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Chemotypes of Origanum vulgare and biological activity: a review of the essential oil

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1. ABSTRACT

This narrative review examines why the essential oil of *Origanum vulgare* does not have a fixed composition. It brings together chemical and preclinical studies on carvacrol, thymol, and other volatile compounds, clarifying that results obtained with concentrated preparations are not comparable to the dietary use of the spice.The authors' synthesis describes *Origanum vulgare* as a highly variable aromatic species. Its essential oil is a mixture of volatile molecules, which are substances that evaporate easily and contribute to the plant's scent. Among the most studied are carvacrol and thymol, two phenolic monoterpenes, which are aromatic compounds capable of interacting with microorganisms and cells in experimental models. The authors report that the quantity and ratio of these components change based on the plant's genetic makeup, subspecies, cultivation conditions, harvesting, and region of origin. For this reason, the label "oregano oil" does not automatically identify chemically equivalent products. The review also collects laboratory studies on antimicrobial, antioxidant, and anti-inflammatory activities, as well as potential skin applications. However, most of the evidence considered comes from test tubes, cell cultures, microorganisms, or topical formulations. Therefore, this is not proof that the spice in meals prevents or treats diseases. The most solid message is methodological: to interpret a result, one must know the species, the plant part, the extraction method, and the composition and concentration of the studied preparation.

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Free from political, industrial and commercial influence, the journal stands as an authoritative and independent editorial space, dedicated to promoting scientific culture, professional development and the growth of health awareness among the public.

2. WHAT THIS RESEARCH ANALYZED

To understand the biological significance of concentrated oregano, Lombrea and colleagues gathered publications dedicated primarily to the essential oil, rather than the spice added to meals. The essential oil is a fraction rich in aromatic molecules obtained from the plant, generally through distillation. The review considers chemical composition, factors that modify it, and experimental results on microorganisms, cells, and preclinical models.The central detail is the concept of chemotype, which is a profile in which certain compounds prevail over others. Carvacrol and thymol are often abundant, but they are not the only constituents: *p*-cymene, gamma-terpinene, linalool, linalyl acetate, and sesquiterpenes can also contribute. This framework helps in interpreting subsequent literature. The limitation is that the review does not apply a systematic study selection protocol and brings together evidence that is very diverse in terms of method and model.

3. WHAT RESULTS EMERGE FROM THE STUDY

The practical takeaway is that two products labeled “oregano essential oil” may have different chemical properties. The authors report that the plant's genetics, subspecies, environment, harvesting, and preparation method all influence yield and composition. Consequently, a high level of carvacrol in one sample cannot be taken for granted in all others.The review reports antimicrobial activities and other biological effects observed primarily *in vitro* —that is, outside the body—and in cell or animal models. In these systems, carvacrol and thymol can contribute to the action on the microorganisms' membrane, the structure that regulates exchanges with the outside environment. However, an effect in a test tube does not measure absorption, distribution, clinical efficacy, or safety in humans. The most reliable result, therefore, remains the documentation of chemical variability, not a therapeutic potential.

4. WHY THIS STUDY IS RELEVANT

This publication is useful because it avoids a common oversimplification: treating oregano, the dried spice, the extract, and the essential oil as if they were the same thing. In reality, their concentration and composition change profoundly. Knowing which preparation was analyzed allows us to understand which products the results actually refer to.Scientifically, the review proposes a cautious interpretive chain: the origin and characteristics of the plant influence the chemotype; the chemotype modifies the mixture of compounds; and the mixture can influence what happens in biological tests. This relationship is plausible and supported by chemical analyses, but it does not imply that a single component alone explains every activity. Therefore, the data do not make the essential oil equivalent to the spice or to a medical treatment.

5. STUDY LIMITATIONS AND WHAT IT DOES NOT DEMONSTRATE

The publication by Lombrea and colleagues is a narrative review. It offers a broad overview, but it does not replace a systematic review with pre-established criteria for research, selection, and risk of bias assessment. Furthermore, the included sources use oils with different compositions, concentrations, and tests; comparing their results requires caution.It does not demonstrate that the essential oil prevents, treats, or improves any specific condition in humans. It does not establish a safe dose for oral intake, does not define the efficacy of the spice in the diet, and does not allow for the automatic translation of laboratory antibacterial results to real-world infections. Evidence from cells, food, or microorganisms is important for formulating hypotheses and designing subsequent studies, but it does not constitute clinical evidence.

6. INDEPENDENT CONFIRMATORY EVIDENCE

Independent evidence primarily supports shifting focus to the upstream part of the chain: the species exhibits significant internal chemical variability. Morshedloo and colleagues studied seven populations grown under the same soil and climate conditions. Analysis using GC-MS, a technique that separates and identifies volatile molecules, detected 42 constituents and four main chemotypes; carvacrol levels varied from 0.3% to 46.8%. This experimental study confirms that the difference does not depend solely on external conditions. The confirmation is direct regarding composition, but it does not measure effects in

humans [1].Verma and colleagues obtained a convergent result in 17 populations grown under comparable conditions. 51 components were identified, accounting for 90.15-99.94% of the oil, along with six chemotypes with different terpene profiles. The work confirms that general botanical identity is not enough to establish the final composition; however, it remains a chemical analysis, not a clinical or pharmacological test [2].The subsequent link, from composition to the response of microorganisms, is supported by Khan and colleagues. In oils obtained from leaves and stems, the authors identified 153 compounds and distinguished a carvacrol-rich profile from a thymol-rich one. In tests on four bacterial species, thymol and carvacrol showed different activities; Gram-negative bacteria were generally found to be less sensitive. The confirmation is direct for *in vitro* activity, but it does not demonstrate an effect against human infections [3].

7. CONFLICTING EVIDENCE

Some data suggest that we should not automatically attribute biological activity to a single predominant component. Zinno and colleagues compared oils from two genotypes—one with a prevalence of carvacrol and one with a prevalence of thymol—obtained from eight different crops. Both showed antimicrobial activity in laboratory tests and food matrix trials; however, the marked chemical diversity did not result in relevant differences in the activities considered. In Caco-2 intestinal cells, a human model of the intestinal barrier, the oils did not show significant anti-inflammatory effects. This limits the idea of predicting bioactivity based solely on the percentage of carvacrol or thymol [4].A previous study on 70 clones selected from 59 populations identified six chemical groups, without finding a correlation between visible morphological characteristics and oil composition. This result does not deny the importance of genetics and the environment, but it shows that the external appearance of the plant is not a reliable indicator of the chemotype. It confirms the dependence on context and highlights the limitations of overly simplistic classifications [5].

8. QUADRO COMPARATIVO E SINTESI DELLE EVIDENZE

Independent studies confirm the strong chemical variability of the essential oil, but show that the profile alone does not always predict biological activity.

Quadro comparativo

Publication	Model and main data	Key finding	Relationship to the study by Lombrea et al.
Morshedloo et al., 2018 [1]	Seven populations; GC-MS; 42 constituents	Four chemotypes; carvacrol 0.3-46.8%	Direct confirmation of intra-species variability
Verma et al., 2010 [2]	Seventeen populations; GC and GC-MS; 51 components	Six chemotypes with different terpene profiles	Direct confirmation of chemical diversity
Khan et al., 2019 [3]	Leaf and stem oils; four bacteria in vitro	Activity varies according to oil, compound, and bacterium	Direct confirmation of the cautious link between mixture and biological test
Zinno et al., 2023 [4]	Eight cultivars; bacteria, food matrix, and Caco-2 cells	Different profiles, overall comparable activity	Limits the prediction of the effect based on composition alone
Chalchat and Pasquier, 1998 [5]	Seventy clones from 59 populations; 33 morphological traits	No correlation between morphology and composition	Shows that the chemotype cannot be deduced from the plant's appearance alone

9. SINTESI EDITORIALE E CONCLUSIONI

EDITORIAL CONCLUSION

The review by Lombrea and colleagues clarifies one main point: the essential oil of *Origanum vulgare* is a variable mixture, not a chemically uniform product. Carvacrol and thymol are important components, but their presence and proportion depend on the plant's characteristics, cultivation, harvesting, and extraction. Independent studies confirm that different chemotypes exist even when plants grow under comparable conditions. They also confirm antimicrobial activity in the laboratory, but highlight that composition is not always enough to predict the intensity of every biological response. The value of the article is therefore interpretive: it invites us to read studies on oils, extracts, and spices with precision. The available evidence does not allow us to equate the essential oil with the food condiment nor to consider it a therapy. For conclusions regarding human health, well-characterized preparations and adequate clinical trials are needed.

Aggiornato al 17/11/2026. Questo contenuto riflette una sintesi divulgativa delle evidenze scientifiche al momento della pubblicazione e non sostituisce il parere medico.

10. TRANSPARENCY AND SCIENTIFIC RESPONSIBILITY

Artificial Intelligence was used solely as a tool for editorial and documentary support. All content, interpretations, bibliographic citations and conclusions have been verified, reviewed and approved by the author, who assumes full scientific responsibility for them.

The manuscript was also subjected to independent peer review prior to publication.

To ensure the greatest transparency, the complete history of the article, including the dates of submission, revision, acceptance and publication, as well as information on the peer review process, is available on the dedicated Article History page.

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