Phenolic Compounds: Their Role During Olive Oil Extraction and in Flaxseed – Transfer and Antioxidant Function

Luz Stella Artajo Medina
Food Engineer

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Supervisors:
María José Motilva Casado, Ph.D
María Paz Romero Fabregat, Ph.D

University of Lleida
Agronomical, Forestal and Food Systems Doctorate Program
Food Technology Department
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4. CONCLUSIONS AND FUTURE RESEARCH

CONCLUSIONS

1. Transfer of phenolic compounds fraction during olive oil extraction process considering some technological variables.

The results corresponding to the transfer of phenolic compounds during olive oil extraction demonstrate the existence of this type of compounds in olive fruit, products and by-products. The identification and quantification of phenolics in the different olive-derived fractions could lead to the understanding of their role as antioxidants in these products as well as its further utilization as functional foods.

- Phenolic profiles of olive paste and pomace were found to be qualitatively similar but quantitatively different in relation to the ripening stage of the olive fruit.

- The newly identified simple phenols detected in olive paste as well as the high concentration of 3,4-DHPEA-EDA suggested that oleuropein (and related compounds) are degraded by β-glucosidases during crushing operation.

- An increase in the ripening index implied an increase in the hydroxytyrosol concentration found in pomace.

- Flavonoids luteolin- 7-glucoside, rutin and luteolin showed a clear trend to increase with the increase in ripening index in all phases evaluated (olive paste, pomace, oil and wastewater).

- The liquid fractions, olive oil and wastewater were found to be a rich source of phenols such as 3,4-DHPEA-EDA, 3,4 DHPEA-EA and *p*-HPEA-EDA, *p*-HPEA-EA and ME 3,4-DHPEA-EA.

- The irrigation applied to olive trees implied a considerable decrease in the phenolic content of olive paste. The water status of the tree affected the phenolic synthesis in the olive fruit**,** and as a consequence**,** the phenolic content of the olive paste.

- The most remarkable point of the phenolic partition concerned the simple phenolics. The higher proportion of them partition into the pomace in samples from non-irrigated trees. Samples of irrigated trees showed that simple phenols were lost in the wasterwater phase.

- The partition of phenolic compounds during the virgin olive oil industrial extraction process showed an important effect of the production season time on the total phenolic compound content as well as the phenolic profile of olive paste and virgin olive oil.

- The molar transfer index showed a minor retention of the secoiridoid compounds in wet pomace in the last period of the production season. Despite of the lower phenolic content in the olive oil at the end of the production period, corresponding to a lower phenolic content in olive fruit due to the advanced ripening process, a major transference of secoiridoid derivatives to the virgin olive oil happened.

- The qualitative and quantitative data corresponding to the partition of phenolic compounds between the different phases resulting from olive processing, provides an approach to understand their formation, solubility and affinity to liquid or oil matrices.

2. Investigation of the antioxidant activity of compounds of olive oil phenolic fraction and their effect of on the bitter sensorial attribute

The systematic study of the addition of phenolic compounds to Refined Olive Oil (ROO) described the individual behavior of phenolics as natural antioxidants.

- There was evidence of protection of the oil matrices against oxidation as a result of the phenolic addition. The antioxidant activity depended on the oil matrix and the concentration of phenolic compound used in the assay. In general, the most positive effects were observed in ROO followed by EVOO (Extra Virgin Olive Oil) matrix obtained from Morrut cultivar and EVOO from Arbequina cultivar.
- A clear positive linear trend between Induction Time (IT) and phenolic compound concentration in ROO highlighted gallic acid, hydroxytyrosol (3,4-DHPEA), caffeic acid, dialdehydic form of elenolic acid linked to hydroxytyrosol (3,4-DHPEA-EDA), and luteolin as effective antioxidants, in terms of their effect in enhancement the oxidative stability of oil matrix at concentrations ranging from 40 mg/Kg oil to 320 mg/kg oil.

- Gallic and caffeic acid had a good linear trend relationship in Extra Virgin Olive Oil (EVOO) matrices. Luteolin showed a similar behavior. However, it appears that the differences in the oxidative stability of EVOO related to the addition of phenolic compounds might be affected by the fatty acid, α-tocopherol, phenolic and pigment composition.

- A synergistic effect was only observed for caffeic acid and luteolin in combination with 3,4-DHPEA-EDA when compared to hydroxytyrosol, apigen, lignans (1-acetoxy-pinoresinol and pinoresinol) and oleuropein. However, the mixture of phenolic compounds induced a significant increase in the oxidative stability when it was added to refined olive oil.

- Highest effect on the bitter index was found for ligstroside derivatives, bearing only one hydroxyl substituent. Phenolic compounds that possess a 3,4-dihydroxyl structure linked to an aromatic ring showed a lower effect**,** excluding the methylated form of 3,4-DHPEA-EA, with a carboxymethyl group in the C9 position of the oleuropein aglicone structure, that supposed an important effect on the bitter index.

- The findings of this research emphasize the new concept that olive biophenols can be recognized as potential targets for the food industries.

3. Develop and validate analytical methods for analysis of phenolic compounds in flaxseed.

4. Investigate the role of the phenolic compounds on flaxseed antioxidant system

Flaxseed is the most prominent oilseed studied to date as a functional food due to its content in omega 3 fatty acids, fiber and lignans.

- After alkaline hydrolysis of an ethanol extract, SDG ferulic and *p*-coumaric acid glycosides were found.

- The flax antioxidant system appears to be a water-soluble system. Hull had no effect on the antioxidant properties of the meal, suggesting that SDG, mainly present in the hull, was not involved in the flax antioxidant system.

- Water extracts of flax meals showed some antioxidant properties but their effect was minimal compared to the antioxidant properties of the non-extracted meal. This suggested that the main flaxseed antioxidant system is water-soluble.

- Flax phenolic compounds were found to have some antioxidant properties but they are not the main flaxseed antioxidant system.

FUTURE RESEARCH LINES

Progress in finding out how food matrices can potentially work as functional foods is an important step in encouraging their consumption. It is similarly rewarding to see that the food industry is attuned to the scientific evidence and to consumer demand, and is competent of producing **enriched products** designed to those seeking healthier food alternatives.

Research on the following subjects is a providing guidance for future scientific projects:

- Study of the complete plant phenolic metabolism and transfer studies involving the total range of the olive tissues and matrices during the olive oil extraction as well in flaxseed processing.

- Optimization of instrumental techniques for improved extraction efficiency for phenolic compounds in different olive, flaxseed matrices and other foods.

- Elucidation of the chemical structure of phenolic-derived compounds occurring in olive matrices, flaxseed and potential "functional foods".

- Maintenance of the study of the biological and antioxidant properties of olive and flaxseed compounds (individual compounds or extracts) via different measurements *in vitro* in the body and in food, such as:

    Body:
        DNA damage/base modification
        Protein modification
        Lipid peroxidation
        Antioxidant status

Food:

Physical and organoleptic

Lipid peroxidation

Reactive oxygen species

Inherent chemicals (nonlipid)

- Determine the functionality of the different phenolic compounds as ingredients in the developing process of functional foods to provide a scientific basis and insights enabling food technologists to design and control food sensory and structural properties of food products.

- Investigation of the metabolism and bioavailability of different "functional foods" containing phenolic compounds or new identified components with potential biological properties.