Identity of Lecithin
by ^{1}H-NMR Spectroscopy

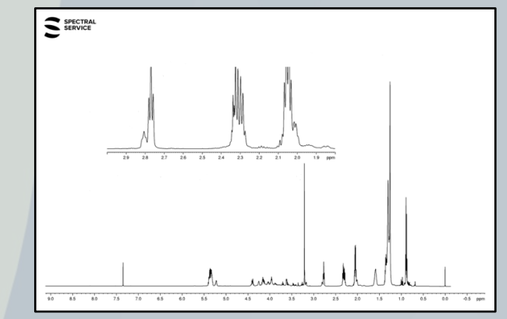

Fig. 1 ^{1}H-NMR of the omega fatty acid profile of a soybean lecithin

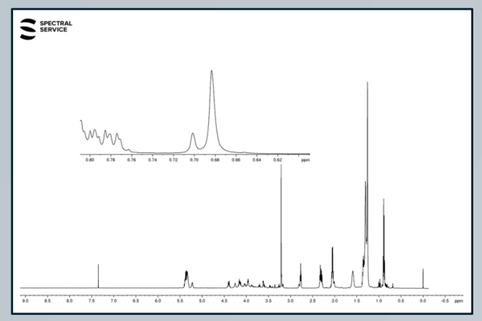

Fig. 2 ^{1}H-NMR of the sterol profile of a soybean lecithin

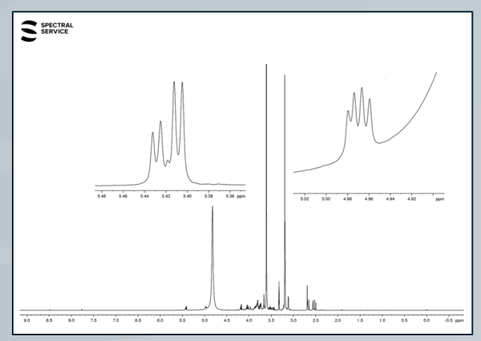

Fig. 3 ^{1}H-NMR of the sugar profile of a soybean lecithin

What is Lecithin?

The term “lecithin” refers to a matrix consisting of various phospholipids, sterols, glycolipids, and sugars. Lecithin is commonly used in the food industry as an emulsifier because it reduces the interfacial tension between water and oil due to the amphiphilic properties of the phospholipids. Different types of lecithin vary in their composition and, thus, their nutritional quality. Lecithin is typically derived from soybeans due to their ease of extraction and cost-effectiveness. However, sunflower lecithin may be favored over soybean lecithin in some markets because lecithin that originates from genetically modified soybeans can trigger allergic reactions in some individuals. Therefore, it is essential for the food industry to know the source of its lecithin additives.

Our ^{1}H NMR method can help confirm soybean oil adulteration and sunflower oil identity.

Identity of Lecithin by ^{1}H-NMR Spectroscopy

With the help of ^{1}H-NMR, we can distinguish lecithin derived from different sources, such as soybean, sunflower, and rapeseed. The distribution of omega-3, 6, and 9 fatty acids is examined and used as a fingerprint. For example, rapeseed lecithin has a very high content of omega-9 fatty acids, which is much lower in sunflower and soybean lecithin. Conversely, soybean and sunflower lecithin are characterized by a higher content of omega-6 fatty acids. Additionally, sunflower lecithin contains almost no omega-3 fatty acids, which is a crucial parameter to distinguish it from other lecithin sources.

Besides the fatty acid distribution, we also examine the sterol profile to determine the identity of the lecithin. While cholesterol is characteristic of animal samples, plant samples contain stigmasterol, sitosterol, and campesterol.

Moreover, the sugar profile is used for precise identity determination as different plants produce different sugars. For example, stachyose is characteristic of soybean lecithin, which is not found in rapeseed and sunflower lecithin.

By considering all these parameters, we can evaluate the origin of your lecithin.

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Phospholipid Analysis
By ^{31}P-NMR Spectroscopy

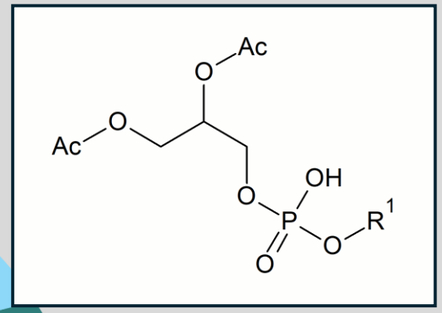

Fig. 1 General structure of phospholipids (R^1 – Head Group)

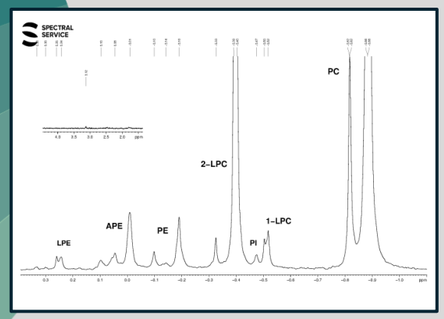

Fig. 2 ^{31}P-NMR profile of a krill sample with assignments

Tab. 1 Overview of our Phospholipid service

Method Scope	
Matrices*	Fish, krill, lecithin, milk, egg
Sample Types*	Powder, liquid, syrup, capsules, gummies
Phospholipids	PC, 1-LPC, 2-LPC, PE, APE, LPE, PI, LPI, PG, DPG, PA, LPA, PS, LPS, SPH, DSPH

*- Special requests welcome

What are Phospholipids?

Phospholipids are amphiphilic and composed of a hydrophilic phosphate head group, a glycerol backbone, and two hydrophobic fatty acid tails. They are present in all cells, forming bilayer cell membranes and facilitating the transport of molecules. Phospholipids provide the cell with essential capabilities such as stability, permeability, and flexibility.

Phospholipid species differ not only in their head groups but also in the functions they perform in the organism. For example, Phosphatidylcholine (PC) is the main phospholipid in our cell membranes and is significantly involved in the breakdown of toxins and proper heart and brain function. Phosphatidylinositol (PI), on the other hand, contributes to the normal function of acetylcholine and serotonin. Phosphatidylserine (PS) is predominantly found in the brain and is important for the cardiovascular system and the regulation of blood pressure. Phosphatidylethanolamine (PE) is involved in membrane fusion and regulates membrane curvature. These different functions of phospholipids highlight why it is important for the food industry to know the precise quantities of each species present in their products. ^{31}P-NMR can help address this issue.

Phospholipid Analysis by ^{31}P-NMR Spectroscopy

Phospholipids can be analyzed using ^{31}P-NMR spectroscopy due to the phosphorus atom in their structure. The various species can then be distinguished by examining the resonance shifts of the different head groups. To quantify the different phospholipid species in the sample, an internal standard is used. Our ^{31}P-NMR method was adopted by the **International Lecithin & Phospholipid Society** (ILPS) as the official phospholipid analysis method. We also developed the **US Pharmacopeia** (USP) monograph for analyzing phospholipids in krill oil. Our method enables the quantification of phospholipids in a variety of matrices such as lecithin, milk, fish, krill, and egg. Additionally, we can analyze several sample types, including powders, liquids, syrups, capsules, and gummies. We have optimized the method to differentiate and quantify the following phospholipids: PC, 1-LPC, 2-LPC, PE, APE, LPE, PI, LPI, PG, DPG, PA, LPA, PS, LPS, SPH, and DSPH.

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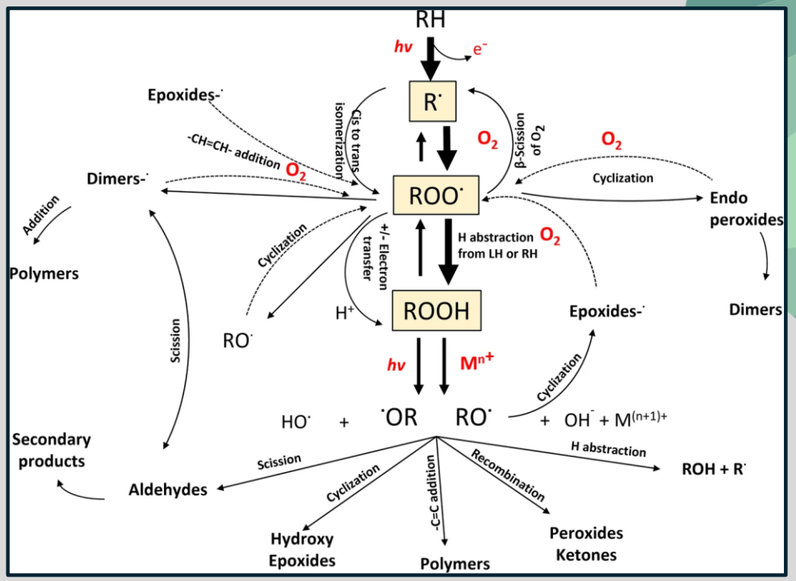

Fig. 1 Lipid oxidation pathways

Lipid / Phospholipid Oxidation Analysis
By ^{19}F-NMR Spectroscopy

Why Analyze for Lipid Oxidation?

Lipid oxidation plays a critical role in determining the shelf life and overall quality of oils, lecithins, and various manufactured materials. In essence, lipid oxidation is the process by which unsaturated fatty acids react with oxygen, leading to the formation of peroxides and other degradation products. This reaction not only alters the flavor, aroma, and nutritional properties of these substances but also accelerates their deterioration. Among the different types of lipids, phospholipids are particularly vulnerable. Their oxidation occurs at a significantly higher rate than hydrolysis, meaning they are often the primary contributors to the degradation observed over time.

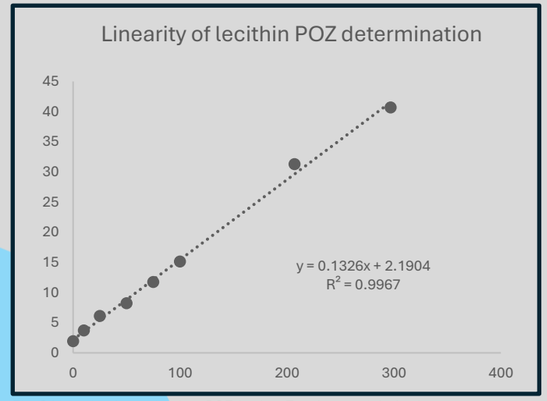

Fig. 2 Linearity determination: POZ (mg) vs Test Item weight (mg)

Traditional Methods

Historically, the industry has relied on iodine titration to measure the total iodine value — a parameter that indirectly reflects the extent of oxidation in a sample. Although this method has been the standard for decades, it suffers from several limitations. It is relatively time-consuming, less sensitive to subtle changes, and does not provide the detailed insight required to understand the complex oxidative processes at work.

Our Superior Solution

In response to these challenges, we propose an innovative approach that leverages the sensitivity of ^{19}F-NMR spectroscopy. Our method involves the addition of a fluorinated reagent, TTP, to a solution of oil or lecithin. TTP reacts with the oxygen present in the sample to form a detectable fluorinated product, thus allowing us to measure oxidation levels as low as 1 ppm equivalent oxygen. This heightened sensitivity, combined with the ability to conduct a concurrent phospholipid analysis in a single preparation, not only streamlines the process but also offers a more comprehensive evaluation of product quality. Ultimately, our advanced method aims to provide a more accurate, efficient, and cost-effective solution for monitoring lipid oxidation in various industrial applications.