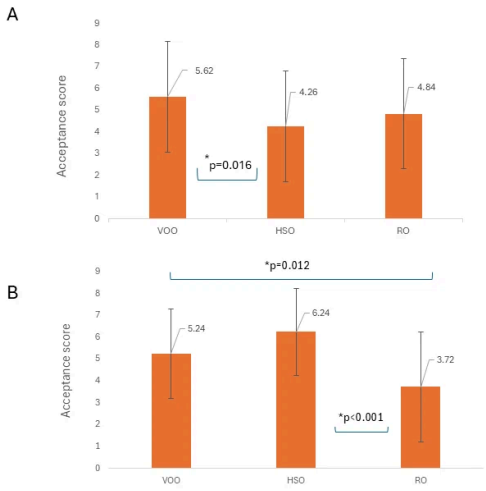


Figure 1. Mean acceptance scores for VOO, HSO, and RO: (**A**) Greek cohort and (**B**) Turkish cohort. Different letters indicate statistically significant differences between oils based on post hoc comparisons.

3.3. Consumer Preference Ranking

The preference-ranking task provided complementary evidence for the hedonic results (Figure 2). In the Greek cohort, VOO was selected as the first choice by 64% of participants, compared with 14% for HSO and 22% for RO. The corresponding first/second/third distributions were 64/14/22% for VOO, 14/46/40% for HSO, and 22/40/38% for RO.

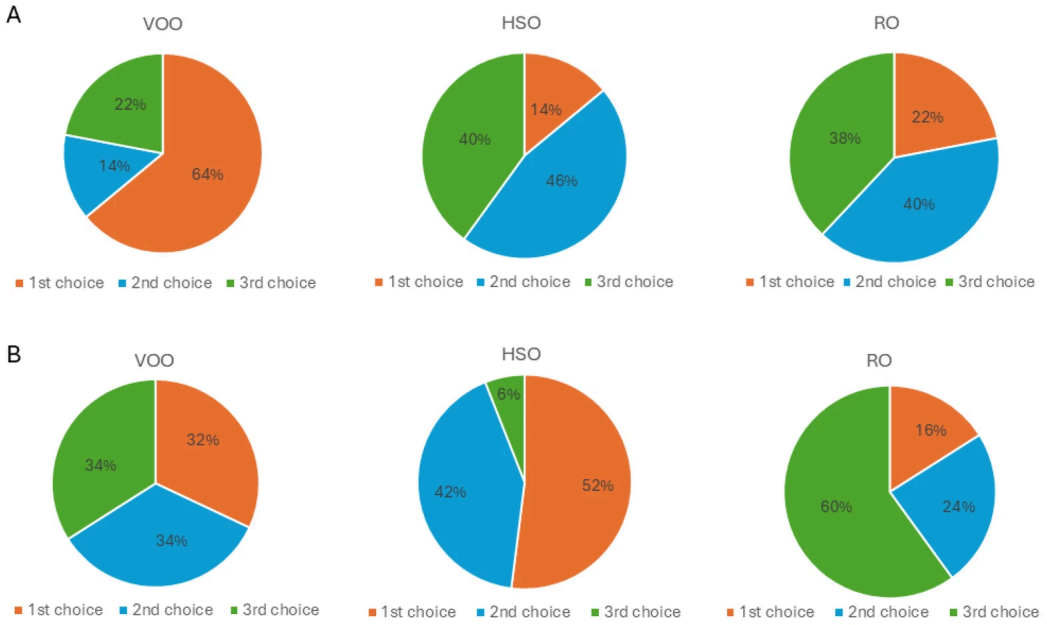


Figure 2. Participants' ranking preferences for VOO, HSO, and RO, expressed as the percentage selecting each oil as their 1st, 2nd, or 3rd choice: (**A**) Greek cohort and (**B**) Turkish cohort.

In the Turkish cohort, HSO was selected as the first choice by 52% of participants, compared with 32% for VOO and 16% for RO. The corresponding distributions were 52/42/6% for HSO, 32/34/34% for VOO, and 16/24/60% for RO. Thus, the ranking results closely followed the hedonic scores, with VOO preferred in Greece and HSO preferred in Türkiye (Figure 2).

3.4. Mediterranean Diet Adherence and Olive Oil Acceptance

Exploratory comparisons by MEDAS category indicated that dietary background may contribute to variation in consumer response (Figure 3). In the Greek cohort, mean acceptance increased from approximately 4.90 among participants with low adherence to 5.81 among those with moderate adherence. In the Turkish cohort, mean acceptance scores were approximately 5.13 among participants with low adherence and 5.33 among those with moderate adherence. Because the MEDAS categories were unevenly distributed and the high-adherence subgroup was small, these observations should be interpreted cautiously.

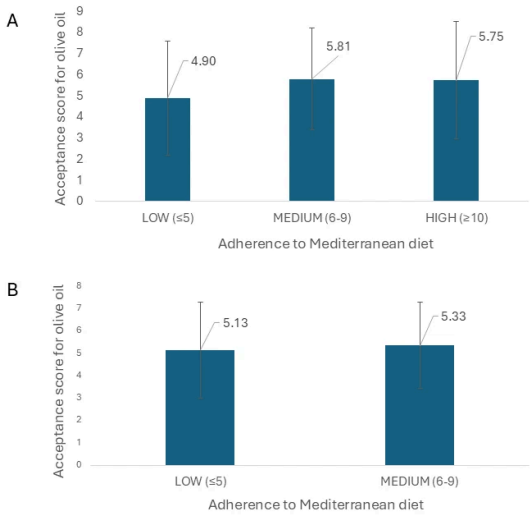


Figure 3. Mean acceptance scores for the oils according to MEDAS adherence categories: (**A**) Greek cohort and (**B**) Turkish cohort. Acceptance scores are presented for low (≤5), medium (6–9), and high (≥10) MEDAS adherence categories, where applicable.

3.5. Instrumental Colour Characteristics

The three oils exhibited distinct instrumental colour characteristics (Figure 4). RO had the highest mean lightness (L* = 47.53 ± 1.09), followed by VOO (46.16 ± 1.48) and HSO (43.46 ± 0.97). The a* values were 1.53 ± 0.11 for RO, 0.34 ± 0.24 for VOO, and 1.35 ± 0.48 for HSO. The b* coordinate was highest for RO (17.55 ± 1.89), followed by VOO (13.36 ± 1.64) and HSO (9.75 ± 1.50). Because the sensory evaluation was performed using opaque cups, visual appearance was minimized as a determinant of consumer acceptance.

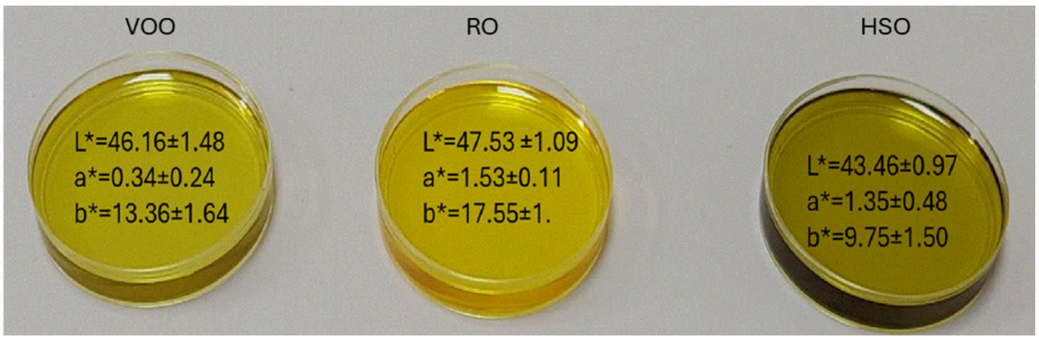


Figure 4. Visual appearance and colour characteristics of VOO, RO, and HSO. Colour parameters are presented as mean ± SD for L* (lightness), a* (red–green coordinate), and b* (yellow–blue coordinate). The oils are shown from left to right as olive oil, rapeseed oil, and hemp oil.

3.6. Fat-Soluble Vitamin Composition

Marked differences in fat-soluble vitamin concentrations were observed among the three oils (Table 2). The total concentration of measured fat-soluble vitamins was highest in HSO (3188.57 ± 62.29 μg/g), followed by RO (1310.87 ± 23.88 μg/g) and VOO (651.34 ± 15.30 μg/g). The dominant component differed by oil type. VOO contained predominantly α-tocopherol (628.63 ± 14.67 μg/g), with lower concentrations of γ-tocopherol (19.64 ± 0.64 μg/g) and β-carotene (3.07 ± 0.05 μg/g). HSO was characterized by a very

high γ-tocopherol concentration (2967.58 ± 65.26 µg/g), together with α-tocopherol (106.16 ± 5.03 µg/g), δ-tocopherol (106.59 ± 8.49 µg/g), xanthophyll (4.54 ± 0.14 µg/g), β-carotene (0.94 ± 0.05 µg/g), and retinol (2.7 ± 0.17 µg/g). RO contained 1014.79 ± 18.65 µg/g γ-tocopherol, 245.48 ± 4.42 µg/g α-tocopherol, 29.20 ± 0.76 µg/g δ-tocopherol, 17.58 ± 0.60 µg/g xanthophyll, and 3.82 ± 0.04 µg/g β-carotene. α-Carotene, lycopene, and β-cryptoxanthin were not detected in any of the three oils.

Table 2. Fat-soluble vitamin composition of VOO, HSO, and RO.

Oil Type	β-Carotene	α-Tocopherol	γ-Tocopherol	δ-Tocopherol	Retinol	Xanthophyll	Fat-Soluble Vitamins
VOO	3.07 ± 0.05 ^{b}	628.63 ± 14.67 ^{c}	19.64 ± 0.64 ^{a}	0.00 ± 0.00 ^{a}	0.00 ± 0.00 ^{a}	0.00 ± 0.00 ^{a}	651.34 ± 15.30 ^{a}
HSO	0.94 ± 0.05 ^{a}	106.16 ± 5.03 ^{a}	2967.58 ± 65.26 ^{c}	106.59 ± 8.49 ^{c}	2.75 ± 0.17 ^{b}	4.54 ± 0.14 ^{b}	3188.57 ± 62.29 ^{c}
RO	3.82 ± 0.04 ^{c}	245.48 ± 4.42 ^{b}	1014.79 ± 18.65 ^{b}	29.20 ± 0.76 ^{b}	0.00 ± 0.00 ^{a}	17.58 ± 0.60 ^{c}	1310.87 ± 23.88 ^{b}

Values are reported as mean ± standard deviation (n = 3) in µg/g of oil. The FSV total is the total sum of the measured compounds. Means followed by different lowercase letters are significantly ($p > 0.05$) different between oil types (columns). β-Cryptoxanthin, lycopene, and α-carotene were not detected, as their concentrations were below the analytical detection limits.

The significant differences among oil types for β-carotene, α-, γ-, and δ-tocopherol, retinol, xanthophyll, and total measured fat-soluble vitamins ($p < 0.05$) are shown in Table 2. For β-carotene, RO showed the highest concentration, followed by VOO and HSO. For α-tocopherol, VOO had the highest concentration, whereas HSO had the highest γ- and δ-tocopherol concentrations. HSO also showed the highest total fat-soluble vitamin concentration, followed by RO and VOO.

3.7. Fatty Acid Composition

The study oils exhibited distinct fatty-acid profiles (Table 3 and Figure 5). VOO was characterized by a high proportion of total monounsaturated fatty acids (MUFA; 71.38%), whereas HSO had the highest total polyunsaturated fatty acid (PUFA) content (76.57%). RO showed an intermediate MUFA content of 59.96%. Total saturated fatty acids (SFA) were highest in VOO (14.72%), followed by HSO (8.00%) and RO (5.72%). The total fat content was 94.99 ± 0.19 for virgin olive oil (VOO), 93.80 ± 0.49 for hemp seed oil (HSO), and 95.90 ± 0.69 for rapeseed oil (RO). The n-3 and n-6 fatty-acid data presented in Figure 6 are expressed relative to the fat content of each oil, as intended, to facilitate comparison of their fatty-acid composition. The n-3 and n-6 PUFA profiles also differed significantly among oils (Figure 6). HSO contained the highest n-3 PUFA concentration (20.48 g/100 g of oil), followed by RO (12.00 g/100 g) and VOO (1.02 g/100 g). Similarly, n-6 PUFA was highest in HSO (61.16 g/100 g), followed by RO (19.04 g/100 g) and VOO (7.53 g/100 g). The n-6/n-3 ratio was highest in VOO (7.36), followed by HSO (2.99) and RO (1.59). One-way ANOVA followed by Tukey's HSD indicated significant differences among all three oils for n-3 PUFA, n-6 PUFA, and the n-6/n-3 ratio ($p < 0.05$; Figure 6).

Table 3. Fatty acid composition of VOO, HSO, and RO.

Oil Type	Palmitic Acid	Trans-Palmitoleic Acid	Palmitoleic Acid	Stearic Acid	Oleic Acid	Linoleic Acid
VOO	11.95 ± 0.07 ^{c}	0.10 ± 0.02 ^{b}	0.83 ± 0.01 ^{b}	2.82 ± 0.03 ^{c}	74.00 ± 0.42 ^{c}	7.36 ± 0.23 ^{a}
HSO	5.22 ± 0.07 ^{b}	0.00 ± 0.00 ^{a}	0.06 ± 0.04 ^{a}	2.13 ± 0.08 ^{b}	9.04 ± 0.05 ^{a}	55.89 ± 0.17 ^{c}
RO	4.05 ± 0.09 ^{a}	0.00 ± 0.00 ^{a}	0.15 ± 0.03 ^{a}	1.01 ± 0.10 ^{a}	61.09 ± 0.05 ^{b}	18.83 ± 0.08 ^{b}

Oil type	Arachidic acid	gamma-Linolenic acid (GLA)	Gondoic acid	a-Linolenic acid	Eicosadienoic acid	Behenic acid	Cetoleic acid	Eicosapentaenoic acid (EPA)	Lignoceric acid	Nervonic acid
VOO	0.49 ± 0.03 ^{a}	0.00 ± 0.00 ^{a}	0.20 ± 0.05 ^{a}	0.97 ± 0.16 ^{a}	0.17 ± 0.03 ^{a}	0.15 ± 0.02 ^{a}	0.00 ± 0.00 ^{a}	0.06 ± 0.01 ^{a}	0.08 ± 0.01 ^{b}	0.00 ± 0.00 ^{a}
HSO	0.74 ± 0.02 ^{b}	3.73 ± 0.01 ^{b}	0.00 ± 0.00 ^{a}	20.36 ± 0.11 ^{c}	1.54 ± 0.01 ^{b}	0.43 ± 0.04 ^{b}	0.00 ± 0.00 ^{a}	0.12 ± 0.02 ^{a}	0.00 ± 0.00 ^{a}	0.00 ± 0.00 ^{a}
RO	0.50 ± 0.01 ^{a}	0.00 ± 0.00 ^{a}	0.61 ± 0.43 ^{a}	11.91 ± 0.51 ^{b}	0.21 ± 0.03 ^{a}	0.35 ± 0.04 ^{b}	0.48 ± 0.00 ^{a}	0.09 ± 0.03 ^{a}	0.06 ± 0.01 ^{b}	0.20 ± 0.02 ^{b}

Values are reported as mean ± standard deviation (n = 3) and expressed as % Fatty Acid Methyl Esters (FAME). ND = None detected. Means followed by different lowercase letters are significantly ($p > 0.05$) different between oil types (columns). Lauric acid, Myristic acid, Pentadecylic acid, and trans-Linoleic acid were not detected, as their concentrations were below the analytical detection limits.

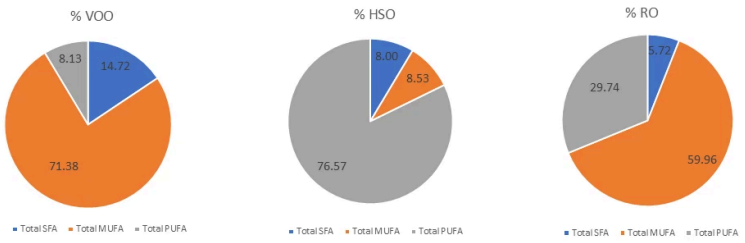


Figure 5. Fatty acid composition of VOO, HSO, and RO, expressed as % of total oil content. The proportions of total saturated fatty acids (SFA), total monounsaturated fatty acids (MUFA), and total polyunsaturated fatty acids (PUFA) are presented for each oil.

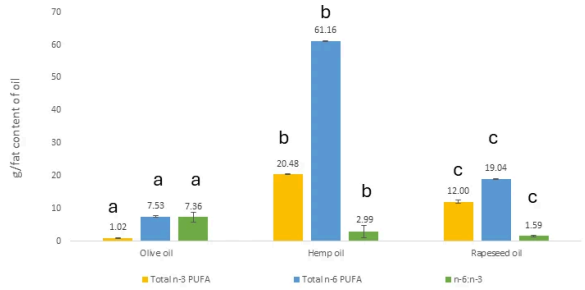


Figure 6. Total n-3 and n-6 polyunsaturated fatty acid (PUFA) content in VOO, HSO, and RO, expressed as g/fat content of oil, and the corresponding n-6/n-3 ratio. Values are presented as mean ± SD. Different lowercase letters indicate statistically significant differences among oils ($p < 0.05$).

3.8. Oxidative Stability (PV)

Peroxide values (PV) differed significantly among the three vegetable oils (p = 0.003). Hemp seed oil (HSO) exhibited the highest PV (35.10 ± 4.23 meq O_2/kg oil), followed by rapeseed oil (RO; 28.93 ± 3.23 meq O_2/kg oil), while virgin olive oil (VOO) presented the lowest value (19.73 ± 1.51 meq O_2/kg oil). Tukey's HSD post hoc test revealed significantly higher PVs in HSO (p = 0.0026) and RO (p = 0.0288) compared with VOO. However, no statistically significant difference was observed between HSO and RO ($p >$ 0.05).

4. Discussion

4.1. Cross-Cultural Differences in Consumer Acceptance

The principal finding of the present study was the substantial difference in consumer acceptance of VOO, HSO, and RO between Greek and Turkish participants. Greek consumers showed the highest acceptance of VOO, whereas Turkish consumers showed the highest acceptance of HSO.

The strong preference for VOO among Greek consumers is consistent with the established role of VOO in Greek and Mediterranean dietary culture. VOO is characterized by a high proportion of monounsaturated fatty acids, particularly oleic acid, together with phenolic compounds and other minor constituents associated with nutritional and sensory characteristics [9–12]. The Mediterranean diet itself is strongly characterized by the use of VOO as a principal dietary fat [5,8].

The present findings are consistent with consumer research demonstrating that prior experience, product type, origin, and other product attributes influence olive-oil preferences and that the importance of these factors can vary across consumer populations [11,12,18]. The Turkish cohort, however, displayed a distinctly different pattern, with HSO receiving the highest mean hedonic score and being the first-choice oil for 52% of participants.

These findings should not be interpreted as demonstrating that Turkish consumers generally prefer HSO to VOO. Several observations indicate that the Turkish result does not reflect a rejection of, or unfamiliarity with, olive oil. Türkiye is one of the world's leading olive oil producers [30]; olive oil is an integral component of Turkish cuisine, and consumer surveys report that approximately 60% of Turkish respondents use olive oil daily and that most prefer extra virgin olive oil [31]. In the present study, 98% of the Turkish participants reported olive oil as their main cooking fat (Table 1), compared with 94% of the Greek participants. Moreover, the mean hedonic score for VOO differed only slightly between the Greek (5.62) and Turkish (5.24) cohorts. The most pronounced cross-cultural difference therefore concerned HSO (4.26 vs. 6.24), not VOO. Even among Greek participants, the VOO was rated only between "neither like nor dislike" and "like slightly". This suggests that the evaluated sample, tasted neat, elicited moderate liking in both countries, rather than strong liking in Greece and rejection in Türkiye.

Rather, under the specific experimental conditions of this study, HSO was the most highly accepted product among the Turkish participants. This acceptability is consistent with the traditional consumption of roasted hemp seed as a snack in Turkish cuisine ('çedene') [32] and suggests that HSO may represent a promising alternative edible oil for consumers who find its sensory profile acceptable. However, to our knowledge, Turkish consumers' attitudes towards HSO have not yet been studied, and it remains unclear whether this preference would persist once participants become familiar with what they are tasting. Studies on other unfamiliar oils show that information on product origin and health benefits can shift consumer responses considerably compared with blind tasting alone [33].

4.2. Nutritional Composition of the Oils

The three oils displayed distinct fatty-acid profiles, illustrating different nutritional characteristics rather than a single hierarchy of quality. VOO was dominated by monounsaturated fatty acids (MUFA; 71.38%) and had the highest saturated fatty-acid proportion (14.72%). RO had the lowest saturated fatty-acid content (5.72%) and an intermediate MUFA proportion (59.96%), whereas HSO had the highest polyunsaturated fatty-acid (PUFA) content (76.57%) [7,13,15–18]. These differences are consistent with the established composition of oleic-acid-rich VOO, RO containing appreciable α-linolenic

acid, and PUFA-rich HSO. The total fat content was 94.99 ± 0.19% for VOO, 93.80 ± 0.49% for HSO, and 95.90 ± 0.69% for RO.

The distribution of fat-soluble vitamins also differed among the oils. HSO had the highest total measured concentration (3188.57 μg/g), mainly because of its high γ-tocopherol concentration, followed by RO (1310.87 μg/g), while VOO had the lowest total measured concentration (651.34 μg/g) but the highest α-tocopherol concentration. RO also had the highest β-carotene concentration. These findings demonstrate that individual micronutrient concentrations vary among oils and that total measured vitamin concentration alone does not establish overall nutritional superiority [15–18,34]. The distinct nutritional profiles also highlight the potential of vegetable oil blending to modify physicochemical and nutritional characteristics, although blending was not investigated in the present study [19].

The fatty-acid composition further revealed differences in the distribution of n-3 and n-6 PUFA. HSO had the highest n-3 (20.48 g/100 g fat) and n-6 PUFA concentrations (61.16 g/100 g fat), with an n-6/n-3 ratio of 2.99. RO had an intermediate profile, with 12.00 g/100 g fat n-3 PUFA, 19.04 g/100 g fat n-6 PUFA, and the lowest n-6/n-3 ratio (1.59). VOO was more strongly MUFA-dominant and had lower n-3 and n-6 PUFA concentrations, with an n-6/n-3 ratio of 7.36. The differences in n-3 and n-6 PUFA concentrations further highlight the distinct nutritional profiles of the oils. HSO provided the highest concentrations of both fatty-acid classes, particularly n-3 PUFA, while RO showed an intermediate profile and VOO contained lower amounts of both. The n-6/n-3 ratio should be interpreted cautiously, as it does not independently establish nutritional quality or health effects. These findings therefore characterize the fatty-acid composition of the tested oils rather than demonstrating differences in their health effects.

4.3. Product-Specific Composition and Processing

The results should be interpreted as characterizing the particular commercial samples examined, rather than all olive, rapeseed, or hemp seed oils. The VOO originated from Crete, whereas the rapeseed and hemp seed oils were sourced from Scotland and differed in their crop and production histories. Cultivar or variety, growing conditions, seed quality, harvest, pressing, filtration, and storage can all contribute to variation in fatty-acid and minor-component profiles. Previous studies have documented variability among commercial HSO samples and differences in their sensory characteristics [17,18]; comparable product-specific variation should also be considered when interpreting the results for olive and rapeseed oils.

The measured fat-soluble vitamin profiles reinforce the importance of considering each oil as an individual product. HSO was characterized by high γ-tocopherol, VOO by high α-tocopherol, and RO by comparatively high β-carotene and substantial γ-tocopherol. Such differences may reflect raw-material and processing characteristics, but the present design included only one commercial sample of each oil and cannot identify the contribution of any single production factor. Further studies involving multiple products and batches would be needed to distinguish oil-type effects from sample-specific variation.

4.4. Cross-Cultural Sensory Acceptance and Consumer Familiarity

Consumer acceptance differed between the Greek and Turkish cohorts for all three oils. Greek participants gave the highest mean hedonic score to VOO (5.62), followed by RO (4.84) and HSO (4.26); Turkish participants gave the highest score to HSO (6.24), followed by VOO (5.24) and RO (3.72). Preference rankings showed a similar pattern: VOO was the first choice of 64% of Greek participants, whereas HSO was the first choice of

52% of Turkish participants. RO was ranked third by 60% of Turkish participants.

These findings indicate that the nutritional composition of an oil does not, by itself, predict consumer acceptance. Familiarity, previous consumption, sensory expectations, product knowledge, and cultural context may all contribute to food choice [11,12,18]. The sensory literature also reports variation in the attributes of cold-pressed HSO, including both desirable and undesirable notes [17]. However, because this study measured overall acceptance rather than conducting a trained-panel descriptive analysis, the specific sensory attributes responsible for the observed preferences cannot be determined. The findings apply to the tested samples and participant cohorts and should not be generalized to all Greek or Turkish consumers.

Notably, VOO acceptance differed only slightly between the Greek and Turkish cohorts, and its moderate scores in both may partly reflect that the robust profile of the Cretan oil tasted neat. Familiarity with the VOO category does not necessarily translate into liking for intensely flavored oils [35]. In a Turkish survey, 47% of respondents stated that they never want a burning sensation in the throat when consuming olive oil [31]. Many Turkish olive oils, such as those from Ayvalık and Gemlik cultivars, also show milder bitterness and pungency [36]. The tested oil may therefore have departed from the Turkish participants' reference profile, whereas for Greek participants it probably represented a familiar regional product [12]. Moreover, olive oil in Türkiye is consumed mainly in cooked dishes and salads [37], a context that neat tasting does not reproduce.

4.5. Integrating Nutritional Composition and Consumer Acceptance

Considering the nutritional and sensory findings together highlights that the three oils offer different compositional profiles alongside different patterns of consumer acceptance. VOO combined MUFA predominance and the highest α-tocopherol concentration with the strongest acceptance among Greek participants. HSO combined the highest PUFA and measured total fat-soluble vitamin concentrations with the strongest acceptance among Turkish participants. RO had the lowest saturated fatty-acid content and the lowest n-6/n-3 ratio yet received the lowest hedonic score in the Turkish cohort. These contrasts demonstrate that no single compositional measure explains consumer preference across both cohorts.

The findings support evaluating edible oils using a multidimensional approach that considers fatty-acid composition, individual fat-soluble vitamins, sensory acceptance, and the consumer context. The high measured vitamin concentration of HSO should not be interpreted as evidence of superior overall nutritional quality, just as the MUFA-rich profile of VOO or the relatively low saturated-fat content of RO does not guarantee preference. Because only one commercial sample of each oil was assessed, future research should include multiple products and batches, alongside detailed sensory profiling and direct oxidative-stability measurements, to establish how compositional variation relates to sensory properties and consumer response.

The findings further suggest that nutritional advantages alone may be insufficient to drive consumer preference when products differ substantially in sensory characteristics and cultural familiarity.

A major implication of the present study is that nutritional quality, sensory acceptance, and technological stability should be considered together when evaluating alternative edible oils. Scottish HSO provides a useful example: its high PUFA content and substantial omega-3 fatty acids provide nutritional interest, while the same high degree of unsaturation contributes to increased oxidative susceptibility [18].The present consumer findings add another dimension to this framework. HSO was the least preferred of the three oils among Greek consumers but the most preferred among Turkish con-

sumers. Therefore, the potential of HSO as an alternative edible oil may depend not only on its nutritional composition but also on the target consumer population and the sensory characteristics of the specific product.

4.6. Mediterranean Diet Adherence and Consumer Preference

The higher MEDAS score observed in the Greek cohort provides additional context for the strong preference for VOO. Olive oil is a defining component of the Mediterranean dietary pattern and is closely associated with the health benefits attributed to this dietary pattern [5,8]. The higher level of Mediterranean-diet adherence among Greek participants may therefore be consistent with greater habitual exposure to olive oil and familiarity with its characteristic sensory properties.

However, the present study does not establish a causal relationship between MEDAS score and oil preference. The cross-sectional design, modest sample size, and unequal distribution of MEDAS categories limit the strength of this interpretation.

4.7. Colour Characteristics

The instrumental colour results demonstrated distinct physical profiles among the three oils. RO had the highest L* and b* values, whereas HSO had the lowest L* and b* values.

Recent work on Scottish HSO indicates that differences in oil colour can be associated with chlorophyll retention and post-pressing processing [38]. Because the present sensory evaluation was conducted using opaque cups, visual appearance was intentionally minimized. Therefore, instrumental colour differences cannot directly explain the observed differences in consumer acceptance.

4.8. Fat-Soluble Vitamin Composition

The tocopherol distribution observed here is consistent with the broader literature describing substantial variation in minor-component composition among vegetable oils and among individual oils within the same category [39]. The predominance of γ-tocopherol in HSO is also compatible with the nutritional characterization of hemp seed oil reported previously [15–18]. However, the present results are specific to the commercial oils examined and should not be extrapolated to all products within each category. Processing conditions, cultivar, seed origin, harvest, filtration, and storage can influence tocopherol and carotenoid concentrations. Importantly, the high fat-soluble vitamin concentration of HSO should not be interpreted in isolation as evidence of superior overall nutritional quality or health value, because fatty-acid composition, bioavailability of micronutrients, phenolic compounds, oxidative stability, and patterns of dietary use also contribute to the nutritional and functional properties of edible oils. These compositional findings provide useful context for the consumer results. The oil with the highest total measured fat-soluble vitamin concentration, HSO, was the least accepted in Greece but the most accepted in Türkiye. Conversely, VOO, which had the lowest total measured fat-soluble vitamin concentration among the three oils, was the most accepted by Greek consumers. Therefore, the present data reinforce that consumer acceptance cannot be inferred from the concentration of a single class of micronutrients. Rather, acceptance appears to reflect the combined influence of sensory properties, familiarity, dietary background, cultural context, and the product's broader chemical composition.

4.9. Fatty Acid Composition and Nutritional Implications

The fatty-acid data further demonstrated the pronounced compositional differences among the three oils. VOO showed the characteristic predominance of MUFA, with

71.38% of the oil represented by total MUFA, whereas HSO contained 76.57% total PUFA. RO displayed an intermediate MUFA content (59.96%). This distribution is consistent with the established nutritional profiles of these oils and reinforces the distinction between an oleic-acid-rich oil such as VOO and the PUFA-rich profile of HSO [7,13,15–18].

The individual n-3 and n-6 PUFA results were particularly informative. HSO contained substantially higher n-3 PUFA (20.48 g/100 g) than RO (12.00 g/100 g) and VOO (1.02 g/100 g), while n-6 PUFA reached 61.16 g/100 g in HSO compared with 19.04 g/100 g in RO and 7.53 g/100 g in VOO. The resulting n-6/n-3 ratios were 2.99 for HSO, 1.59 for RO, and 7.36 for VOO. These findings are broadly consistent with the reported PUFA-rich composition of Scottish cold-pressed hemp oils, which have been characterized by high omega-6 and omega-3 concentrations and n-6/n-3 ratios around 2.67–2.82 [18].

From a nutritional and technological perspective, the high PUFA content of HSO provides substantial polyunsaturated fatty acids, including α-linolenic acid, but the same degree of unsaturation can increase susceptibility to lipid oxidation [17,18,35]. RO showed a comparatively balanced profile, combining substantial MUFA with a higher n-3 content than VOO and the lowest n-6/n-3 ratio among the three oils. VOO, in contrast, was strongly MUFA-dominant and contained substantially less n-3 and n-6 PUFA. These differences should be considered together with the fat-soluble vitamin results: HSO combined a PUFA-rich profile with the highest measured fat-soluble vitamin concentration, whereas VOO combined MUFA predominance with the highest α-tocopherol concentration. Thus, no single oil can be characterized as nutritionally superior across all measured parameters; rather, the oils exhibited distinct nutritional profiles that may confer different dietary and technological characteristics.

The data generated indicate that all three oils were substantially oxidized. HSO and RO exceeded the Codex limit of 15 meq O_2/kg for cold-pressed oils [40,41], and VOO approached the 20 meq O_2/kg limit for virgin olive oils [41]. Such levels are not unexpected, given the strong influence of storage on the oxidative status of virgin oils [42]. Nevertheless, the three oils were handled in the same way, yet their PVs differed significantly, which points to their composition as the main source of variation. The order HSO ≥ RO > VOO follows their degree of unsaturation [43], with HSO having the highest PUFA content (76.57%; Section 3.7). HSO had the highest tocopherol concentration, but its much higher degree of unsaturation seems to have outweighed this antioxidant capacity. In cold-pressed oils, the protection related to the natural antioxidants within the oil is dependent on its PUFA content and on the overall balance between pro- and antioxidant compounds [44,45]. The lower PV of VOO can be attributed mainly to its MUFA-dominant profile. The phenolic compounds typical of virgin olive oil may also have offered some protection [46]. In short, the high PVs are largely a consequence of the handling of the oils after the sensory evaluation, while the differences between them may be explained by their fatty-acid composition.

The observed differences may also have implications for dietary fat quality. The high MUFA content of VOO is consistent with the lipid profile characteristic of traditional Mediterranean diets, while the high concentrations of α-linolenic acid and other PUFA in HSO and RO may contribute to increased dietary intake of essential fatty acids. Moreover, the relatively low n-6/n-3 ratios observed in HSO and RO align with recommendations to increase omega-3 intake and improve the balance between n-6 and n-3 fatty acids in Western diets. The substantial tocopherol content of HSO, particularly γ-tocopherol, may further contribute antioxidant activity within the oil matrix, although the bioavailability and physiological effects of these compounds depend on multiple dietary and metabolic factors. These nutritional attributes should therefore be considered along-

side sensory acceptance, culinary applications, and stability characteristics when evaluating the potential role of different edible oils in healthy dietary patterns.

4.10. Strengths and Limitations

A major strength of the present study is its cross-cultural design, involving consumers from Greece and Türkiye who evaluated the same three oils under standardized sensory-testing conditions. The combination of hedonic evaluation and preference ranking provided complementary measures of consumer response, while the inclusion of MEDAS data enabled consideration of participants' dietary background. Furthermore, the integration of consumer acceptance data with the nutritional characterization of the same oil samples allowed consumer responses to be considered alongside their measured fatty-acid and fat-soluble vitamin profiles.

Several limitations should nevertheless be acknowledged. First, the sample size was relatively modest, with 50 participants per country, and the participants may not be representative of the wider Greek and Turkish populations. The demographic characteristics of the two cohorts also differed, particularly in age, education, and employment status, which may have influenced consumer acceptance independently of cultural differences. Although the analyses were conducted separately within each cohort to characterize acceptance patterns and preferences, they do not directly establish whether differences between countries were statistically significant. Therefore, the findings should be interpreted as describing cohort-specific consumer responses rather than demonstrating statistically confirmed cross-cultural differences.

Second, the study assessed consumer acceptance rather than detailed descriptive sensory characteristics. Although this approach was appropriate for the primary objective of comparing consumer preferences, it does not identify the specific sensory attributes underlying acceptance. Characteristics such as bitterness, pungency, aroma, and potential off-flavours may have contributed to participants' evaluations but were not systematically assessed. Future studies should combine trained-panel descriptive sensory analysis with consumer acceptance testing to identify the sensory drivers of preferences.

Third, evaluations were conducted under controlled sensory-testing conditions and may not fully reflect consumer responses during habitual use of the oils in home cooking, food preparation, or consumption as part of complete meals. Participants also evaluated the oils without receiving information about their nutritional composition, origin, or potential health benefits. Consequently, the present findings reflect acceptance under the testing conditions and do not establish how familiarity, culinary applications, or nutrition-related information might influence consumer perceptions and purchasing intentions. Future studies should investigate acceptance under both blind and informed conditions and incorporate commonly consumed foods and culinary applications.

Fourth, although MEDAS scores were collected, detailed information on participants' habitual consumption of VOO, RO, and HSO, including frequency, quantity, familiarity, and previous exposure, was not assessed. MEDAS scores do not provide oil-specific consumption estimates, and comparable consumption statistics for all three oils in Greece and Türkiye, particularly HSO, were not readily available. Consequently, the potential influence of habitual dietary practices and familiarity on consumer acceptance could not be fully evaluated. Future research should incorporate oil-specific dietary assessment alongside consumer testing to investigate whether differences in acceptance are associated with habitual consumption or previous exposure.

Fifth, the nutritional composition analyses were conducted on triplicate subsamples from a single representative 2025 production batch of each oil type. While this approach

provides robust analytical repeatability, it does not account for potential variability between production batches, manufacturers, harvest years, or geographical origins. Therefore, the compositional results should be interpreted as representative of the specific oils used in this study rather than the broader commercial oil categories. Future studies should include multiple independent commercial batches to better characterise compositional variability and improve the generalisability of the findings.

Finally, although oxidative stability was experimentally assessed, PV was measured several months after the sensory evaluation. By that time, the oils had been stored for an extended period, transferred between containers, transported between countries and opened repeatedly. The values therefore reflect the oxidative status of the oils at the time of analysis rather than at the time of tasting.

Future studies should therefore combine more comparable consumer cohorts, oil-specific dietary assessment, detailed descriptive sensory analysis, and consumer acceptance testing under blind and informed conditions. The inclusion of multiple independent commercial samples and additional chemical analyses would also help clarify the relationships between nutritional composition, familiarity, sensory characteristics, and consumer acceptance across different cultural and dietary contexts.

5. Conclusions

The present cross-cultural study demonstrated substantial differences in consumer acceptance and preference for VOO, HSO, and RO between Greek and Turkish consumers. Greek consumers showed the highest acceptance of VOO, which was selected as the first choice by 64% of participants. In contrast, Turkish consumers showed the highest acceptance of HSO, which was selected as the first choice by 52% of participants. RO showed comparatively lower acceptance, particularly among Turkish consumers.

The oils also showed clearly differentiated fatty-acid profiles. VOO was characterized by MUFA predominance (71.38%), HSO by high PUFA content (76.57%) and the highest n-3 and n-6 PUFA concentrations, while RO showed an intermediate MUFA content and the lowest n-6/n-3 ratio among the three oils. These compositional differences highlight distinct nutritional characteristics among the three oils and should be considered alongside sensory acceptance and technological stability.

HSO represents a particularly interesting case because its high PUFA content and relatively low n-6/n-3 ratio provide nutritional interest, while its high degree of unsaturation also results in greater susceptibility to oxidative deterioration [18]. In the present study, HSO also showed the highest concentration of measured fat-soluble vitamins, driven predominantly by γ-tocopherol, whereas VOO contained the highest α-tocopherol concentration. Overall, the findings demonstrate that consumer acceptance cannot be predicted solely from fatty-acid or micronutrient composition and is likely influenced by the combined effects of sensory properties, familiarity, dietary background, cultural context, and product-specific characteristics.

Together, these results support the need for context-specific approaches to the promotion of edible oils, recognizing that nutritional attributes alone may not determine consumer acceptance.

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