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LYSOLECITHINS

Fig 1.

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Introduction

Since the 1990's the use of lysolecithins in animal nutrition has gained widespread acceptance by the scientific community. Although many experts recognize the benefits of inclusion of lysolecithins in animal diets, how it works to improve animal performance is often less well understood.

Form and Function

Phospholipids, including lysolecithins, are ubiquitous in nature as they form one of the essential structures of all living cells - the membrane. The plasma membrane provides the fundamental architecture of the cell, allowing what is technically `living' to be isolated from the inert. However, this separation is far from absolute since the membrane must permit the flow of nutrients into the cell and also allow the cell to express a variety of metabolites. The ability of phospholipids and lysophospholipids to arrange themselves in such a way as to make this possible comes from their unique molecular structure.

Ordinary phospholipid molecules are made up of a polar head group and two hydrophobic fatty acyl chains (see Fig. 2).

Fig 2. Ordinary phospholipid molecule

In the case of lysophospholipids only one of these chains is present (see Fig. 3).

Fig 3. Lysophospholipid molecule

The polar head groups may include choline, ethanolamine, serine and inositol (see Fig. 4a-d).

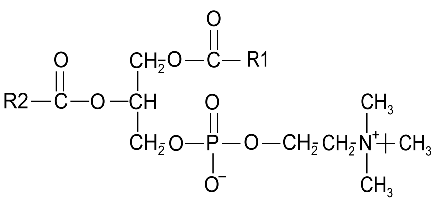


Fig 4a. Phosphatidylcholine

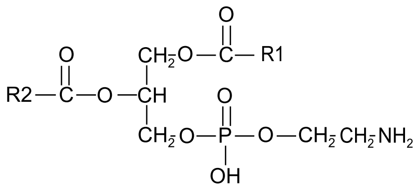


Fig 4b. Phosphatidylethanolamine

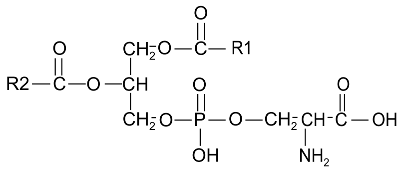


Fig 4c. Phosphatidylserine

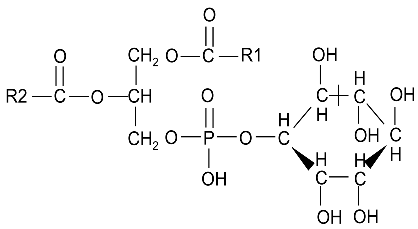


Fig 4d. Phosphatidylinositol

In addition, each fatty acyl chain has a specific length and degree of saturation. Thus, there are a number of parameters that can alter the physical and biochemical properties of these remarkable compounds. Small changes to the molecules can radically alter the functionalities and this is the case with lysolecithins - sometimes called lysolipids or lysophospholipids.

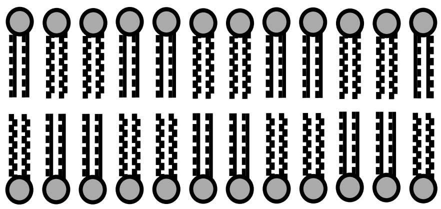


Fig 5. Phospholipid bilayer

However phospholipids and lysophospholipids do not only form bilayer plasma membranes - they are also able to form micelles or liposomes spontaneously - so creating microscopic envelopes that can be filled with useful substrates. This is also a feature of the molecules' shape and charge and the way in which complex mixtures of phospholipids are able to arrange themselves into highly ordered arrays at the macroscopic level.

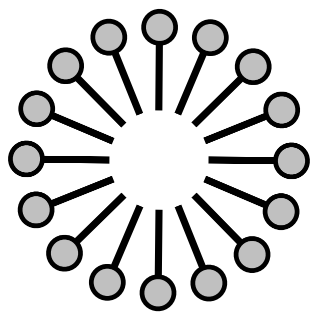


Fig 6. Lysophospholipid micelle

A third attribute of these lipids is their surfactant property - the ability to solubilise fats into aqueous emulsions. Each of these behaviours can be used to positively impact animal health and nutrition if correctly applied following scientific principles.

Although lysolipids account for a very small (<1%) of the total lipid content in the membrane, they do have a vital role to play. One of their characteristics is that they act as membrane fluidity modulators and it is through this function that the permeability of the membrane can be altered. When an ordinary membrane (that is to say a membrane that is at equilibrium) comes into contact with an excess of lysolipids these exogenous lipids are quickly interdigitated into the bilayer. The membrane becomes more fluid and as a consequence, more permeable. The exact formula by which permeability is derived from fluidity is highly complicated but the following is a brief description of what may occur at a macromolecular level.

Each membrane at equilibrium will contain pores or holes - these are best thought of as gaps or vacancies where phospholipids are missing from the lattice structure. Sometimes there will be clusters of these vacancies of various sizes so it is clear that there will be a statistical distribution of pore-sizes in the membrane. When additional lysolipids are introduced it is this distribution that is affected and results in increase in both the number and size of larger pores [3]. Through the normal passive transport processes, nutrients of larger molecular weights can then pass more readily across the membrane. In the case of lysolipids in the diet, this means that the nutrient absorption profile of the gut is beneficially altered with the passive flux 'hurdle' temporarily lowered. If no further lysolipids are applied to the system the normal acyltransferase enzymes quickly redress this balance and return the lyso-molecules to their diacyl forms and the cell returns to equilibrium.

This is a key application of lysolipids in animal nutrition because it means it is possible to extract more nutrient value from every kilogram of diet, even when such nutrients are normally poorly absorbed.

A second feature of using lysolipids in diets comes from their ability to form liposomes. Normal phospholipids produce micelles but they tend to be large and less well absorbed in the intestine. Lysolipids on the other hand naturally form small, tightly packed liposomes that are very well absorbed. This is because smaller vesicles are better able to fuse into the membranes that make up the wall of the gastrointestinal tract.

Lastly, we have the surfactant properties of phospholipids. Again, due to the size, shape and electric charge of the lysolipids they are better oil-in-water emulsifiers than ordinary phospholipids (see Fig. 6).

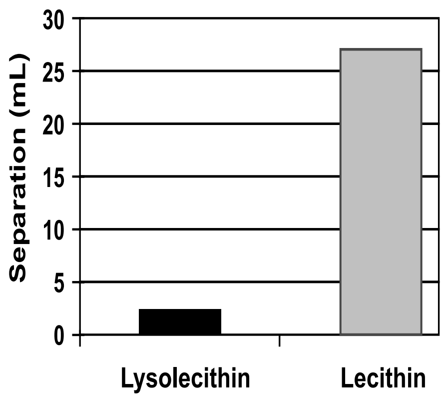


Fig. 6 Emulsification test. Separation of oil and water emulsion after 30 minutes.

Animal Nutrition

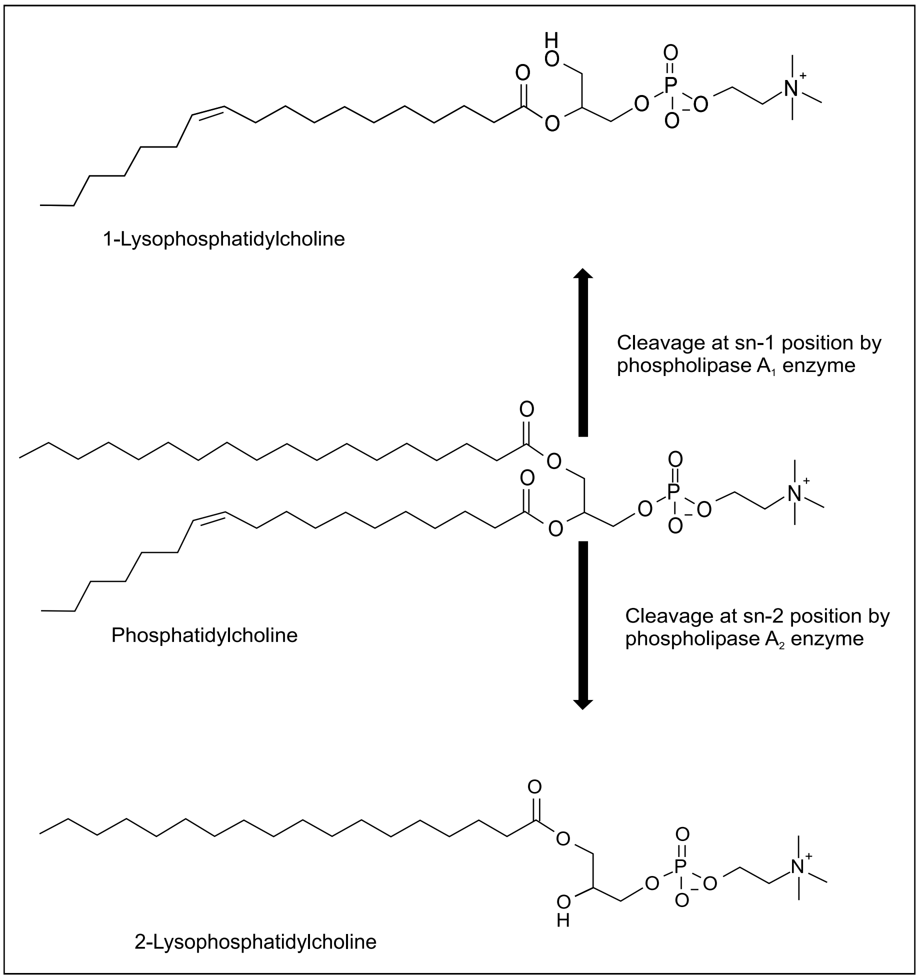
In all species of animal beneficial effects can be seen. In pigs for example, lysolecithins improved ADG linearly ($p=0.04$) between day 15 and 35 and overall. Dietary lysolecithins at 0.02% improved digestibility of fat ($P=0.10$), DM ($P=0.003$) and protein ($P=0.001$) [4]. Also, inclusion levels of dietary lysine can be reduced using lysolecithins and it has been hypothesized that improved homogenisation of the feed by lysolipids results in enhanced digestibility of many water-soluble nutrients [5]. Also, it has been found that lysolecithins significantly improve solubilisation of long-chain fatty acids in sheep [6]. In poultry, the benefits are seen primarily in reduced FCR figures and reduced mortality.

Studies have shown that fish benefit from lysolecithins in more than one way. Many fish species are deficient in choline and this extra source of readily available choline has a marked effect. Similarly, lysolecithins are known to increase the absorption of tocopherols and cholesterol, which is an added benefit [7]. Fish appear to require exogenous phospholipids in order to sustain a sufficient rate of lipoprotein biosynthesis [8].

Products

Lecithin is a complex mixture of phospholipids, glycolipids and glycerides that can be extracted from plant material. Soybeans are the predominant source of industrial lecithins although rapeseed is an increasingly interesting alternative. Each plant variety has a characteristic phospholipid profile so that the functionality of the derived lecithin varies between plant species (see Fig. 7).

Fig. 8 Enzyme cleavage sites



To produce lysolecithins the crude lecithin extract is modified using enzymes to produce the exact degree of hydrolysis needed to make the required lysolipids.

The use of nuclear magnetic resonance spectrometry to analyse the lipids ensures that both the raw materials and the reaction end-point are optimal.

Using highly purified phospholipid fractions to re-create lecithin mixtures it became possible to determine the optimum ratio of constituent lipids. Recent advances in production technology mean that now the most powerful commercial lysolipids have been tailor-made for the best possible impact on animal performance.

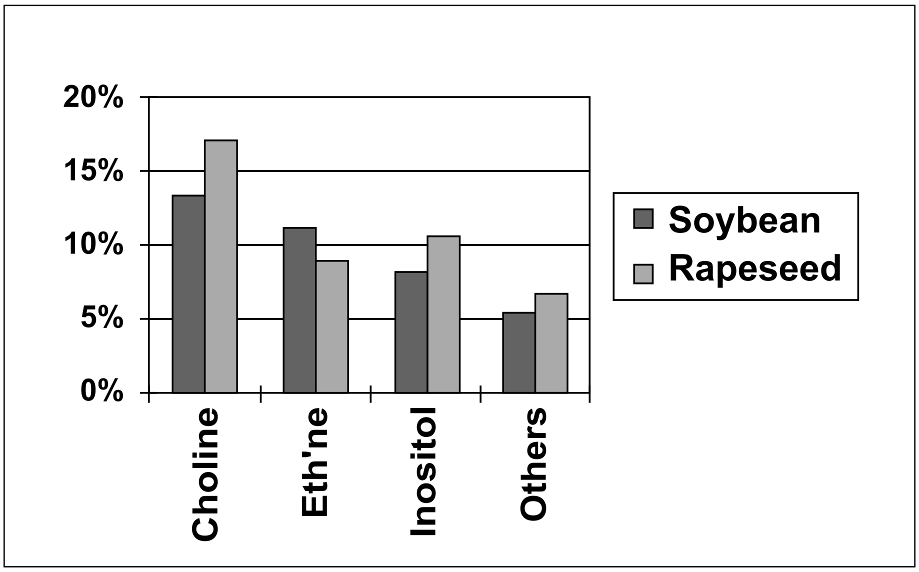


Fig. 7 Phospholipid species profile of soybean and rapeseed

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