Oxidomics: A new approach to study the lipid oxidation and qualitative properties of cold-pressed vegetable oils

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Introduction

Antioxidants are components which prevent auto-oxidation of oils and fats by giving their hydrogen to free radicals formed in the initiation and propagation stages of autoxidation by following reactions (Bose et al., 2021). The antioxidant activity of the oils arises of phenolic compounds, vitamin-E-active compounds, phytosterols and other bioactive compounds.

The published results for the antioxidant activity of edible oils varies in huge range due to the different amount of bioactive compounds as well as different antioxidant assays (DPPH, TEAC and FRAP and Hemoglobin assay) (Kostadinović Veličkovska et al., 2015). Cold-pressed oils are known for their antioxidant and other positive health effects. Among them, virgin cold-pressed olive oil has the primate between the other vegetable edible oils. Other oils, as well as sesame seed oil, pumpkin seed oil, "sweet" and "bitter" apricot kernel oils, and paprika seed oil, have also been recognized as rich sources of tocopherols and tocotrienols, polyphenols, and essential mono and polyunsaturated fatty acids (Kostadinović Veličkovska et al., 2018). But the process of extraction or modification of these oils could affect their ability to capture the free radicals and even in theory it is very smooth and easy, in practice, antioxidant capacity could be altered by many factors.

The aim of this review is to presented new oxidomics-guided approach which enable combining the increased generation of natural antioxidants in the oil seeds and the transfer of these bioactive compounds to the oil.

Materials and Methods

Starting from the basic studies of the contents of oilseeds, cold pressed olive oils in focus, and some other oils as well as sesame seed oil, pumpkin seed oil, and flax seed oil, we have covered the results for antioxidant capacities, and assessment of oxidation processes. We searched literature for different ways for increasing the antioxidant level in cold pressed oils by application of oxidomics approach

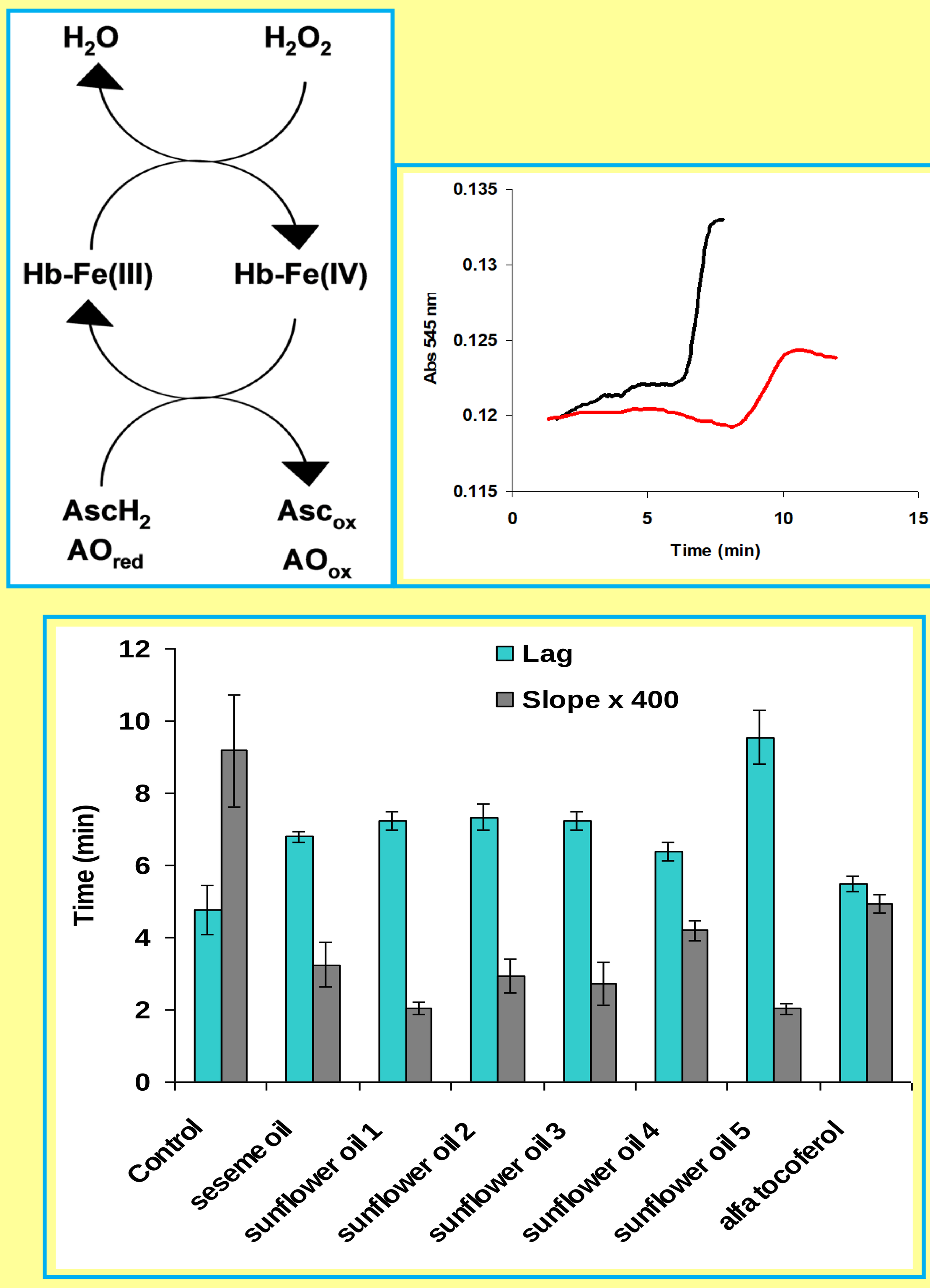

Fig.1 Hemoglobin assay for antioxidant activity of oils (Kostadinovic Velickovska et al., 2018)

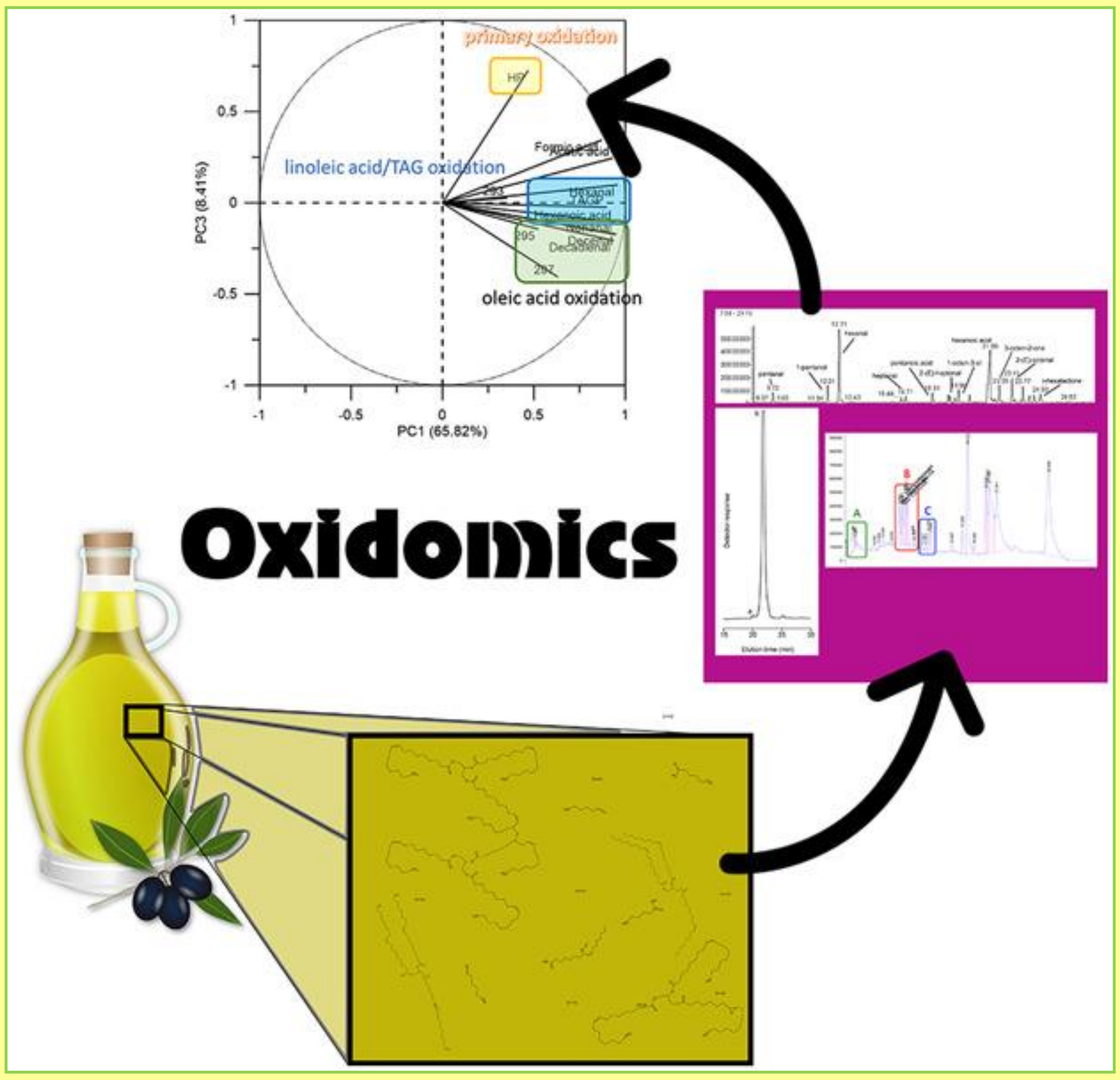

Fig.2. An "Omics" Approach for Lipid Oxidation in Foods: The Case of Free Fatty Acids in Bulk Purified Olive Oil, Paradiso et al., (2018)

Results and discussion

To understand the processes of oxidation and antioxidative mechanisms in vegetable oils we must study first their composition. Applying different physical or chemical conditions allows for the investigation of these processes in more detail and enables a multivariant analysis of the oxidative/antioxidative potential of the oils. In a comparative study Cicero et al., (2018) confirmed that cold-pressed olive oil exhibited the highest content of monounsaturated fatty acids, mainly due to high oleic acid levels, while oils from grapeseed, Brazil nut, and canola were rich in nutritionally important polyunsaturated fatty acid levels.

Hayakawa et al., (2020) suggested that by determining squalene and tyrosol they could see that they are most abundant in extra virgin olive oil, compared to pure olive oils, blended oils (extra virgin olive oils with sunflower oil or grapeseed oil) and other vegetable oils.

The process of lipid oxidation involves different interactions related to several factors such as time temperature, light exposure, catalysts, etc (Gómez-Cortés and Camina, 2019). So, Paradiso et el., (2018) have applied this holistic oxidomics approach to highly purified olive oil by adding increasing amounts of purified free fatty acids. They have examined the oxidation pathways during accelerated oxidation and concluded that free fatty acids affect the overall balance of the oxidation pathways and consequently cause a drift in the evolution of the pattern of oxidation products. Moreover, this balance between the accelerating activity of free fatty acid toward triacylglycerol oxidation and their high susceptibility to undergo oxidation turns have shown dose and time-dependent activity and shifted the resulting oxidation profile of the oil (Paradiso et al., 2018). Lately, they have shown that the radical scavenging activity of olive oil phenolic antioxidants (OPAs) is affected by the phase in which they were added (Paradiso et al., 2020). They have shown that OPAs in the water phase were more effective in slowing down hydroperoxide decomposition due to the hydrophilic radical initiator, but OPAs present in the oil phase was more effective in preventing radical propagation. In another study, oxydomics approach was performed on edible oils that differed in their origin (marine or vegetable) and their omega-3 fatty acid profile. They have achieved 3D matrix, by oxidizing every oil at 6 different time points.

These models classified edible oils according to their volatile degradation patterns. They have shown that oxidation of α-linolenic acid represented mostly in flax seed oil was mainly related to its volatiles 1-hydroxy-2-butanone and 5-ethyl-2(5H)-furanone.

By application of 3-way regression analysis on the quantitative volatile profile of degraded oils, they have found certain compounds that can be used as degradation markers. These specific volatiles of α-linolenic acid oxidation would help to determine the quality and the oxidation state of commercial oils.

Conclusion

The oxidomics approach applied to food lipids contribute to better understanding on the complex patterns of reactions taking place in vegetable oils. This review suggests deeper multivariant investigations of the oxidation process of free fatty acid in vegetable oils. Considering the complex oxidation reactions and investigating the effects of different external factors, as well as added molecules could predict the qualitative and quantitative properties, shelf-life, and healthy properties of commercial cold-pressed oils. The degradation process of free fatty acids could produce compounds with different effects on human health. Subsequent studies in the oxidomics approach may use such degradation volatiles to estimate the potential effects of lipid oxidation on consumer health.

Acknowledgments

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References

Bose, R., Bhattacharya, E., Pramanik, A., Hughes, T.A. & Biswas, S.M. 2021. Potential oil resources from underutilized seeds of Sterculia foetida, L. - Quality assessment and chemical profiling with other edible vegetable oils based on fatty acid composition, oxidative stability, antioxidant activity and cytotoxicity. Biocatal. Agric. Biotechnol. 33, 102002https://doi.org/10.1016/j.bcab.2021.102002

Cicero, N., Albergamo, A., Salvo, A., Bua, G. D., Bartolomeo, G., Mangano, V., Rotondo, A., Di Stefano, V., Di Bella, G., & Dugo, G. 2018. Chemical characterization of a variety of cold-pressed gourmet oils available on the Brazilian market. Food Res. Int. 109, 517–525. https://doi.org/10.1016/j.foodres.2018.04.064

Gómez-Cortés, P., and Camina, J.M. 2019. Oxidomics on the omega-3 volatile degradation pattern to determine differences between vegetable and marine oils. Food Res.Int.122,10-15. https://doi.org/10.1016/j.foodres.2019.03.064

Hayakawa, T., Yanagawa, M., Yamamoto, A., Aizawa, S. I., Taga, A., Mochizuki, N., Itabashi, Y., Uchida, H., Ishihara, Y., & Kodama, S. 2020. A Simple Screening Method for Extra Virgin Olive Oil Adulteration by Determining Squalene and Tyrosol. J.Oleo Sci. 69(7), 677–684.

Kostadinović, Veličkovska, S., & Matthäus, B. 2018. Bioactive compounds and "in vitro" antioxidant activity of some traditional and non-traditional cold-pressed edible oils from Macedonia. J Food Sci Technol, 55(5), 1614–1623. https://doi.org/10.1007/s13197-018-3050-0

Kostadinović, Veličkovska, S., Bruhl, L., Mitrev, S., Mirhosseini, H., & Matthäus, B. 2015. Quality evaluation of cold-pressed edible oils. Eur. J Lipid Sci. Technol. 117, 2023-2035. https://doi.org/10.1002/ejlt.201400623

Paradiso, V.M., Flamminii, F., Pittia, P., Caponio, F., Mattia, C.D. 2020. Radical Scavenging Activity of Olive Oil Phenolic Antioxidants in Oil or Water Phase during the Oxidation of O/W Emulsions: An Oxidomics Approach. Antioxidants.9(10),996. https://doi.org/10.3390/antiox9100996

Paradiso, V.M., Pasqualone, A., Summo, C. and Caponio, F. 2018, An "Omics" Approach for Lipid Oxidation in Foods: The Case of Free Fatty Acids in Bulk Purified Olive Oil. Eur. J. Lipid Sci. Technol., 120, 1800102. https://doi.org/10.1002/ejlt.201800102