Edible Oils: Balancing the Refining Process to protect Antioxidants

Swiss-based Nutriswiss AG has optimized the refining process for fats and oils to such an extent that it can preserve valuable components and remove undesirable substances without impairing the stability of the end product. In an exclusive interview, Frank Möllering, Head of Research & Development at Nutriswiss, discussed the role of tocopherol retention in product stability and how a combination of mild physical refining and molecular distillation is the most efficient strategy.

by Frank Möllering

FMT: Why do fats and oils have to be refined?

Frank Möllering: Fats and oils have to be refined in order to remove contaminants, volatile compounds and unwanted by-products that will affect oil quality, shelf life, and palatability. These include pesticides, herbicides, insecticides, plasticizer impurities and mineral oil saturated and aromatic hydrocarbons (MOSH/MOAH).

For the last 30-40 years, physical refining has been widely accepted as being the best way of achieving purity as it guarantees the removal of a certain amount of impurities as well as eliminating free fatty acids.

What is the problem with conventional physical refining processes?

Firstly, it is known that this type of refining introduces process contaminants such as 3-MCPD/glycidol and trans fatty acids. Secondly, during refining, a proportion of the naturally occurring vitamins and antioxidants are degraded or converted to other compounds through chemical reactions such as esterification. Historically, up to 50% of tocopherols have been lost during processing.

In addition to losses during the pre-treatment of fats, the main reduction of heat-sensitive nutrients like tocopherols occurs during high-temperature deodorization, in which the free fatty acids are physically distilled off.

Why is it important to safeguard tocopherols?

Tocopherols, commonly known as vitamin E, are categorized into four types. α- and β-tocopherols provide the highest vitamin functionality, while γ- and δ-tocopherols have low vitamin activity but strong antioxidant properties. All four forms are present in vegetable oils in varying concentrations. For example, sunflower oil naturally contains more α-tocopherol and therefore has a higher vitamin E content, while rapeseed oil contains more γ and δ forms, and therefore has better antioxidant stability.

Tocopherols have a positive effect on the storage stability of fats and oils and provide protection against oxidation when the oil is heated. Tocopherols are therefore valuable not only from a nutritional point of view, but also for product stability during storage and in specific applications, for example, frying oils.

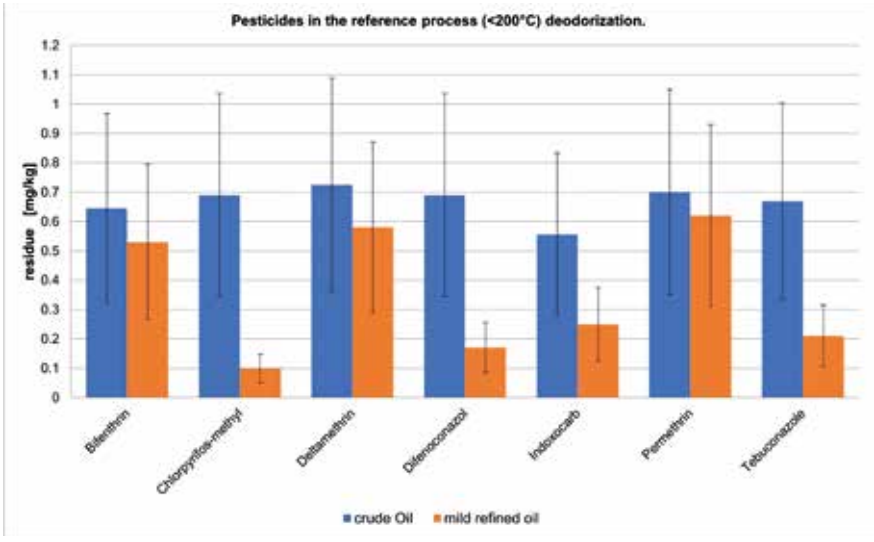
The ideal refining process would preserve the γ and δ forms to maintain the storage stability of the final product, and avoid the degradation of α- and β- forms so they can be recovered and used as nutritional ingredients.

Is there an alternative to deodorization? What other technologies exist for refining oils?

Short path distillation (SPD) or molecular distillation is much gentler on the product than deodorization.

This technique is central to Nutriswiss AG's optimized solution for refining oils and fats. The SPD we use is a continuous vacuum distillation process supplied by VTA Verfahrenstechnische Anlagen GmbH & Co. KG. A scraper or wiper on the cylindrical evaporator inside distributes the oil to be distilled in a thin layer on the heated wall of the evaporator. Because the apparatus operates at a vacuum of up to 10-3 mbar, volatile components such as pesticides and free fatty acids, as well as tocopherols, evaporate more easily under low thermal stress. They are subsequently liquefied again and removed via the nearby condenser; the cleaned oil then flows off the evaporator wall. The evaporation rate is normally in the range of a few per cent; the temperature and pressure depend

Pesticide levels are significantly lower after SPD treatment (Copyright: Nutriswiss)



on the oil to be processed and the substances to be separated.

Surely the loss of antioxidants with the free fatty acids is still a problem with molecular distillation?

It is true that with molecular distillation, despite the gentler conditions, the loss of some tocopherol content along with free fatty acids is unavoidable. However, several studies have documented the high recovery rates and low degradation of tocopherols using molecular distillation, making this a more efficient approach.

Through our own work, we have discovered that storage stability is not affected by molecular distillation if the process is managed carefully to preserve the more heat stable γ and δ forms. Storage stability measurements, including the peroxide number (POZ) and the TOTOX number, which denote the development of primary and secondary oxidation products, showed no negative effects from molecular distillation compared to conventional processes such as deodorization. The Rancimat test, an accelerated oxidation test that measures the stability of fats, also yielded better results.

What's more, time to the onset of oxidation, which is characterized by the formation of secondary oxidation products such as aldehydes, ketones and short-chain fatty acids, is significantly extended. Nutriswiss conducted a specific comparative test with a palm oil fraction that had been conventionally processed and then either deodorized or subjected to a gentle short path distillation. This showed that the oxidation values of the sample from the short path distillation increased much more slowly.

The underlying mechanism for this observation is not yet known, but it is clear that the oil or fat enters storage with a lower load of oxidation products and it appears that the formation of these products is delayed.

Besides using short path distillation, what else can be done to purify oils whilst safeguarding their antioxidant content?

Based on practical experience, Nutriswiss AG combines mild physical refining with SPD to maximize the benefits of both processes.

Mild refining with alkaline neutralization of free fatty acids and subsequent SPD avoids the formation of process contaminants and yields more stable products in terms of shelf life and sensory characteristics.

But it is not just about altering one process step; for the best outcomes, the refining process must be coordinated across all treatment steps.

One of the reasons for taking a holistic view of the process is that while

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tocopherols are lost in the refining process through separation or oxidation, regeneration or even an increase in tocopherol content is possible in certain process steps. This can be explained by cleavage of dimeric bonds between tocopherol molecules or ester bonds between tocopherols and other compounds. Step analyses performed at Nutriswiss revealed that in some cases even more tocopherols were found than were present in the original material. We therefore adjust the refining processes to take advantage of these effects.

Our approach also takes account of the importance of maximizing the recovery of the nutritional components. It is better to remove these valuable components from the highest possible starting point than from a tocopherol content that has already been reduced by half.

Nutriswiss AG designs its processes in such a way that contaminants and other undesirable ingredients are largely removed, while a higher proportion of natural antioxidants and vitamins are retained. Thanks to the gentle refining process, Nutriswiss fats and oils - depending on the type and batch - can be stored for as long as or even longer than conventionally refined fats and oils. By carefully selecting and managing the process parameters, the valuable antioxidant ingredients are optimally protected and preserved.

Historically, 20-50% of tocopherols were lost during refining. What improvement does your optimized process deliver on this figure?

Nutriswiss now achieves significantly lower losses than the 20-50% cited in literature; in some cases, depending on the material, there are no losses.

Is there more optimization still to be done, or is your process now 'perfect'?

Whilst we have succeeded in preserving natural antioxidants through a controlled process, we are continually looking at how we can improve and advance our solution, investigating underlying mechanisms and gaining more understanding of how different treatments affect outcomes.

For example, we are currently working with a German university to test the effect of our process on the quality of fatty acid oxidation products such as E,E-hydroperoxy, E,E-hydroxy, trans-epoxy and erythro-dihydroxy fatty acids. Initial results show that the combination of mild refining and SPD does not result in any significant changes compared with mild refining alone and in contrast to physical refining, which shows significant changes.

Our ultimate aim is to preserve as much natural vitamin and antioxidant content in the oil as possible through carefully controlled processing. With our process, we have established the optimum parameters for achieving this goal.

Industrial SPD plant supplied to Nutriswiss AG by VTA Verfahrenstechnische Anlagen GmbH & Co. KG (Copyright: VTA)

In summary, the combination of mild refining and SPD results in a product of equivalent quality and, in some cases, one that is even more stable than obtained from mild refining alone. In addition, the purity of such a product is significantly higher and can even exceed the results of typical physical refining with its associated high temperatures. fmt

The Author

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For more information: www.nutriswiss.ch/en

The MOAH fraction >C25 to ≤C35 can be expected to be reduced by about 70% and the fraction >C35 to ≤C50 by approximately 30% (Copyright: Nutriswiss)