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MAPPING DIGITAL INTEREST IN EU-REGISTERED TURKISH OLIVE AND OLIVE OIL GEOGRAPHICAL INDICATIONS: AN INFODEMIOLOGICAL STUDY THROUGH A FOOD LITERACY AND HEALTH PERCEPTION LENS

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ABSTRACT

This infodemiological study examined the digital search visibility of European Union-registered Turkish olive and olive oil geographical indication (GI) products across 13 countries using Google Trends Relative Search Volume data over a seven-year period (2019-2025). 'A composite Digital Gastrodiplomacy Index (DGDI) was developed to quantify GI-specific digital interest. Mann-Whitney U tests revealed a pronounced digital visibility gap between generic food topic searches and GI-labeled products ($Z = -4.308$, $P<0.001$). Wilcoxon signed-rank tests showed that table olives had significantly higher DGDI scores than olive oils ($W=3.0$, $P=0.002$). Hierarchical cluster analysis identified three country typologies: GI-aware, partially aware, and GI-blind. Spearman correlations between olive and olive oil DGDI were nonsignificant ($\rho=0.280$), indicating product-specific digital recognition. These findings reveal a structural disconnect between GI registration and digital food literacy internationally.

Key words: Geographical indication, olive oil, Google Trends, digital food literacy, Mediterranean diet, infodemiological study, food origin, consumer behaviour

AB TESCİLLİ TÜRK ZEYTİN VE ZEYTİNYAĞI COĞRAFİ İŞARETLERİNİN DİJİTAL İLGİSİNİN HARİTALANMASI: GIDA OKURYAZARLIĞI VE SAĞLIK ALGISI PERSPEKTİFİNDEN BİR İNFODEMİYOLOJİK ÇALIŞMA

ÖZ

Bu infodemiyolojik çalışma, Avrupa Birliği tescilli Türk zeytin ve zeytinyağı coğrafi işaret (Cİ) ürünlerinin 13 ülkedeki dijital arama görünürlüğünü Google Trends Göreli Arama Hacmi verileriyle yedi yıllık bir dönemde (2019-2025) incelemiştir. Cİ'ye özgü dijital ilgiyi ölçmek amacıyla Dijital Gastrodiplomasi Endeksi (DGDI) geliştirilmiştir. Mann-Whitney U testleri, jenerik gıda konuları ile Cİ etiketli ürünler arasında belirgin bir görünürlük açığı ortaya koymuştur ($Z=-4.308$, $P<0.001$). Wilcoxon testi, sofralık zeytinlerin zeytinyağına göre anlamlı şekilde yüksek DGDI skorlarına sahip olduğunu göstermiştir ($W=3.0$, $P=0.002$). Hiyerarşik kümeleme analizi üç ülke tipolojisi belirlemiştir: Cİ-bilinçli, kısmen bilinçli ve Cİ-kör. Bulgular, Cİ tescili ile uluslararası dijital gıda okuryazarlığı arasında yapısal bir kopukluk olduğunu ortaya koymaktadır.

Anahtar kelimeler: Coğrafi işaret, zeytinyağı, Google Trends, dijital gıda okuryazarlığı, Akdeniz diyeti, infodemiyoloji, menşei algısı, tüketici davranışı

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INTRODUCTION

The Mediterranean diet, recognized by UNESCO as an Intangible Cultural Heritage, is consistently associated with reduced risks of cardiovascular disease, type 2 diabetes, and certain cancers (Dinu et al., 2018; Martínez-González et al., 2015). Olive oil, central to this dietary pattern, contains bioactive compounds-including oleic acid, polyphenols, and tocopherols-that confer well-documented cardioprotective and anti-inflammatory benefits (Santangelo et al., 2018; Gorzynik-Debicka et al., 2018). Türkiye, as the world's fourth-largest olive oil producer, has secured European Union (EU) registration for multiple geographically indicated (GI) olive and olive oil products. These registrations confer legal protection and signal distinct organoleptic and compositional qualities tied to terroir-the unique interaction of soil, climate, and traditional production knowledge (Checchinato et al., 2024).

Despite this institutional recognition, the extent to which these origin-labeled products achieve visibility in international digital information ecosystems remains largely unknown. Understanding how populations search for origin-specific food information reflects dimensions of digital food literacy-the capacity to access, evaluate, and apply food-related information in digital environments (Consavage Stanley et al., 2022; Kraak, 2025). Infodemiological approaches, which analyze digital trace data to understand population-level health information behavior, provide a methodological framework for such investigations (Eysenbach, 2009; Mavragani & Ochoa, 2019). Google Trends, reporting normalized Relative Search Volume (RSV), has been validated for monitoring public interest in dietary topics across countries (Kamiński et al., 2020; Nuti et al., 2014). Previous studies employed Google Trends to map interest in various diets (Kamiński et al., 2020), weight-loss search patterns across Europe (Bayram & Ozturkcan, 2023), and food sustainability awareness (Portugal-Nunes et al., 2023). However, no study has applied infodemiological methods to examine the digital visibility of specific GI-labeled food products across countries.

Several theoretical perspectives inform the interpretation of cross-national variation in food origin search behavior. The country-of-origin (COO) effect demonstrates that origin information functions as a cognitive heuristic influencing product evaluation (Farina et al., 2024; Thøgersen, 2023). The health halo effect suggests that GI designations may generate positive attributional spillovers to health perceptions (Innerbichler et al., 2024; Stranieri et al., 2025). The familiarity bias and availability heuristic suggest that culturally salient food categories are more readily accessed in cognitive processing and search behavior (Wang et al., 2024).

This study aimed to (1) measure and compare the digital search visibility of EU-registered Turkish olive and olive oil GI products across 13 countries; (2) develop a composite Digital Gastrodiplomacy Index (DGDI); (3) identify country typologies through cluster analysis; and (4) examine associations between DGDI scores and country-level characteristics.

In line with these aims, the study tested the following hypotheses: (H1) generic food category searches exhibit significantly higher relative search volume than GI-labeled product searches across countries; (H2) digital visibility (DGDI) differs significantly between table olive and olive oil GI products; (H3) DGDI scores cluster into distinct cross-national typologies reflecting differing levels of GI awareness; and (H4) DGDI scores are associated with country-level characteristics (per capita olive oil consumption, internet penetration, GDP per capita, and Turkish diaspora size).

MATERIAL AND METHODS

Research Design and Data Source

This study employed a quantitative, cross-sectional, comparative infodemiological design following the Google Trends methodology framework of Mavragani and Ochoa (2019). Digital search data were obtained from Google Trends (https://trends.google.com), which reports normalized RSV values on a 0-100 scale representing relative search intensity within a geographic unit and time frame. Topic-based searches were used to minimize language bias (Kamiński et al., 2020; Mavragani & Ochoa, 2019).

Products and Countries

Eight EU-registered Turkish GI products were examined: four olive varieties (Gemlik Zeytini, Milas Yağlı Zeytini, Aydın Memecik Zeytini, and Edremit Körfezi Yeşil Çizik Zeytini) and four olive oil varieties (Milas Zeytinyağı, Edremit Zeytinyağı, Mut Zeytinyağı, and Aydın Memecik Zeytinyağı). These eight products comprised all Turkish olive and olive oil geographical indications holding registered Protected Designation of Origin or Protected Geographical Indication status in the European Union eAmbrosia register at the time of data extraction; because

the EU register is dynamic, the registration status reported here reflects the official situation on the data extraction date. Thirteen countries were selected for cross-national comparison: Germany, France, Italy, the United Kingdom (UK), the United States (USA), Spain, the Netherlands, Sweden, Canada, Australia, Japan, South Korea, and Türkiye. Selection criteria included stable RSV data availability, geographical and cultural diversity, connection to Mediterranean food networks, and diaspora ties with Türkiye. RSV data were collected over seven-year period (2019-2025).

Variables and Index Construction

For each country, Topic RSV (mean RSV for the generic category) and Total GI RSV (sum of mean RSV across four GI products) were computed. Two derived metrics were calculated:

GI Intensity=Total GI RSV / Topic RSV

DGDI=(GI Intensity$_{country}$ / GI Intensity$_{max}$) × 100

The DGDI normalizes GI intensity to a 0-100 scale using Türkiye as the reference, enabling cross-national comparison.

Macro-Level Variables

Four country-level variables were compiled: per capita olive oil consumption (FAO, 2025), internet penetration rate (ITU DataHub, 2024), GDP per capita (World Bank, 2023), and Turkish diaspora population (UN DESA, 2024).

Statistical Analysis

Analyses were conducted using Python 3.11 (SciPy 1.11, NumPy 1.24). Given the small sample (n=13) and non-normal distributions, nonparametric methods were employed: Mann-Whitney U tests, Wilcoxon signed-rank tests, Kruskal-Wallis H tests, hierarchical cluster analysis (average linkage, squared Euclidean distance), and Spearman correlations with bootstrapped 95% confidence intervals (B=10000). Asymptotic Z statistics were computed with continuity correction and tie-corrected variance. When the two distributions do not overlap, the U statistic attains its theoretical maximum ($U=n_1 \times n_2$) and Z converges to a limiting value determined solely by the sample sizes; near-identical Z values across comparisons therefore reflect complete separation of the distributions. Effect sizes were calculated as $r=|Z| / \sqrt{N}$ (Fritz et al., 2012). Significance was set at $P<0.05$.

Ethical Considerations

This study used publicly available, aggregated, anonymized Google Trends data. No individual-level data were collected; ethical approval was not required.

RESULTS AND DISCUSSION

Digital Visibility Gap

A pronounced digital visibility gap was identified between generic food category searches and GI-labeled counterparts. Mann-Whitney U tests revealed statistically significant differences for both olive products (U=169.0, Z=-4.308, $P<0.001$, r=0.845) and olive oil products (U=169.0, Z=-4.309, $P<0.001$, r=0.845). In both comparisons the U statistic equalled its theoretical maximum ($U=n_1 \times n_2=13 \times 13=169$), indicating complete separation of the two distributions: every generic topic RSV value exceeded every GI-specific RSV value. Under complete separation with $n_1=n_2=13$, the continuity-corrected Z approaches its limiting value of 4.308; the negligible difference between the two comparisons (-4.308 vs. -4.309) arises solely from the tie correction applied to the variance. The large effect size (r=0.845) indicates that generic topic RSV values (ranging from 24.32 to 76.82) vastly exceeded GI-specific RSV values (rarely exceeding 5.00 outside Türkiye). Country-level DGDI scores are presented in Table 1.

Table 1. Digital Gastrodiplomacy Index (DGDI) scores for olive and olive oil products across countries

Country	Topic RSV (Olive)	GI RSV (Olive)	DGDI (Olive)	Topic RSV (Oil)	GI RSV (Oil)	DGDI (Oil)	ΔDGDI
Germany	57.31	1.06	14.44	46.87	0.38	2.40	+12.04
France	33.83	1.27	29.32	59.54	1.15	5.68	+23.64
Italy	41.14	2.19	41.57	46.24	0.38	2.44	+39.13
UK	29.23	1.66	44.35	48.98	1.13	6.81	+37.54

Table 1. Continued

USA	66.57	1.07	12.55	63.68	1.15	5.31	+7.24
Spain	50.01	0.61	9.53	24.32	0.71	8.62	+0.91
Netherlands	63.76	1.77	21.68	32.20	2.01	18.44	+3.24
Sweden	64.85	1.55	18.66	46.88	0.96	6.06	+12.61
Canada	61.41	2.11	26.83	64.58	1.73	7.92	+18.91
Australia	60.54	1.14	14.70	53.22	3.39	18.78	-4.07
Japan	64.38	1.69	20.50	64.99	2.05	9.31	+11.19
S. Korea	53.03	1.45	21.35	48.21	1.04	6.38	+14.97
Türkiye	41.70	5.34	100.00	51.98	17.61	100.00	0.00

RSV: Relative Search Volume; GI: Geographical Indication; DGDI: Digital Gastrodiplomacy Index; ΔDGDI: DGDI(olive) - DGDI(oil). Scores normalized to Türkiye (=100).

This gap carries direct implications for digital food literacy. Within the Multidimensional Digital Food and Nutrition Literacy framework (Consavage Stanley et al., 2022), functional food literacy includes the ability to identify and interpret food labels including origin designations. The near-zero RSV values for Turkish GI products outside Türkiye suggest that these origin labels have not penetrated the informational repertoire of international consumers. This aligns with Ruani et al. (2023), who demonstrated that internet searches constitute the most frequently used but least trusted nutrition information source. When consumers search for "olive oil" generically rather than by specific origin, they encounter undifferentiated information that obscures compositional differences between production regions-differences GI systems are designed to communicate (Checchinato et al., 2024).

Product-Category Differences: Olives Versus Olive Oil

A Wilcoxon signed-rank test revealed a statistically significant difference between olive and olive oil DGDI scores (W=3.0, *P*=0.002). Olive products exhibited higher DGDI scores in 11 of 13 countries, with only Australia showing the reverse pattern (ΔDGDI=-4.07). The mean DGDI difference was 13.32 points (95% bootstrap CI: 6.79-20.57).

The Spearman correlation between olive and olive oil DGDI was weak and nonsignificant (ρ=0.280, *P*=0.354; 95% bootstrap CI: -0.381 to 0.792), indicating that a country's awareness of Turkish GI olives does not predict its awareness of Turkish GI olive oils. This product-category-specific pattern challenges the assumption in country-of-origin research that origin reputation transfers across related product categories (Farina et al., 2024; Thøgersen, 2023). From a health perception perspective, olive oil-the more nutritionally consequential product in the Mediterranean diet-paradoxically demonstrates weaker GI visibility than table olives. If health halo effects from GI labeling exist (Innerbichler et al., 2024; Stranieri et al., 2025), they appear to operate more effectively for whole foods than processed ingredients.

Variation Among Individual GI Products

Among olive GI products, Gemlik Zeytini exhibited the highest mean RSV (M=0.86, SD=1.01), followed by Edremit Körfezi Yeşil Çizik Zeytini (M=0.42, SD=0.27), Milas Yağlı Zeytini (M=0.37, SD=0.23), and Aydın Memecik Zeytini (M=0.23, SD=0.25). A Kruskal-Wallis test indicated a difference that did not reach statistical significance (H=7.418, P=0.060). Among olive oil GI products, no significant differences were found (H=0.445, *P*=0.931), confirming uniformly low digital recognition.

Country Typologies

Hierarchical cluster analysis revealed a three-cluster solution for olive GI awareness. Cluster 1 (GI-aware) comprised Türkiye and Mediterranean countries (Italy, Spain). Cluster 2 (partially aware) included Western European countries (France, UK, Germany, Netherlands) and Anglo-Saxon markets (Canada, USA). Cluster 3 (GI-blind) consisted of countries with limited olive cultural integration (Sweden, Japan, South Korea, Australia).

Counterintuitively, Mediterranean countries demonstrated relatively low DGDI scores (Spain: 9.53 for olives; Italy: 2.44 for olive oil). This can be interpreted through the familiarity bias framework: in countries where olive production is culturally embedded, consumers may search for local products rather

than foreign GI designations-a "taken-for-granted" effect. Conversely, countries with limited olive traditions (UK, Canada, Japan) showed higher DGDI scores, potentially reflecting an "exoticism premium" consistent with the availability heuristic (Wang et al., 2024).

Macro-Level Associations

Exploratory Spearman correlations examined associations between DGDI scores and four country-level indicators (Table 2). No statistically significant correlations were identified. Per capita olive oil consumption showed a weak positive association with olive oil DGDI (ϱ=0.346, *P*=0.247; 95% bootstrap CI: -0.257 to 0.847). All bootstrap confidence intervals were computed by resampling country pairs with replacement (B=10,000, percentile method) with a fixed random seed to ensure reproducibility. Turkish diaspora showed weak negative associations with both olive (ϱ=-0.231) and olive oil DGDI (ϱ=-0.313). The wide bootstrap confidence intervals reflect the limited sample size and underscore the exploratory nature ofthese analyses.

Table 2. Spearman correlations between DGDI scores and country-level indicators (n=13)

Variable	ϱ (Olive)	P	95% CI (Olive)	ϱ (Oil)	P	95% CI (Oil)
Olive oil consumption (kg/cap)	0.093	.762	[-0.552, 0.739]	0.346	.247	[-0.257, 0.847]
Internet penetration (%)	-0.175	.568	[-0.756, 0.583]	-0.069	.822	[-0.702, 0.583]
GDP per capita (USD)	-0.335	.263	[-0.862, 0.369]	-0.165	.590	[-0.739, 0.522]
Turkish diaspora (n)	-0.231	.448	[-0.771, 0.413]	-0.313	.297	[-0.829, 0.361]

Note. Bootstrap confidence intervals (B=10,000, percentile method) are reported for both olive and olive oil DGDI correlations. All analyses are exploratory; P-values are unadjusted.

Limitations

Several limitations should be acknowledged. The sample of 13 countries limits statistical power for detecting moderate-effect correlations. Google Trends RSV reflects relative rather than absolute search volume and is subject to Google's sampling algorithm (Rovetta, 2024). Google's market share varies across countries, creating potential coverage bias. The cross-sectional design precludes causal inference, and population-level search patterns cannot be attributed to specific demographic segments. Several further limitations specific to the present design warrant attention. First, because the GI product names are in Turkish, searches for these products in non-Turkish-speaking markets may be undercounted, and diaspora-driven searches conducted in local languages may not be captured. Second, for low-volume queries Google Trends may return zero or missing values, which can deflate GI-specific RSV estimates outside Türkiye. Third, the analysis relied on Google Trends topic searches rather than individual search terms; although topic searches reduce language bias, the distinction between topic-level and term-level aggregation may itself influence the observed values.

CONCLUSION

This study provides quantitative evidence that EU-registered Turkish olive and olive oil GI products exhibit systematically weak digital visibility across international markets, revealing a structural disconnect between GI registration and digital food awareness. The DGDI offers a replicable tool for monitoring GI digital presence across countries and product categories.

GI-labeled products carry nutritionally relevant information about production methods and compositional quality, yet this information fails to reach international consumers through digital channels. GI registration alone is insufficient for visibility; digital communication strategies must complement legal protection. Because GI awareness does not transfer across product categories, promotion strategies must be product-specific. The three-cluster country typology suggests differentiated communication approaches: deepening origin narratives in partially aware markets and building foundational GI identity in GI-blind markets.

Future research should incorporate longitudinal designs, triangulate Google Trends data with social media and retail data, and employ individual-level surveys to examine cognitive mechanisms underlying GI search behavior.

AUTHOR CONTRIBUTIONS

B.U.: Conceptualization, methodology, data collection, formal analysis, writing-original draft, writing-review and editing. E.D.:

Methodology, data collection, writing-review and editing. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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