

Stability of fatty acid composition, phenolic and volatile compounds in varietal extra virgin olive oils during storage and heating

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Doctoral thesis / Disertacija

2023

Degree Grantor / Ustanova koja je dodijelila akademski / stručni stupanj: **University of Zagreb, Faculty of Food Technology and Biotechnology / Sveučilište u Zagrebu, Prehrambeno-biotehnološki fakultet**

Permanent link / Trajna poveznica: <https://urn.nsk.hr/urn:nbn:hr:159:768445>

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Download date / Datum preuzimanja: **2024-04-19**



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University of Zagreb

Faculty of Food Technology and Biotechnology

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**STABILITY OF FATTY ACID
COMPOSITION, PHENOLIC AND
VOLATILE COMPOUNDS IN VARIETAL
EXTRA VIRGIN OLIVE OILS DURING
STORAGE AND HEATING**

DOCTORAL DISSERTATION

Zagreb, 2023



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Supervisor:
Karolina Brkić Bubola, Ph.D.

Zagreb, 2023



Sveučilište u Zagrebu

Prehrambeno-biotehnološki fakultet

Dora Klisović

**STABILNOST FENOLNIH I HLAPLJIVIH
TVARI TE SASTAVA MASNIH KISELINA
SORTNIH EKSTRA DJEVIČANSKIH
MASLINOVIH ULJA TIJEKOM
SKLADIŠTENJA I ZAGRIJAVANJA**

DOKTORSKI RAD

Mentor:
dr. sc. Karolina Brkić Bubola

Zagreb, 2023.

BASIC DOCUMENTATION CARD

University of Zagreb

Ph.D. thesis

Faculty of Food Technology and Biotechnology

Postgraduate study in Biotechnology and Bioprocess Engineering, Food Technology and Nutrition

UDK: 347.767:536.423.16:543.635.355:665.327.3(043.3)

Scientific Area: Biotechnical Sciences

Scientific Field: Food Technology

STABILITY OF FATTY ACID COMPOSITION, PHENOLIC AND VOLATILE COMPOUNDS IN VARIETAL EXTRA VIRGIN OLIVE OILS DURING STORAGE AND HEATING

Dora Klisović, MSc. med.chem.

Thesis performed at the Institute of Agriculture and Tourism, Poreč

Supervisor: Karolina Brkić Bubola, Ph.D., Scientific Advisor

Short abstract

This study aimed to investigate the influence of real storage conditions and daily consumption, heating, and presence of food during storage (dried tomatoes, cheese) and heating (vegetables) of monovarietal EVOOs on its fatty acid composition, phenolic and volatile compounds, antioxidant activity, sensory properties, and quality. The results indicated that under consumption conditions used in this study (gradual headspace increasing, darkness, room temperature), EVOO's composition of fatty acid, phenolic and volatile compounds remained preserved within one month. The presence of food during storage and heating significantly decreased the quality and the concentration of total identified phenolic and volatile compounds of the used EVOO. The use of monovarietal oils indicated varietal specificity under different conditions of its use, related to the composition of fatty acids, phenolic and volatile compounds.

Number of pages: 156

Number of figures: 17

Number of tables: 8

Number of references: 176

Number of supplements: 0

Original in: English

Key words: antioxidant activity, extra virgin olive oil, fatty acid composition, heating, phenolic compounds, storage, sensory attributes, volatile compounds

Date of the thesis defense: February 9th, 2023

Reviewers:

1. Associate Professor Klara Kraljić, Ph.D.
2. Full Professor Dubravka Škevin, Ph.D.
3. Full Professor Olivera Koprivnjak, Ph.D.

Thesis deposited in: Library of Faculty of Food Technology and Biotechnology, Kačićeva 23; National and University Library, Hrvatske bratske zajednice 4; University of Zagreb, Trg Republike Hrvatske 14.

TEMELJNA DOKUMENTACIJSKA KARTICA

Sveučilište u Zagrebu

Disertacija

Prehrambeno-biotehnološki fakultet

Sveučilišni poslijediplomski studij Biotehnologija i bioproceno inženjerstvo, prehrambena tehnologija i nutricionizam

UDK: 347.767:536.423.16:543.635.355:665.327.3(043.3)

Znanstveno područje: Biotehničke znanosti

Znanstveno polje: Prehrambena tehnologija

STABILNOST FENOLNIH I HLAPLJIVIH TVARI TE SASTAVA MASNIH KISELINA SORTNIH EKSTRA DJEVIČANSKIH MASLINOVIH ULJA TIJEKOM SKLADIŠTENJA I ZAGRIJAVANJA

Dora Klisović, mag. med. chem.

Rad je izrađen na Institutu za poljoprivredu i turizam u Poreču

Mentor: dr. sc. Karolina Brkić Bubola, znanstvena savjetnica

Kratki sažetak disertacije

Cilj ovog istraživanja bio je ispitati utjecaj realnih uvjeta upotrebe i svakodnevnog korištenja, zagrijavanja i prisutnosti hrane tijekom skladištenja (sušena rajčica, sir) i zagrijavanja (povrće) sortnih EDMU na sastav masnih kiselina, fenola i hlapljivih spojeva, antioksidacijsku aktivnost, senzorska svojstva i kvalitetu ulja. Dobiveni rezultati pokazali su da je sastav masnih kiselina, fenolnih i hlapljivih spojeva EDMU u uvjetima svakodnevnog korištenja (postepeno povećavanje nadprostora boce, bez svjetlosti, sobna temperatura) ostao nepromijenjen unutar mjesec dana skladištenja. Prisutnost hrane tijekom skladištenja i zagrijavanja značajno je utjecala na smanjenje kvalitete te koncentracije ukupnih identificiranih fenolnih i hlapljivih spojeva korištenog EDMU. Primjenom sortnih ulja utvrđena je sortna specifičnost u različitim uvjetima uporabe vezana uz početni sastav masnih kiselina, fenolnih i hlapljivih spojeva.

Broj stranica: 156

Broj slika: 17

Broj tablica: 8

Broj literaturnih navoda: 176

Broj priloga: 0

Jezik izvornika: engleski

Ključne riječi: antioksidacijska aktivnost, ekstra djevičansko maslinovo ulje, fenolni spojevi, hlapljivi spojevi, sastav masnih kiselina, senzorska svojstva, skladištenje, zagrijavanje

Datum obrane: 9. veljače 2023.

Stručno povjerenstvo za obranu:

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3. prof. dr. sc. Olivera Koprivnjak

Rad je pohranjen u: knjižnici Prehrambeno-biotehnološkog fakulteta u Zagrebu, Kačićeva 23; Nacionalnoj i sveučilišnoj knjižnici u Zagrebu, Hrvatske bratske zajednice 4; Sveučilištu u Zagrebu, Trg Republike Hrvatske 14.

The dissertation topic was accepted at the 8th regular session of the Faculty Council of the Faculty of Food Technology and Biotechnology, University of Zagreb in the academic year 2020/2021 held on May 25th, 2021. The University of Zagreb Senate approved the initiation of the procedure for obtaining a doctorate of science within the doctoral study on July 13th, 2021 at the 12th regular session in the 352nd academic year (2020/2021).

This work has been supported by the Croatian Science Foundation under the project “Young researchers' career development project – training of new doctoral students” (DOK-2018-09-2293); by the Horizon 2020 European Research project OLEUM “Advanced solutions for assuring the authenticity and quality of olive oil at a global scale” (grant agreement No. 635690); and by the Institute of Agriculture and Tourism in Poreč.

INFORMATION ABOUT THE SUPERVISOR

Ph.D. Karolina Brkić Bubola is employed as a Senior Research Associate at the Institute for Agriculture and Tourism in Poreč. Since 2018, she has been elected to the scientific position of Scientific Advisor. She graduated in 2004 at the Faculty of Food Technology and Biotechnology, University of Zagreb, where she defended her doctoral thesis in 2011 and obtained the academic degree of Doctor of science in the field of biotechnical sciences, food technology. She has been employed at the Institute since 2005, where since 2005 she has been the deputy head of the Laboratory of Food Technology and Biotechnology, and since 2008 she has been the head of the accredited and official Panel for sensory analysis of virgin olive oils, recognized by the International Olive Council (IOC) and the Ministry of Agriculture of the Republic of Croatia. She participated in 12 scientific projects, mostly related to the quality and technology of olive oils and sensory properties of agro-food products. She was the principal investigator of the VIP project "Application of filtration for the purpose of improving the quality of olive oils" financed by the Ministry of Agriculture of the Republic of Croatia, and the leader of the research group of the Institute within the HORIZON 2020 project "Advanced solutions for assuring the overall authenticity and quality of olive oil - OLEUM" financed by the EU. Since 2018, she has been the head of two career development projects for young researchers founded by the Croatian Science Foundation (DOK-2018-09-2293 and DOK-2018-01-4693). To date, 1 book chapter and more than 40 scientific papers have been published, of which 31 papers are represented in the CC and SCI Expanded databases. She participated in more than 40 international conferences, at 3 of them she was a member of the organizing committee. She was cited more than 400 times with an h-index of 14. She reviewed about a hundred scientific articles for 15 reputable scientific journals. In 2008, she received an IOC scholarship for training in the sensory analysis of olive oils at the University of Jaén, Spain. In 2014, she was the winner of the "Knight of Croatian Olive Oil" charter, an award for scientific and professional work in the field of olive oil production. She is a member of professional societies: European Federation of the Science and Technology of Lipids, and Croatian Society of Food Technologists, Biotechnologists and Nutritionists. She is a member of the international judging panels of the world olive oil competitions (NYIOOC, New York, USA; EVOOLEUM, Cordoba, Spain). Since 2014, she has been a member of the working group of experts for the analysis of olive oils in the European Commission, and since 2018, a member of the IOC working group for the sensory analysis of olive oil (representative of Croatia). Since 2021, she has been a member of the Scientific field committee for biotechnical sciences of the Agency for science and higher education.

STABILITY OF FATTY ACID COMPOSITION, PHENOLIC AND VOLATILE COMPOUNDS IN VARIETAL EXTRA VIRGIN OLIVE OILS DURING STORAGE AND HEATING

The usage of extra virgin olive oil (EVOO) in food preparation implies its frequent contact with air, exposition to high temperatures, and interaction with other food ingredients. The influence of real conditions of EVOO usage in households has been insufficiently investigated. Therefore, this study aimed to investigate the influence of real storage conditions and daily consumption, heating, and presence of food during storage (dried tomatoes, cheese) and heating (vegetables) of monovarietal EVOOs on its fatty acid composition, phenolic and volatile compounds, antioxidant activity, sensory properties, and quality. The results indicated that under consumption conditions used in this study (gradual headspace increasing, darkness, room temperature), EVOO's composition of fatty acid, phenolic and volatile compounds remained preserved within one month. The presence of food during storage and heating significantly decreased the quality and the concentration of total identified phenolic and volatile compounds of the used EVOO. This investigation unveiled the important role of the initial composition of the EVOO (phenolic compounds), but also of the food (moisture content) immersed in EVOO, as parameters that influence the degradation rate of EVOO during simultaneous storage and heating. The use of monovarietal oils indicated varietal specificity under different conditions of its use, related to the composition of fatty acids, phenolic and volatile compounds.

Keywords: *antioxidant activity, extra virgin olive oil, fatty acid composition, heating, phenolic compounds, quality; storage, sensory attributes, volatile compounds*

STABILNOST FENOLNIH I HLAPLJIVIH TVARI TE SASTAVA MASNIH KISELINA SORTNIH EKSTRA DJEVIČANSKIH MASLINOVIH ULJA TIJEKOM SKLADIŠTENJA I ZAGRIJAVANJA

Prilikom upotrebe ekstra djevičanskog maslinovog ulja (EDMU) u pripremi jela dolazi do njegovog učestalog kontakta sa zrakom, izloženosti visokim temperaturama i interakcijama sa sastojcima druge hrane. Utjecaj realnih uvjeta upotrebe EDMU u domaćinstvima nedovoljno je istražen. Prema tome, cilj ovog istraživanja bio je ispitati utjecaj realnih uvjeta upotrebe i svakodnevnog korištenja, zagrijavanja i prisutnosti hrane tijekom skladištenja (sušena rajčica, sir) i zagrijavanja (povrće) sortnih EDMU na sastav masnih kiselina, fenola i hlapljivih spojeva, antioksidacijsku aktivnost, senzorska svojstva i kvalitetu ulja. Dobiveni rezultati pokazali su da je sastav masnih kiselina, fenolnih i hlapljivih spojeva EDMU u uvjetima svakodnevnog korištenja (postepeno povećavanje nadprostora boce, bez svjetlosti, sobna temperatura) ostao nepromijenjen unutar mjesec dana skladištenja. Prisutnost hrane tijekom skladištenja i zagrijavanja značajno je utjecala na smanjenje kvalitete te koncentracije ukupnih identificiranih fenolnih i hlapljivih spojeva korištenog EDMU. Ovo istraživanje ukazalo je na važnu ulogu početnog kemijskog sastava EDMU (fenolni spojevi), ali i sastava korištene hrane (udio vode), kao parametara koji utječu na brzinu degradacije EDMU prilikom zajedničkog skladištenja i zagrijavanja. Primjenom sortnih ulja utvrđena je sortna specifičnost u različitim uvjetima uporabe vezana uz početni sastav masnih kiselina, fenolnih i hlapljivih spojeva.

Ključne riječi: *antioksidacijska aktivnost, ekstra djevičansko maslinovo ulje, fenolni spojevi, hlapljivi spojevi, kvaliteta, sastav masnih kiselina, senzorska svojstva, skladištenje, zagrijavanje*

Posebno se želim zahvaliti svojoj mentorici dr. sc. Karolini Brkić Bubola koja mi je pružila priliku te me izabrala za svoju doktorandicu. Hvala mentorici na viziji, velikoj pomoći, svakodnevnoj motivaciji, savjetima te što je bila moj vjetar u leđa tijekom četiri godine izrade ovog rada. Hvala Vam na tome što ste u meni probudili ljubav prema znanosti i maslinovom ulju. Bila mi je iznimna čast biti Vaša doktorandica. Hvala i kolegici Anji koja je bila neizostavni dio našega tima i bez koje to ne bi bio trio iz snova. Hvala ti na svemu.

Veliko hvala dr. sc. Klari Kraljć, prof. dr. sc. Dubravki Škevin i prof. dr. sc. Oliveri Koprivnjak na susretljivosti i vrijednim sugestijama kojima su doprinijele izradi i kvaliteti ove doktorske disertacije. Hvala prof. dr. sc. Oliveri Koprivnjak i na konstruktivnim savjetima i pomoći prilikom izrade jednog djela istraživanja. Veliko hvala dr. sc. Marini Lukić i dr. sc. Igoru Lukiću na nesebičnom dijeljenju znanja i savjeta tijekom cijelog razdoblja mog zaposlenja. Hvala prof. dr. sc. Jelki Pleadin i dr. sc. Tini Lešić s Hrvatskog veterinarskog instituta za pomoć pri provođenju kemijskih analiza sira.

Zahvaljujem se svim kolegicama iz Vinarskog i Prehrambeno - biotehnološkog laboratorija, a posebno hvala najboljim kolegicama iz Barake 3b koje su uvijek bile tu uz mene, u trenucima veselja, ali i u onima gdje nam je trebala međusobna podrška i oslonac za nastavak ovog putovanja. Hvala vam cure što ste mi ovaj period života učinile nestvarno lijepim i što sam s veseljem svakoga dana išla na posao!

Posebno hvala mojem tati, sestrama Sari i Foški, cijeloj obitelji te svim mojim prijateljima i prijateljicama bez kojih to ne bih bila ja, koji su uvijek tu uz mene i čine me boljom osobom. Hvala i najdražem Paolu. Hvala vam svima na neizmjernoj ljubavi, razumijevanju i podršci koju ste mi pružali. Posebno hvala mojoj majci koja je moj najveći uzor, potpora i motivacija, ovaj rad posvećujem tebi!

LIST OF ABBREVIATIONS

ANOVA – Analysis of variance

B – Buža

DPPH – 2,2-diphenyl-1-picrylhydrazyl

EEC – European Commission Regulation

EFSA – European Food Safety Authority

EVOO – Extra virgin olive oil

FFA – Free fatty acid

GC-FID – Gas chromatography–flame ionization detection

GC-MS – Gas chromatography–mass spectrometry

HPLC – High performance liquid chromatography

IB – Istarska bjelica

IOC – International Olive Council

L – Leccino

MUFA – Monounsaturated fatty acids

VOO – Virgin olive oil

PCA – Principal component analysis

PUFA – Polyunsaturated fatty acids

PV – Peroxide value

RAF – Refined olive oil

RSA – Radical-scavenging activity

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Other parts of the thesis will be available after the publication of all the research data.

(Ostali dijelovi doktorata bit će dostupni nakon objave svih podataka)

References

- Al-Ismail, K., Al-Awamleh, S.A., Saleh, M., Al-Titi, H. (2019) Impacts of oil types and storage conditions on milk fat quality of strained yogurt immersed in oil. *JAOCS, J. Am. Oil Chem. Soc.* **96**, 171–178.
- Ali, M.Y., Sina, A.A.I., Khandker, S.S., Neesa, L., Tanvir, E.M., Kabir, A., Khalil, M.I., Gan, S.H. (2020) Nutritional composition and bioactive compounds in tomatoes and their impact on human health and disease: A review. *Foods*, **10**, 45.
- Allouche, Y., Jiménez, A., Gaforio, J.J., Uceda, M., Beltrán, G. (2007) How heating affects extra virgin olive oil quality indexes and chemical composition. *J. Agric. Food Chem.* **55**, 9646–9654.
- Alzaa, D.F. (2018) Evaluation of chemical and physical changes in different commercial oils during heating. *Acta Sci. Nutr. Heal.* **2**, 2–11.
- Andrewes, P., Busch, J.L.H.C., De Joode, T., Groenewegen, A., Alexandre, H. (2003) Sensory properties of virgin olive oil polyphenols: Identification of deacetoxy-ligstroside aglycon as a key contributor to pungency. *J. Agric. Food Chem.* **51**, 1415–1420.
- Angerosa, F., Basti, C., Vito, R., Lanza, B. (1999) Effect of fruit stone removal on the production of virgin olive oil volatile compounds. *Food Chem.* **67**, 295–299.
- Angerosa, F., Servili, M., Selvaggini, R., Taticchi, A., Esposto, S., Montedoro, G. (2004) Volatile compounds in virgin olive oil: Occurrence and their relationship with the quality. *J. Chromatogr. A* **1054**, 17–31.
- Aparicio, R., Harwood, J. (2013) *Handbook of olive oil: Analysis and properties*. 2nd Ed. Springer, Switzerland.
- Aranda, F., Gómez-Alonso, S., Rivera Del Álamo, R.M., Salvador, M.D., Fregapane, G. (2004) Triglyceride, total and 2-position fatty acid composition of Cornicabra virgin olive oil: Comparison with other Spanish cultivars. *Food Chem.* **86**, 485–492.
- Aranda, V., Macci, C., Peruzzi, E., Masciandaro, G. (2015) Biochemical activity and chemical-structural properties of soil organic matter after 17 years of amendments with olive-mill pomace co-compost. *J. Environ. Manage.* **147**, 278–285.
- Azaizeh, H., Abu Tayeh, H.N., Gerchman, Y. (2020) *Biovalorisation of wastes to renewable chemicals and biofuels: Valorisation of olive oil industry solid waste and production of ethanol and high value-added biomolecules*. Elsevier Inc., Amsterdam, Netherlands.

- Bach-Faig, A., Berry, E.M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Medina, F.X., Battino, M., Belahsen, R., Miranda, G., et al. (2011) Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutr.* **14**, 2274–2284.
- Baldioli, M., Servili, M., Perretti, G., Montedoro, G.F. (1996) Antioxidant activity of tocopherols and phenolic compounds of virgin olive oil. *JAOCS, J. Am. Oil Chem. Soc.* **73**, 1589–1593.
- Ben-Hassine, K., Taamalli, A., Ferchichi, S., Mlaouah, A., Benincasa, C., Romano, E., Flamini, G., Lazzez, A., Grati-Kamoun, N., Perri, E., Malouche, D., Hammami, M. (2013) Physicochemical and sensory characteristics of virgin olive oils in relation to cultivar, extraction system and storage conditions. *Food Res. Int.* **54**, 1915–1925.
- Bendini, A., Cerretani, L., Carrasco-Pancorbo, A., Gómez-Caravaca, A.M., Segura-Carretero, A., Fernández-Gutiérrez, A., Lercker, G. (2007) Phenolic molecules in virgin olive oils: A survey of their sensory properties, health effects, antioxidant activity and analytical methods. An overview of the last decade. *Molecules* **12**, 1679–1719.
- Berbel, J., Posadillo, A. (2018) Review and analysis of alternatives for the valorisation of agro-industrial olive oil by-products. *Sustainability* **10**, 1–9.
- Berdeaux, O., Mermesat, S., Velasco, J., Dobarganes, M.C. (2012) Apparent and quantitative loss of fatty acids and triacylglycerols at frying temperatures. *Grasas aceites* **63** 284–289.
- Blasi, F., Urbani, E., Simonetti, M.S., Chiesi, C., Cossignani, L. (2016) Seasonal variations in antioxidant compounds of *Olea europaea* leaves collected from different Italian cultivars. *J. Appl. Bot. Food Qual.* **89**, 202–207.
- Blekas, G., Tsimidou, M., Boskou, D. (1995) Contribution of α -tocopherol to olive oil stability. *Food Chem.* **52**, 289–294.
- Boskou, D. (2006) Sources of natural phenolic antioxidants. *Trends Food Sci. Technol.* **17**, 505–512.
- Boskou, D. (2015) *Olive and olive oil bioactive constituents: Olive fruit, table olives, and olive oil bioactive constituents*. AOCS Press. Published by Elsevier Inc., Amsterdam, Netherlands.
- Boskou, D., Blekas, G., Tsimidou, M. (2006) *Olive oil: chemistry and technology*. 2nd Ed. Taylor & Francis, London, England.

- Brenes, M., García, A., García, P., Garrido, A. (2001) Acid hydrolysis of secoiridoid aglycons during storage of virgin olive oil. *J. Agric. Food Chem.* **49**, 5609–5614.
- Brenes, M., García, A., García, P., Rios, J. J., Garrido, A. (1991) Phenolic Compounds in Spanish Olive Oils. *J. Agric. Food Chem.* **47**, 3535–3540.
- Brkić Bubola, K., Klisović, D., Lukić, I., Novoselić, A. (2020a) Vegetable species significantly affects the phenolic composition and oxidative stability of extra virgin olive oil used for roasting. *LWT - Food Sci. Technol.* **129**, 109628.
- Brkić Bubola, K., Koprivnjak, O., Sladonja, B., Belobrajčić, I. (2014) Influence of storage temperature on quality parameters, phenols and volatile compounds of Croatian virgin olive oils. *Grasas Aceites* **65**. e034.
- Brkić Bubola, K., Koprivnjak, O., Sladonja, B., Lukić, I. (2012) Volatile compounds and sensory profiles of monovarietal virgin olive oil from Buža, Črna and Rosinjola cultivars in Istria (Croatia). *Food Technol. Biotechnol.* **50**, 192–198.
- Brkić Bubola, K., Lukić, M., Lukić, I., Koprivnjak, O. (2019) Effect of different clarification methods on volatile aroma compound composition of virgin olive oil. *Food Technol. Biotechnol.* **57**, 503–512.
- Brkić Bubola, K., Lukić, M., Novoselić, A., Krapac, M., Lukić, I. (2020b) Olive fruit refrigeration during prolonged storage preserves the quality of virgin olive oil extracted therefrom. *Foods* **9**, 1445.
- Brühl, L. (2014) Fatty acid alterations in oils and fats during heating and frying. *Eur. J. Lipid Sci. Technol.* **116**, 707–715.
- Caipo, L., Sandoval, A., Sepúlveda, B., Fuentes, E., Valenzuela, R., Metherel, A.H., Romero, N. (2021) Effect of storage conditions on the quality of Arbequina extra virgin olive oil and the impact on the composition of flavor-related compounds (Phenols and volatiles). *Foods* **10**, 2161.
- Cámara, M., Del Valle, M., Torija, M.E., Castilho, C. (2001) Fatty acid composition of tomato pomace. *Acta Hortic.* **542**, 175–181.
- Campestre, C., Angelini, G., Gasbarri, C., Angerosa, F. (2017) The compounds responsible for the sensory profile in monovarietal virgin olive oils. *Molecules* **22**, 1–28.
- Caponio, F., Bilancia, M.T., Pasqualone, A., Sikorska, E., Gomes, T. (2005) Influence of the

- exposure to light on extra virgin olive oil quality during storage. *Eur. Food Res. Technol.* **221**, 92–98.
- Caponio, F., Gomes, T., Summo, C. (2003) Assessment of the oxidative and hydrolytic degradation of oils used as liquid medium of in-oil preserved vegetables. *J. Food Sci.* **68**, 147–151.
- Carrasco-Pancorbo, A., Cerretani, L., Bendini, A., Segura-Carretero, A., Lercker, G., Fernández-Gutiérrez, A. (2007) Evaluation of the influence of thermal oxidation on the phenolic composition and on the antioxidant activity of extra-virgin olive oils. *J. Agric. Food Chem.* **55**, 4771–4780.
- Casal, S., Malheiro, R., Sendas, A., Oliveira, B.P.P., Pereira, J.A. (2010) Olive oil stability under deep-frying conditions. *Food Chem. Toxicol.* **48**, 2972–2979.
- Castillo-Luna, A., Criado-Navarro, I., Ledesma-Escobar, C.A., López-Bascón, M.A., Priego-Capote, F. (2021) The decrease in the health benefits of extra virgin olive oil during storage is conditioned by the initial phenolic profile. *Food Chem.* **336**, 127730.
- Cavalli, J.F., Fernandez, X., Lizzani-Cuvelier, L., Loiseau, A.M. (2004) Characterization of volatile compounds of French and Spanish virgin olive oils by HS-SPME: Identification of quality-freshness markers. *Food Chem.* **88**, 151–157.
- Chiavaro, E., Vittadini, E., Rodrigues-Estrada, M.T., Cerretani, L., Bendini, A. (2008) Monovarietal extra virgin olive oils. Correlation between thermal properties and chemical composition: heating thermograms. *J. Agric. Food Chem.* **56**, 496–501.
- Choe, E., Min, D.B. (2007) Chemistry of deep-fat frying oils. *J. Food Sci.* **72**, 5.
- Chousou, C., Tsakiridou, E., Mattas, K. (2018) Valuing Consumer Perceptions of Olive Oil Authenticity. *J. Int. Food Agribus. Mark.* **30**, 1–16.
- Cicerale, S., Conlan, X.A., Barnett, N.W., Keast, R.S.J. (2013) Storage of extra virgin olive oil and its effect on the biological activity and concentration of oleocanthal. *Food Res. Int.* **50**, 597–602.
- Cicerale, S., Conlan, X.A., Barnett, N.W., Sinclair, A.J., Keast, R.S.J. (2009) Influence of heat on biological activity and concentration of oleocanthal - A natural anti-inflammatory agent in virgin olive oil. *J. Agric. Food Chem.* **57**, 1326–1330.
- Cicerale, S., Lucas, L., Keast, R. (2010) Biological activities of phenolic compounds present

- in virgin olive oil. *Int. J. Mol. Sci.* **11**, 458–479.
- Conte, L., Bendini, A., Valli, E., Lucci, P., Moret, S., Maquet, A., Lacoste, F., Brereton, P., García-González, D.L., Moreda, W., Gallina Toschi, T. (2019) Olive oil quality and authenticity: A review of current EU legislation, standards, relevant methods of analyses, their drawbacks and recommendations for the future. *Trends Food Sci. Technol.* **105**, 483–493.
- Conte, L., Milani, A., Calligaris, S., Rovellini, P., Lucci, P., Nicoli, M.C. (2020) Temperature dependence of oxidation kinetics of extra virgin olive oil (EVOO) and shelf-life prediction. *Foods* **9**, 295.
- Dabbou, Samia, Gharbi, I., Dabbou, Sihem, Brahmi, F., Nakbi, A., Hammami, M. (2011) Impact of packaging material and storage time on olive oil quality. *African J. Biotechnol.* **10**, 16937–16947.
- Daskalaki, D., Kefi, G., Kotsiou, K., Tasioula-Margari, M. (2009) Evaluation of phenolic compounds degradation in virgin olive oil during storage and heating. *J. Food Nutr. Res.* **48**, 31–41.
- De Toffoli, A., Monteleone, E., Bucalossi, G., Veneziani, G., Fia, G., Servili, M., Zanoni, B., Pagliarini, E., Gallina Toschi, T., Dinnella, C. (2019) Sensory and chemical profile of a phenolic extract from olive mill waste waters in plant-based food with varied macro-composition. *Food Res. Int.* **119**, 236–243.
- Debnath, S., Vidyarthi, S.K., Singh, R.P. (2010) Impact of blending of frying oils on viscosity and heat transfer coefficient at elevated temperatures. *J. Food Process Eng.* **33**, 144–161.
- Di Trana, A., Di Rosa, A.R., Addis, M., Fiori, M., Di Grigoli, A., Morittu, V.M., Spina, A.A., Claps, S., Chiofalo, V., Licitra, G., Todaro, M. (2022) The quality of five natural, historical Italian cheeses produced in different months: Gross composition, fat-soluble vitamins, fatty acids, total phenols, antioxidant capacity, and health index. *Animals* **12**, 199.
- Diamantakos, P., Ioannidis, K., Papanikolaou, C., Tsolakou, A., Rigakou, A., Melliou, E., Magiatis, P. (2021) A new definition of the term “high-phenolic olive oil” based on large scale statistical data of greek olive oils analyzed by qnmr. *Molecules* **26**, 1115.
- Distefano, M., Mauro, R.P., Page, D., Giuffrida, F., Bertin, N., Leonardi, C. (2022) Aroma volatiles in tomato fruits: the role of genetic, preharvest and postharvest factors.

- Agronomy* **12**, 1–27.
- Dordevic, D., Kushkevych, I., Jancikova, S., Zeljkovic, S.C., Zdarsky, M., Hodulova, L. (2020) Modeling the effect of heat treatment on fatty acid composition in home-made olive oil preparations. *Open Life Sci.* **15**, 606–618.
- EFSA Panel on Dietetic Products Nutrition and Allergens (2011) Scientific Opinion on the substantiation of health claims related to polyphenols in olive and protection of LDL particles from oxidative damage (ID 1333, 1638 1639, 1696 2865), maintenance of normal blood HDL cholesterol concentrations (ID 1639), maintenance of normal blood pressure (ID 3781), “anti-inflammatory properties” (ID 1882), “contributes to the upper respiratory tract health” (ID 3468), “can help to maintain a normal function of gastrointestinal tract” (3779), and “contributes to body defences against external agents” (ID 3467) pursuant to Article 13(1) of Regulation (EC) No. 1924/ 2006. *EFSA J.* **9**, 2033–2058.
- Esposito, S., Selvaggini, R., Taticchi, A., Veneziani, G., Sordini, B., Servili, M. (2020) Quality evolution of extra-virgin olive oils according to their chemical composition during 22 months of storage under dark conditions. *Food Chem.* **311**, 126044.
- Esposito, S., Taticchi, A., Urbani, S., Selvaggini, R., Veneziani, G., Di Maio, I., Sordini, B., Servili, M. (2017) Effect of light exposure on the quality of extra virgin olive oils according to their chemical composition. *Food Chem.* **229**, 726–733.
- EEC (2012) European Commission Regulation No 432/2012. Commission Regulation (EU) No 432/2012 of 16 May 2012 establishing a list of permitted health claims made on foods, other than those referring to the reduction of disease risk and to children’s development and health Text with EEA relevance. *Off. J. Eur. Communities*, **L136**, 281–320.
- EEC (2013) European Commission Regulation No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products. *Off. J. Eur. Union*, **L347/692**.
- EEC (2020) World olive oil production figures. https://ec.europa.eu/info/news/producing-69-worlds-production-eu-largest-producer-olive-oil-2020-feb-04_en. Accessed 25/7/2022.
- EEC (2022) Commission Delegated Regulation (EU) 2022/2104 of 29 July 2022 supplementing Regulation (EU) No 1308/2013 of the European Parliament and of the

- Council as regards marketing standards for olive oil. *Off. J. Eur. Union*, **L284**, 1–22.
- Fabiani, R. (2016) Anti-cancer properties of olive oil secoiridoid phenols: A systematic review of: In vivo studies. *Food Funct.* **7**, 4145–4159.
- Fernandes, G.D., Ellis, A.C., Gámbaro, A., Barrera-Arellano, D. (2018) Sensory evaluation of high-quality virgin olive oil: panel analysis versus consumer perception. *Curr. Opin. Food Sci.* **21**, 66–71.
- Frankel, E.N. (2010) Chemistry of extra virgin olive oil: Adulteration, oxidative stability, and antioxidants. *J. Agric. Food Chem.* **58**, 5991–6006.
- Fregapane, G., Salvador, M.D. (2013) Production of superior quality extra virgin olive oil modulating the content and profile of its minor components. *Food Res. Int.* **54**, 1907–1914.
- Fregapane, G., Salvador, M.D. (2017) Oxidative Stability and the Role of Minor and Functional Components of Olive Oil. *Olives Olive Oil as Funct. Foods* 249–265.
- Gaforio, J.J., Visioli, F., Alarcón-de-la-Lastra, C., Castañer, O., Delgado-Rodríguez, M., Fitó, M., Hernández, A.F., Huertas, J.R., Martínez-González, M.A., Menendez, J.A., de la Osada, J., Papadaki, A., Parrón, T., Pereira, J.E., Rosillo, M.A., Sánchez-Quesada, C., Schwingshackl, L., Toledo, E., Tsatsakis, A.M. (2019) Virgin olive oil and health: Summary of the III international conference on virgin olive oil and health consensus report, JAEN (Spain) 2018. *Nutrients* **11**. 2039.
- Garcia, B., Magalhães, J., Fregapane, G., Salvador, M.D., Paiva-Martins, F. (2012) Potential of selected Portuguese cultivars for the production of high quality monovarietal virgin olive oil. *Eur. J. Lipid Sci. Technol.* **114**, 1070–1082.
- Genovese, A., Caporaso, N., Sacchi, R. (2015) Temporal changes of virgin olive oil volatile compounds in a model system simulating domestic consumption: The role of biophenols. *Food Res. Int.* **77**, 670–674.
- Genovese, A., Caporaso, N., Sacchi, R. (2021) Flavor chemistry of virgin olive oil: An overview. *Appl. Sci.* **11**, 1–21.
- Giourga, C., Loumou, A. (2002) Olive groves: “The life and identity of the Mediterranean”. *Agric. Human Values* **20**, 87–95.
- Giuffrè, A.M., Capocasale, M., Macrì, R., Caracciolo, M., Zappia, C., Poiana, M. (2020)

- Volatile profiles of extra virgin olive oil, olive pomace oil, soybean oil and palm oil in different heating conditions. *LWT - Food Sci. Technol.* **117**, 108631.
- Giuffrè, A.M., Zappia, C., Capocasale, M. (2017) Effects of High Temperatures and Duration of Heating on Olive Oil Properties for Food Use and Biodiesel Production. *JAOCS, J. Am. Oil Chem. Soc.* **94**, 819–830.
- Gómez-Alonso, S., Fregapane, G., Desamparados Salvador, M., Gordon, M.H. (2003) Changes in phenolic composition and antioxidant activity of virgin olive oil during frying. *J. Agric. Food Chem.* **51**, 667–672.
- Gómez-Alonso, S., Mancebo-Campos, V., Salvador, M.D., Fregapane, G. (2007) Evolution of major and minor components and oxidation indices of virgin olive oil during 21 months storage at room temperature. *Food Chem.* **100**, 36–42.
- Guerrero, A. (2017) The dietary and thermoregulatory role of blubber as revealed by fatty acids, PhD thesis, Tracey Rogers (supervisor), University of New South Wales, United Kingdom.
- Gupta, M.K. (2005) *Bailey's Industrial Oil and Fat Products: Frying Oils*, John Wiley & Sons, Inc. New York, USA.
- Han, J., Chang, Y., Britten, M., St-Gelais, D., Champagne, C.P., Fustier, P., Lacroix, M., (2019) Interactions of phenolic compounds with milk proteins. *Eur. Food Res. Technol.* **245**, 1881–1888.
- Hohmann, C.D., Cramer, H., Michalsen, A., Kessler, C., Steckhan, N., Choi, K., Dobos, G. (2015) Effects of high phenolic olive oil on cardiovascular risk factors: A systematic review and meta-analysis. *Phytomedicine* **22**, 631–640.
- Hrnčirik, K., Fritsche, S. (2004) Comparability and reliability of different techniques for the determination of phenolic compounds in virgin olive oil. *Eur. J. Lipid Sci. Technol.* **106**, 540–549.
- IOC (2020) Consumer guidelines on the best storage conditions for olive oils and olive pomace oils. COI/ CBPS/ Doc. No 1. Retrieved September 04, 2022 from: <https://www.internationaloliveoil.org/wp-content/uploads/2020/12/COI-CBPS-Doc.-n%C2%BA-1-ENG.pdf>
- IOC (2022) Trade standard applying to olive oils and olive pomace oils. Tables of the International Olive Oil council. Retrieved September 04, 2022 from:

- <https://www.internationaloliveoil.org/>
- Iqdiam, B.M., Welt, B.A., Goodrich-Schneider, R., Sims, C.A., Baker, G.L., Marshall, M.R. (2020) Influence of headspace oxygen on quality and shelf life of extra virgin olive oil during storage. *Food Packag. Shelf Life* **23**, 100433.
- Jakobek, L. (2015) Interactions of polyphenols with carbohydrates, lipids and proteins. *Food Chem.* **175**, 556–567.
- Jerman Klen, T., Golc Wondra, A., Vrhovšek, U., Mozetič Vodopivec, B. (2015) Phenolic Profiling of Olives and Olive Oil Process-Derived Matrices Using UPLC-DAD-ESI-QTOF-HRMS Analysis. *J. Agric. Food Chem.* **63**, 3859–3872.
- Jimenez-Lopez, C., Carpena, M., Lourenço-Lopes, C., Gallardo-Gomez, M., Lorenzo, J.M., Barba, F.J., Prieto, M.A., Simal-Gandara, J. (2020) Bioactive compounds and quality of extra virgin olive oil. *Foods* **9**, 1014.
- Jukić Špika, M., Kraljić, K., Škevin, D. (2016) *Products from Olive Tree: Tocopherols: chemical structure, bioactivity, and variability in Croatian virgin olive oils*, 1st Ed., IntechOpen, London.
- Jukić Špika M., Liber Z., Montemurro C., Miazzi M.M., Ljubenković I., Soldo B., Žanetić M., Vitanović E., Politeo O., Škevin D. (2022) Quantitatively unraveling hierarchy of factors impacting virgin olive oil phenolic profile and oxidative stability. *Antioxidants* **11**, 594.
- Jukić Špika, M., Perica, S., Žanetić M., Škevin, D. (2021) Virgin olive oil phenols, fatty acid composition and sensory profile: Can cultivar overpower environmental and ripening effect? *Antioxidants* **10**, 689.
- Kalua, C.M., Allen, M.S., Bedgood, D.R., Bishop, A.G., Prenzler, P.D., Robards, K. (2007) Olive oil volatile compounds, flavour development and quality: A critical review. *Food Chem.* **100**, 273–286.
- Katsuta, I., Shimizu, M., Yamaguchi, T., Nakajima, Y. (2008) Emission of volatile aldehydes from DAG-rich and TAG-rich oils with different degrees of unsaturation during deep-frying. *J. Am. Oil Chem. Soc.* **85**, 513–519.
- Keceli, T., Robinson, R.K., Gordon, M.H. (1999) The role of olive oil in the preservation of yogurt cheese (labneh anbaris). *Int. J. Dairy Technol.* **52**, 68–72.
- Kelebek, H., Kesen, S., Sonmezdag, A.S., Cetiner, B., Kola, O., Selli, S. (2018)

- Characterization of the key aroma compounds in tomato pastes as affected by hot and cold break process. *J. Food Meas. Charact.* **12**, 2461–2474.
- Kiralan, M., Ramadan, M.F. (2016) Volatile oxidation compounds and stability of safflower, sesame and canola cold-pressed oils as affected by thermal and microwave treatments. *J. Oleo Sci.* **65**, 825–833.
- Kiralan, S.S., Karagoz, S.G., Ozkan, G., Kiralan, M., Ketenoglu, O. (2021) Changes in Volatile Compounds of Virgin Olive Oil Flavored with Essential Oils During Thermal and Photo-Oxidation. *Food Anal. Methods* **14**, 883–896.
- Kiritsakis, A.K. (1998) Flavor components of olive oil - A review. *J. Am. Oil Chem.* **75**, 673–681.
- Koprivnjak, O. (2006) Djevičansko maslinovo ulje. Od masline do stola. CIP, Poreč, Croatia. (In Croatian)
- Koprivnjak, O., Vrhovnik, I., Hladnik, T., Prgomet, Ž., Hlevnjak, B., Majetić Germek, V. (2012) Characteristics of nutritive value of virgin olive oils from Buža, Istarska bjelica, Leccino and Rosulja cultivars. *Croatian J. Food Technol., Biotechnol. Nutrition* **7**, 172–178. (in Croatian)
- Kostadinovic-Velickovska, S., Mitrev, S. (2013) Characterization of fatty acid profile, polyphenolic content and antioxidant activity of cold pressed and refined edible Oils from Macedonia. *J. Food Chem. Nutr.* 1–6.
- Kotsiou, K., Tasioula-Margari, M. (2015) Changes occurring in the volatile composition of Greek virgin olive oils during storage: Oil variety influences stability. *Eur. J. Lipid Sci. Technol.* **117**, 514–522.
- Kotsiou, K., Tasioula-Margari, M. (2016) Monitoring the phenolic compounds of Greek extra-virgin olive oils during storage. *Food Chem.* **200**, 255–262.
- Krichene, D., Salvador, M.D., Fregapane, G. (2015) Stability of Virgin Olive Oil Phenolic Compounds during Long-Term Storage (18 Months) at Temperatures of 5-50°C. *J. Agric. Food Chem.* **63**, 6779–6786.
- Kritioti, A., Menexes, G., Drouza, C. (2018) Chemometric characterization of virgin olive oils of the two major Cypriot cultivars based on their fatty acid composition. *Food Res. Int.* **103**, 426–437.

- Labuckas, D.O., Maestri, D.M., Perelló, M., Martínez, M.L., Lamarque, A.L. (2008) Phenolics from walnut (*Juglans regia* L.) kernels: Antioxidant activity and interactions with proteins. *Food Chem.* **107**, 607–612.
- Lamothe, S., Azimy, N., Bazinet, L., Couillard, C., Britten, M. (2014) Interaction of green tea polyphenols with dairy matrices in a simulated gastrointestinal environment. *Food Funct.* **5**, 2621–2631.
- Lazzerini, C., Cifelli, M., Domenici, V. (2016) *Products from Olive Tree: Pigments in extra-virgin olive oil*, 1st Ed., IntechOpen, London.
- Lazzerini, C., Domenici, V. (2017) Pigments in extra-virgin olive oils produced in Tuscany (Italy) in different years. *Foods* **6**, 1–11.
- Li, X., Bremer, G.C., Connell, K.N., Ngai, C., Pham, Q.A.T., Wang, S., Flynn, M., Ravetti, L., Guillaume, C., Wang, Y., Wang, S.C. (2016) Changes in Chemical Compositions of Olive Oil under Different Heating Temperatures Similar to Home Cooking. *J. Food Chem. Nutr.* **4**, 7–15.
- Longobardi, F., Ventrella, A., Casiello, G., Sacco, D., Tasioula-Margari, M., Kiritsakis, A.K., Kontominas, M.G. (2012) Characterisation of the geographical origin of Western Greek virgin olive oils based on instrumental and multivariate statistical analysis. *Food Chem.* **133**, 169–175.
- Lozano-Castellón, J., López-Yerena, A., Domínguez-López, I., Siscart-Serra, A., Fraga, N., Sámano, S., López-Sabater, C., Lamuela-Raventós, R.M., Vallverdú-Queralt, A., Pérez, M. (2022b) Extra virgin olive oil: A comprehensive review of efforts to ensure its authenticity, traceability, and safety. *Compr. Rev. Food Sci. Food Saf.* **21**, 2639–2664.
- Lozano-Castellón, J., Rinaldi de Alvarenga, J.F., Vallverdú-Queralt, A., Lamuela-Raventós, R.M. (2022a) Cooking with extra-virgin olive oil: A mixture of food components to prevent oxidation and degradation. *Trends Food Sci. Technol.* **123**, 28–36.
- Lozano-Castellón, J., Vallverdú-Queralt, A., de Alvarenga, J.F.R., Illán, M., Torrado-Prat, X., Lamuela-Raventós, R.M. (2020) Domestic sautéing with EVOO: Change in the phenolic profile. *Antioxidants* **9**, 1–12.
- Lucci, P., Bertoz, V., Pacetti, D., Moret, S., Conte, L. (2020) Effect of the refining process on total hydroxytyrosol, tyrosol, and tocopherol contents of olive oil. *Foods* **9**, 1–11.
- Lucci, P., Saurina, J., Núñez, O. (2017) Trends in LC-MS and LC-HRMS analysis and

- characterization of polyphenols in food. *TrAC - Trends Anal. Chem.* **88**, 1-24.
- Lukić, I., Horvat, I., Godena, S., Krapac, M., Lukić, M., Vrhovsek, U., Brkić Bubola, K. (2018) Towards understanding the varietal typicity of virgin olive oil by correlating sensory and compositional analysis data: a case study. *Food Res. Int.* **112**, 78–89.
- Lukić, I., Žanetić, M., Jukić Špika, M., Lukić, M., Koprivnjak, O., Brkić Bubola, K. (2017) Complex interactive effects of ripening degree, malaxation duration and temperature on Oblica cv. virgin olive oil phenols, volatiles and sensory quality. *Food Chem.* **232**, 610–620.
- Lukić, M., Lukić, I., Moslavac, T. (2021) Sterols and triterpene diols in virgin olive oil: A comprehensive review on their properties and significance, with a special emphasis on the influence of variety and ripening degree. *Horticulturae* **7**, 493.
- Luna, G., Aparicio, R. (2002) Characterisation of monovarietal virgin olive oils. *Eur. J. Lipid Sci. Technol.* **104**, 614–627.
- Martínez-González, M.A., García-López, M., Bes-Rastrollo, M., Toledo, E., Martínez-Lapiscina, E.H., Delgado-Rodríguez, M., Vazquez, Z., Benito, S., Beunza, J.J. (2011) Mediterranean diet and the incidence of cardiovascular disease: A Spanish cohort. *Nutr. Metab. Cardiovasc. Dis.* **21**, 237–244.
- Mathieu, S., Cin, V.D., Fei, Z., Li, H., Bliss, P., Taylor, M.G., Klee, H.J., Tieman, D.M. (2009) Flavour compounds in tomato fruits: Identification of loci and potential pathways affecting volatile composition. *J. Exp. Bot.* **60**, 325–337.
- Mazzocchi, A., Leone, L., Agostoni, C., Pali-Schöll, I. (2019) The secrets of the mediterranean diet. Does [only] olive oil matter? *Nutrients* **11**, 1–14.
- Mesić, Ž., Tomić, M. (2015) Analiza svjetskog i Hrvatskog tržišta maslinovog ulja. *Glas. Hrvat. Agron. društva* **77**, 227–240. (In Croatian)
- Miho, H., Moral, J., Barranco, D., Ledesma-Escobar, C.A., Priego-Capote, F., Díez, C.M. (2021) Influence of genetic and interannual factors on the phenolic profiles of virgin olive oils. *Food Chem.* **342**, 128357.
- Milotić, A., Šetić, E., Peršuić, D. (2005) Identification and characterization of autochthonous olive varieties in Istria. *Ann. ser hist nat* **15**, 251–256. (In Croatian)
- Minguez-Mosquera, M.I., Rejano-Navarro, L., Gandul-Rojas, B., SanchezGomez, A.H.,

- Garrido-Fernandez, J. (1991) Color-pigment correlation in virgin olive oil. *J. Am. Oil Chem. Soc.* **68**, 332–336.
- Montedoro, G., Servili, M., Baldioli, M., Selvaggini, R., Miniati, E., Macchioni, A. (1993) Simple and hydrolyzable compounds in virgin olive oil. Spectroscopic characterizations of the secoiridoid derivatives. *J. Agric. Food Chem.* **41**, 2228–2234.
- Morales, M.T., Luna, G., Aparicio, R. (2005) Comparative study of virgin olive oil sensory defects. *Food Chem.* **91**, 293–301.
- Nayak, J., Pal, P. (2013) Transforming waste cheese-whey into acetic acid through a continuous membrane-integrated hybrid process. *Ind. Eng. Chem. Res.* **52**, 2977–2984.
- Obied, H. K., Prenzler, P. D., Ryan, D., Servili, M., Taticchi, A., Esposto, S., Robards, K. (2008) Biosynthesis and biotransformations of phenol-conjugated oleosidic secoiridoids from *Olea europaea* L. *Nat. Prod. Rep.* **25**, 1167–1179.
- Oliveras-López, M.J., Berná, G., Jurado-Ruiz, E., López-García de la Serrana, H., Martín, F. (2014) Consumption of extra-virgin olive oil rich in phenolic compounds has beneficial antioxidant effects in healthy human adults. *J. Funct. Foods* **10**, 475–484.
- Oueslati, I., Krichene, D., Manaï, H., Taamalli, W., Zarrouk, M., Flamini, G. (2018) Monitoring the volatile and hydrophilic bioactive compounds status of fresh and oxidized Chemlali virgin olive oils over olive storage times. *Food Res. Int.* **112**, 425–433.
- Ozdal, T., Capanoglu, E., Altay, F. (2013) A review on protein-phenolic interactions and associated changes. *Food Res. Int.* **51**, 954–970.
- Paiva-Martins, F. and Kiritsakis, A. (2017) *Olives and Olive Oil as Functional Foods: Bioactivity, Chemistry and Processing: Olive fruit and olive oil composition and their functional compounds*, 1st Ed. John Wiley & Sons, New York, USA.
- Paiva-Martins, F., Santos, V., Mangericão, H., Gordon, M.H. (2006) Effects of copper on the antioxidant activity of olive polyphenols in bulk oil and oil-in-water emulsions. *J. Agric. Food Chem.* **54**, 3738–3743.
- Palermo, M., Pellegrini, N., Fogliano, V. (2014) The effect of cooking on the phytochemical content of vegetables. *J. Sci. Food Agric.* **94**, 1057–1070.
- Pedan, V., Popp, M., Rohn, S., Nyfeler, M., Bongartz, A. (2019) Characterization of phenolic

- compounds and their contribution to sensory properties of olive oil. *Molecules* **24**, 2041.
- Pereira-Caro, G., Mateos, R., Sarria, B., Cert, R., Goya, L., Bravo, L. (2012) Hydroxytyrosyl acetate contributes to the protective effects against oxidative stress of virgin olive oil. *Food Chem.* **131**, 869–878.
- Pripp, A.H., Vreeker, R., Van Duynhoven, J. (2005) Binding of olive oil phenolics to food proteins. *J. Sci. Food Agric.* **85**, 354–362.
- Pristouri, G., Badeka, A., Kontominas, M.G. (2010) Effect of packaging material headspace, oxygen and light transmission, temperature and storage time on quality characteristics of extra virgin olive oil. *Food Control* **21**, 412–418.
- Procida, G., Cichelli, A., Compagnone, D., Maggio, R.M., Cerretani, L., Del Carlo, M. (2009) Influence of chemical composition of olive oil on the development of volatile compounds during frying. *Eur. Food Res. Technol.* **230**, 217–229.
- Psathas, D., Lioupi, A., Rebholz, A.M., Zinoviadou, K., Tsaftaris, A., Theodoridis, G., Papoti, V.T. (2022) Volatile profile and quality characteristics of the Greek “Chondrolia Chalkidikis” virgin olive oils: effect of ripening stage. *Eur. Food Res. Technol.* **248**, 1977–1990.
- Psomiadou, E., Tsimidou, M., Boskou, D. (2000) α -Tocopherol content of Greek virgin olive oils. *J. Agric. Food Chem.* **48**, 1770–1775.
- Ramírez-Anaya, J.D.P., Samaniego-Sánchez, C., Castañeda-Saucedo, M.C., Villalón-Mir, M., De La Serrana, H.L.G. (2015) Phenols and the antioxidant capacity of Mediterranean vegetables prepared with extra virgin olive oil using different domestic cooking techniques. *Food Chem.* **188**, 430–438.
- Rinaldi de Alvarenga, J.F., Quifer-Rada, P., Juliano, F.F., Hurtado-Barroso, S., Illan, M., Torrado-Prat, X., Lamuela-Raventós, R.M. (2019) Using extra virgin olive oil to cook vegetables enhances polyphenol and carotenoid extractability: A Study Applying the sofrito Technique. *Molecules* **24**, 1555.
- Roca, M., Gandul-Rojas, B., Gallardo-Guerrero, L., Mínguez-Mosquera, M.I. (2003) Pigment parameters determining spanish virgin olive oil authenticity: stability during storage. *JAOCS, J. Am. Oil Chem. Soc.* **80**, 1237–1240.
- Rodrigues, N., Dias, L.G., Veloso, A.C.A., Pereira, J.A., Peres, A.M. (2016) Monitoring olive oils quality and oxidative resistance during storage using an electronic tongue. *LWT -*

- Food Sci. Technol.* **73**, 683–692.
- Rodrigues, N., Oliveira, L., Mendanha, L., Sebti, M., Dias, L.G., Oueslati, S., Veloso, A.C.A., Pereira, J.A., Peres, A.M. (2018) Olive oil quality and sensory changes during house-use simulation and temporal assessment using an electronic tongue. *JAOCS, J. Am. Oil Chem. Soc.* **95**, 1121–1137.
- Roila, R., Valiani, A., Ranucci, D., Ortenzi, R., Servili, M., Veneziani, G., Branciari, R. (2019) Antimicrobial efficacy of a polyphenolic extract from olive oil by-product against “Fior di latte” cheese spoilage bacteria. *Int. J. Food Microbiol.* **295**, 49–53.
- Romani, A., Ieri, F., Urciuoli, S., Noce, A., Marrone, G., Nediani, C., Bernini, R. (2019) Health effects of phenolic compounds found in extra-virgin olive oil, by-products, and leaf of *Olea europaea* L. *Nutrients* **11**, 1776.
- Roselli, L., Clodoveo, M.L., Corbo, F., De Gennaro, B. (2017) Are health claims a useful tool to segment the category of extra-virgin olive oil? Threats and opportunities for the Italian olive oil supply chain. *Trends Food Sci. Technol.* **68**, 176–181.
- Rugini, E., Fedeli, E. (1990) Olive (*Olea europaea* L.) as an Oilseed Crop. Bajaj, Y.P.S., Ed.; Springer: Berlin. In *Biotechnology in Agriculture and Forestry*. **10**, 593–641.
- Saini, R.K., Zamany, A.J., Keum, Y.S. (2017) Ripening improves the content of carotenoid, α -tocopherol, and polyunsaturated fatty acids in tomato (*Solanum lycopersicum* L.) fruits. *3 Biotech* **7**, 43.
- Sánchez, J., Harwood, J.L. (2002) Biosynthesis of triacylglycerols and volatiles in olives. *Eur. J. Lipid Sci. Technol.* **104**, 564–573.
- Santos, C. S. P., Cruz, R., Cunha, S. C., Casal, S. (2013) Effect of cooking on olive oil quality attributes. *Food Res. Internat.*, **54**, 2016–2024.
- Segura-Carretero, A., Menéndez-Menéndez, J., Fernández-Gutiérrez, A. (2010) *Olives and Olive Oil in Health and Disease Prevention: Polyphenols in olive oil the importance of phenolic compounds in the chemical composition of olive oil, olives and olive oil in health and disease prevention*, 2nd ed., Elsevier Inc. Amsterdam, The Netherlands.
- Serrano, A., De la Rosa, R., Sánchez-Ortiz, A., Cano, J., Pérez, A.G., Sanz, C., Arias-Calderón, R., Velasco, L., León, L. (2021) Chemical components influencing oxidative stability and sensorial properties of extra virgin olive oil and effect of genotype and location on their expression. *LWT- Food Sci. Technol.* **136**, 110257.

- Servili, M., Conner, J.M., Piggott, J.R., Withers, S.J., Paterson, A. (1995) Sensory characterisation of virgin olive oil and relationship with headspace composition. *J. Sci. Food Agric.* **67**, 61–70.
- Servili, M., Esposto, S., Fabiani, R., Urbani, S., Taticchi, A., Mariucci, F., Selvaggini, R., Montedoro, G.F. (2009) Phenolic compounds in olive oil: Antioxidant, health and organoleptic activities according to their chemical structure. *Inflammopharmacology* **17**, 76–84.
- Servili, M., Montedoro, G.F. (2002) Contribution of phenolic compounds to virgin olive oil quality. *Eur. J. Lipid Sci. Technol.* **104**, 602–613.
- Sicari, V., Leporini, M., Romeo, R., Poiana, M., Tundis, R., Loizzo, M.R. (2021) Shelf-life evaluation of “san marzano” dried tomato slices preserved in extra virgin olive oil. *Foods* **10**, 1–21.
- Silva, L., Garcia, B., Paiva-Martins, F. (2010a) Oxidative stability of olive oil and its polyphenolic compounds after boiling vegetable process. *LWT - Food Sci. Technol.* **43**, 1336–1344.
- Silva, L., Pinto, J., Carrola, J., Paiva-Martins, F. (2010b) Oxidative stability of olive oil after food processing and comparison with other vegetable oils. *Food Chem.* **121**, 1177–1187.
- Škevin, D., Rade, D., Štrucelj, D., Mokrovčak, Ž., Nederal, S., Benčić, D. (2003) The influence of variety and harvest time on the bitterness and phenolic compounds of olive oil. *Eur. J. Lipid Sci. Technol.* **105**, 536–541.
- Tsimidou, M.Z., Nenadis, N., Servili, M., García Gonzáles, D.L., Gallina Toschi, T. (2018) Why Tyrosol derivatives have to be quantified in the calculation of “olive oil polyphenols” content to support the health claim provisioned in the EC Reg. 432/2012. *Eur. J. Lipid Sci. Technol.* **120**, 1–6.
- Tsolakou, A., Diamantakos, P., Kalaboki, I., Mena-Bravo, A., Priego-Capote, F., Abdallah, I.M., Kaddoumi, A., Melliou, E., Magiatis, P. (2018) Oleocanthalic Acid, a Chemical Marker of Olive Oil Aging and Exposure to a High Storage Temperature with Potential Neuroprotective Activity. *J. Agric. Food Chem.* **66**, 7337–7346.
- Tsuzuki, W., Nagata, R., Yunoki, R., Nakajima, M., Nagata, T. (2008) Cis/trans-Isomerisation of triolein, trilinolein and trilinolenin induced by heat treatment. *Food Chem.* **108**, 75–80.

- Valli, E., Bendini, A., Popp, M., Bongartz, A. (2014) Sensory analysis and consumer acceptance of 140 high-quality extra virgin olive oils. *J. Sci. Food Agric.* **94**, 2124–2132.
- Varzakas, T. (2021) Extra virgin olive oil (EVOO): Quality, safety, authenticity, and adulteration. *Foods* **10**, 1–3.
- Velasco, J., Dobarganes, C. (2002) Oxidative stability of virgin olive oil. *Eur. J. Lipid Sci. Technol.* **104**, 661–676.
- Vrdoljak, J., Dobranić, V., Filipović, I., Zdolec, N. (2016) Microbiological quality of soft, semi-hard and hard cheeses during the shelf-life. *Maced. Vet. Rev.* **39**, 59–64.
- Walker, R.B., Everette, J.D., Bryant, Q.M., Green, A.M., Abbey, Y.A., Wangila, G.W. (2010) Reactivity of various compound classes towards the Folin-Ciocalteu reagent. *AIP Conf. Proc.* **1229**, 16–22.
- Yildirim-Elikoglu, S., Erdem, Y.K. (2018) Interactions between milk proteins and polyphenols: Binding mechanisms, related changes, and the future trends in the dairy industry. *Food Rev. Int.* **34**, 665–697.
- Žanetić, M., Škevin, D., Vitanovi, E. (2011) Survey of phenolic compounds and sensorial profile of Dalmatian virgin olive oils. *Pomologia Croatica* **17**, 19–30.
- Zanoni, B. (2014) *The extra-virgin olive oil handbook: The role of oxygen and water in the extra-virgin olive oil process*. John Wiley & Sons, New York, USA.
- Zoidou, E. (2016) A new whey cheese analogue made from whey protein concentrate and vegetable fat with 15% olive oil. *J. Nutr. Med. Diet Care* **2**, 2–6.

Autobiography

Dora Klisović, MSc, was born in Rijeka on November 11th, 1994. After finishing grammar school, she graduated from the Department of Biotechnology at the University of Rijeka in 2018, where she gained an MSc in Medicinal Chemistry. Since 2019 she is employed at the Institute of Agriculture and Tourism in Poreč as a research assistant, hired under the Young researcher career program - Training of new doctoral students by the Croatian Science Foundation and under the OLEUM project – *Advanced solutions for assuring the overall authenticity and quality of olive oil* financed from the European Union's Horizon 2020. She is finishing her Postgraduate University Doctoral Study at the Faculty of Food Technology and Biotechnology at the University of Zagreb, in which she has enrolled in 2019. Her working skills are primarily related to analytical methods for determining oil quality, which include work on sophisticated devices (liquid and gas chromatography) for determining the composition of fatty acids, phenolic and volatile compounds, and sensory analysis of olive oils. During her employment, she spent two months at the University of Barcelona, Spain, as part of an Erasmus + scholarship for a professional stay, where she gained new knowledge on the gas chromatography analysis of virgin oils. She presented the results of her research at numerous international conferences, five of which were results produced from the doctoral research presented in the form of posters or oral presentations. To date, her research work has resulted in eight scientific papers indexed in Web of Science/Current Contents Connect in the field of food technology, while four of them were a product of the doctoral research where she was the main or corresponding author.

LIST OF AUTHORS PUBLICATIONS

Original scientific publications indexed in Web of Science (Current Contents Connect)

- Vidović, N., Pasković, I., Marcelić, Š., Lukić, I., Brkić Bubola, K., **Klisović, D.**, Novoselić, A., Palčić, I., Polić Pasković, M., Herak Ćustić, M. (2022) Effect of combined sulfur and nitrogen foliar supply on olive oil volatile compounds and sensory attributes. *Horticulturae* 8, 912.
- **Klisović, D.**, Koprivnjak, O., Novoselić, A., Pleadin, J., Lešić, T., Brkić Bubola, K. (2022) Compositional changes in the extra virgin olive oil used as a medium for cheese preservation. *Foods* **11**, 2329.
- Brkić Bubola, K., Kolega, Š., Marcelić, Š., Šikić, Z., Gašparović Pinto, A., Zorica, M., **Klisović, D.**, Novoselić, A., Jukić Špika, M., Kos, T. (2022) Effect of different watering regimes on olive oil quality and composition of Coratina cultivar olives grown on karst soil in Croatia. *Foods* **11**, 1767.
- **Klisović, D.**, Novoselić, A., Lukić, I., Brkić Bubola, K. (2022) Extra virgin olive oil under simulated consumption conditions: Evaluation of quality, health, and flavour properties. *J. Food Compos. Anal.* **110**, 104570.
- Novoselić, A., **Klisović, D.**, Lukić, I., Lukić, M., Brkić Bubola, K. (2021) The use of olive leaves in Buža olive cultivar oil production: exploring the impact on oil yield and chemical composition. *Agriculture* **11**, 917.
- **Klisović, D.**, Novoselić, A., Režek Jambrak, A., Brkić Bubola, K. (2021) The utilisation solutions of olive mill by- products in the terms of sustainable olive oil production: a review. *Int. J. Food Sci. Tech.* **56**, 4851-4860
- Brkić Bubola, K., **Klisović, D.**, Lukić, I., Novoselić, A. (2020) Vegetable species significantly affects the phenolic composition and oxidative stability of extra virgin olive oil used for roasting. *LWT - Food Sci. Technol.* **129**, 109628.
- Peršurić, Ž., Saftić, L., **Klisović, D.**, Kraljević Pavelić, S. (2019) Polyphenol-based design of functional olive leaf infusions, *Food Technol. Biotechnol.* **57**, 171-182.

Other original scientific publications

- Novoselić, A., **Klisović, D.**, Lukić, M., Horvat, I., Lukić, I., Brkić Bubola, K. (2021) Influence of small amount of water addition in the extraction process on the olive oil yield and phenolic compounds. *ACS - Agric. Conspec. Sci.* **86**, 251-257.

Publications in conference proceedings with an international review

- **Klisović, D.**, Novoselić, A., Lukić, I., Brkić Bubola, K (2020) Evolution of phenolic compounds and quality parameters after storage of Istarska bjelica and Buža cv. virgin olive oil. In: Mioč, B., Širić, I. (ed.) Proceedings of the 55th Croatian and 15th International Symposium on Agriculture. Zagreb, University of Zagreb, Faculty of Agriculture, pp. 527-532.
- Novoselić, A., **Klisović, D.**, Lukić, I., Horvat, I., Brkić Bubola, K. (2020) The strategies for antioxidant enrichment of Buža cv. virgin olive oil; In: Mioč, B., Širić, I. (ed.) Proceedings of the 55th Croatian and 15th International Symposium on Agriculture. Zagreb, University of Zagreb, Faculty of Agriculture, pp. 533-537.