Swine

Poultry

Fish

Shrimp

How to maximize fat energy?

Technical brochure about the molecular structure and mode of action of **lysolecithins**

Introduction

The intensive animal production industry requires animals to grow fast with a minimum amount of feed. Therefore, dietary energy needs to be increased, which is usually done by a high inclusion rate of fat. However, this energy is only available when properly emulsified. This can be a real challenge in young animals, as they do not produce sufficient amounts of bile salts. Moreover, they do not have sufficient bile phospholipids for an efficient fat emulsification and absorption. This is important since feed nutrients only have value if they are absorbed.

The challenge in animal nutrition is to make efficient use of high fat diets, maximizing the ability of the animal to digest fat and to absorb nutrients in general, and fat, more particularly.

The answer: **Lysolecithins!**

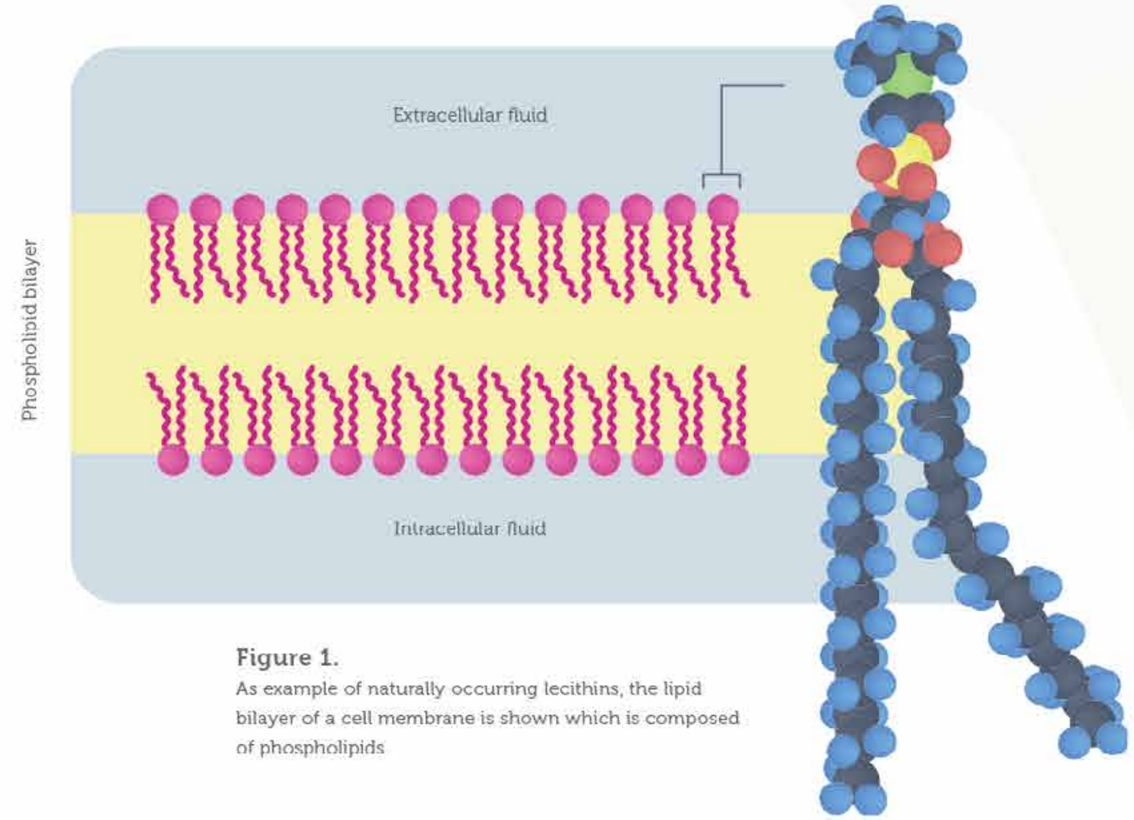

Figure 1.
As example of naturally occurring lecithins, the lipid bilayer of a cell membrane is shown which is composed of phospholipids

Lecithin and lysolecithin

Lecithin is a complex mixture of phospholipids, some oil, glycolipids and carbohydrates. Lecithins are naturally occurring in plant and animal tissues ***(Figure 1)***. Sometimes the term phospholipid is also used for lecithin. Phospholipids have an amphiphilic character, meaning the molecule has both hydrophobic and hydrophilic characteristics. This can be explained by the molecular structure, which consists of two hydrophobic fatty acid tails and a hydrophilic phosphate head, joined together by a glycerol molecule. The phosphate group can be modified with simple organic molecules such as choline, ethanolamine or inositol forming phosphatidylcholine, phosphatidylethanolamine and phosphatidylinositol, respectively ***(Figure 2)***.

Lysolecithins are formed by hydrolysis of a lecithin due to the enzyme phospholipase A2 ***(Figure 2)***. The hydrophobic fatty acid tail at the C2 position of the glycerol molecule is removed by the action of this enzyme. The obtained lysolecithins are a more powerful emulsifier and have a more hydrophilic character than native lecithins. Due to this characteristic, lysolecithins induce an oil-in-water emulsion.

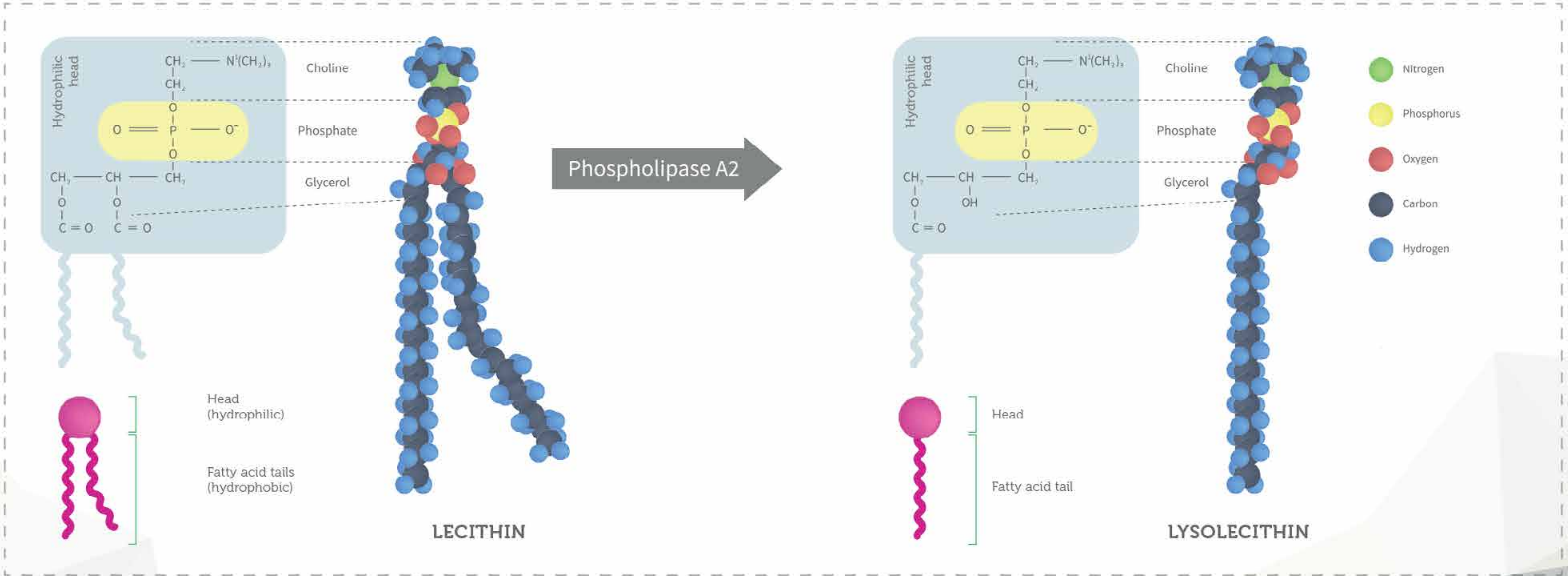

Figure 2.
The formation of a lysophospholipid. As an example the formation of lysophosphatidylcholine from phosphatidylcholine is shown.

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Normal fat digestion

Fat digestion is a three stage process:

1 Fat emulsification

In the first stage of fat digestion, fat is emulsified by the action of bile salts. As fat is insoluble in water, fat droplets will accumulate into bigger fat globules in the aqueous environment of the small intestine. To avoid this, fat emulsification by bile salts is required. Bile contains, next to bile salts, among others phospholipids. The hydrophilic side can interact with water, while the hydrophobic tails interact with lipids, thereby emulsifying large lipid globules into small lipid droplets.

2 Fat hydrolysis

As the contact surface of the fat globules is increased by reducing the fat globule size, more fat is exposed to lipase. The enzyme lipase is involved in the second stage of fat digestion, namely fat hydrolysis. The fat molecule, a triglyceride, is broken down by the action of lipase into two free fatty acids and one sn2-monoglyceride.

3 Micelle formation and fat absorption

After hydrolysis, mixed micelles of fatty acids, sn2-monoglycerides, bile salts and bile phospholipids are formed. These mixed micelles facilitate the transport of lipophilic substances in the aqueous environment of the intestinal lumen and finally through the unstirred water layer surrounding the enterocytes. At the side of the enterocytes, the fatty substances leave the micelle and enter the intestinal cell. To maximize the utilization of dietary fat all three stages must be taken into account and promoted by a dietary biosurfactant.

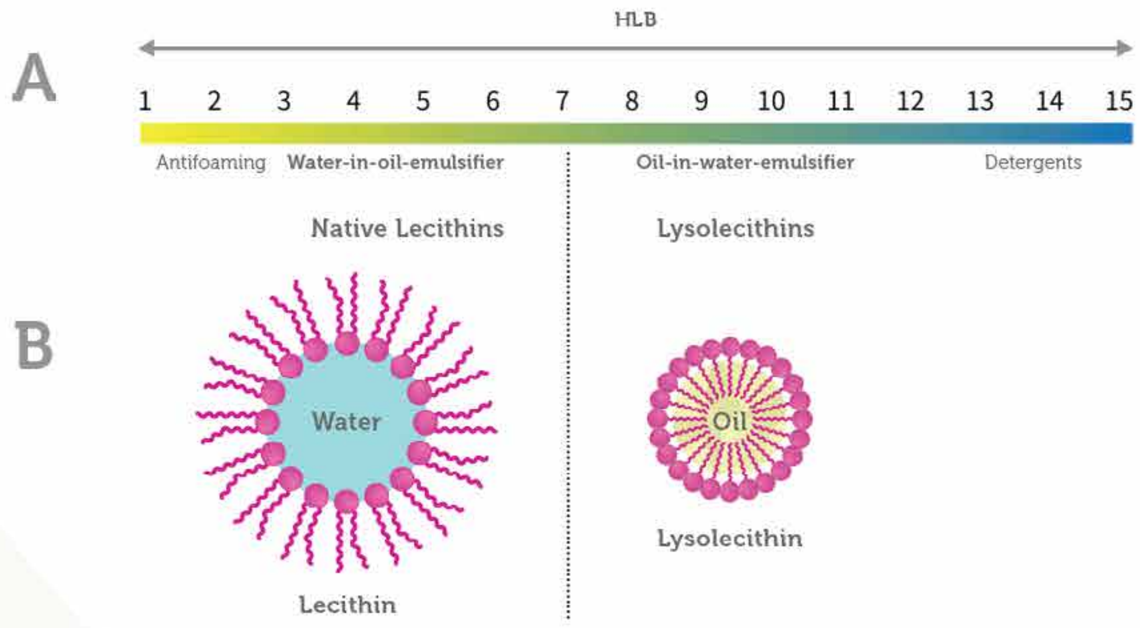


Figure 3.
A. Schematic overview of the HLB value.
B. Schematic representation of the size of an emulsification droplet formed with lecithins or lysolecithins.

Mode of action of lysolecithins

OIL-IN-WATER EMULSIFICATION

One of the most important characteristics of lysolecithins as a dietary emulsifier is the promotion of an oil-in-water emulsion. To what extent an emulsifier is able to promote an oil-in-water emulsion largely depends on the hydrophilic-lipophilic balance (HLB) of the bio-surfactant. Native lecithins, which contain two fatty acid tails, are more lipophilic and have a lower HLB value promoting a water-in-oil emulsification **(Figure 3A)**. In contrast, a lysolecithin is more hydrophilic, promoting an oil-in-water emulsion and smaller fat droplets **(Figure 3B)**. This results in an increased surface area for the pancreatic enzymes, stimulating optimal fat hydrolysis.

CRITICAL MICELLE CONCENTRATION

Compared to other biosurfactants, such as bile salts and native lecithins, the Critical Micelle Concentration (CMC) of lysolecithins is lower. The CMC is the concentration of a surfactant at which micelles form spontaneously. Micelles are only formed when the concentration of a biosurfactant is greater than its CMC. As a result, much lower concentrations of lysolecithins are needed to reach sufficient emulsification and to obtain an efficient micelle formation.

NUTRIENT TRANSPORT AND ABSORPTION

After hydrolysis, mixed micelles with fatty acids and other lipophilic nutrients are formed **(Figure 4)**.
Lysolecithins promote the formation of small and highly hydrophilic mixed micelles, improving nutrient transport through the unstirred water layer surrounding the intestinal villi. Hence, fat absorption is increased. The more specific lysophosphatidylcholine and lysophosphatidylethanolamine also interfere with the phospholipid bilayer of the cell membranes of the epithelium cells, increasing their fluidity and permeability and thus facilitating nutrient absorption.

Figure 4
Schematic representation of a mixed micelle. Micelles are lipid molecules that arrange themselves in a spherical form in aqueous solutions. The formation of a micelle is a response to the amphipathic nature of the components such as fatty acids and lysolecthins. The surface of the micelle is formed by the hydrophilic head groups, whereas the hydrophobic tails are turned inside and away from the water.

❶ Fat Emulsification

Lysolecithins and bile salts emulsify large fat globules into smaller fat droplets in the duodenum.

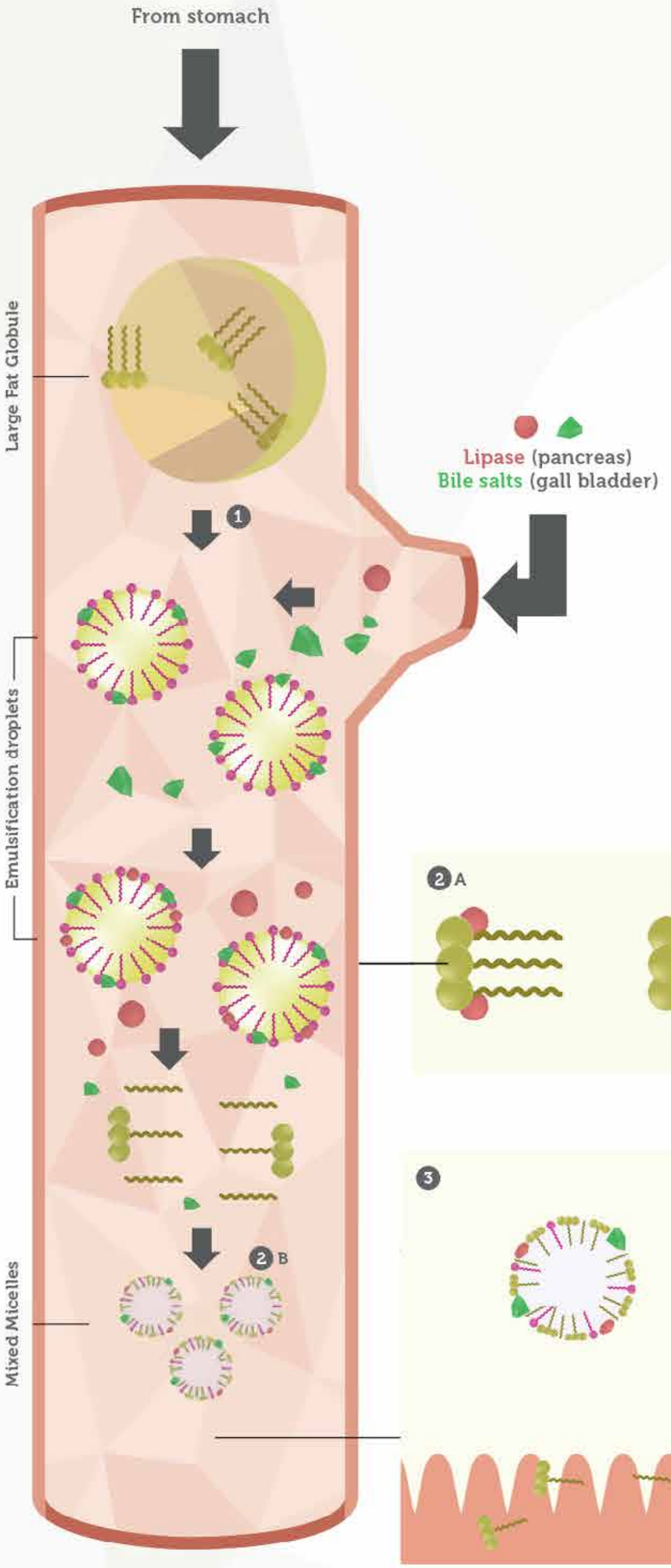
❷ Fat Hydrolysis

a. Pancreatic lipase hydrolysis the first and third fatty acid from triglycerides, creating a sn2-monoglyceride and two free fatty acids.

b. Lysolecithins and bile salts form together with the free fatty acids and the sn2-monoglycerides mixed micelles. These micelles transfer through the unstirred water layer, transporting the fatty substances to the enterocytes.

❸ Fat Absorption

The fatty acids and sn2-monoglycerides leave the mixed micelle and are absorbed in the intestinal cells.



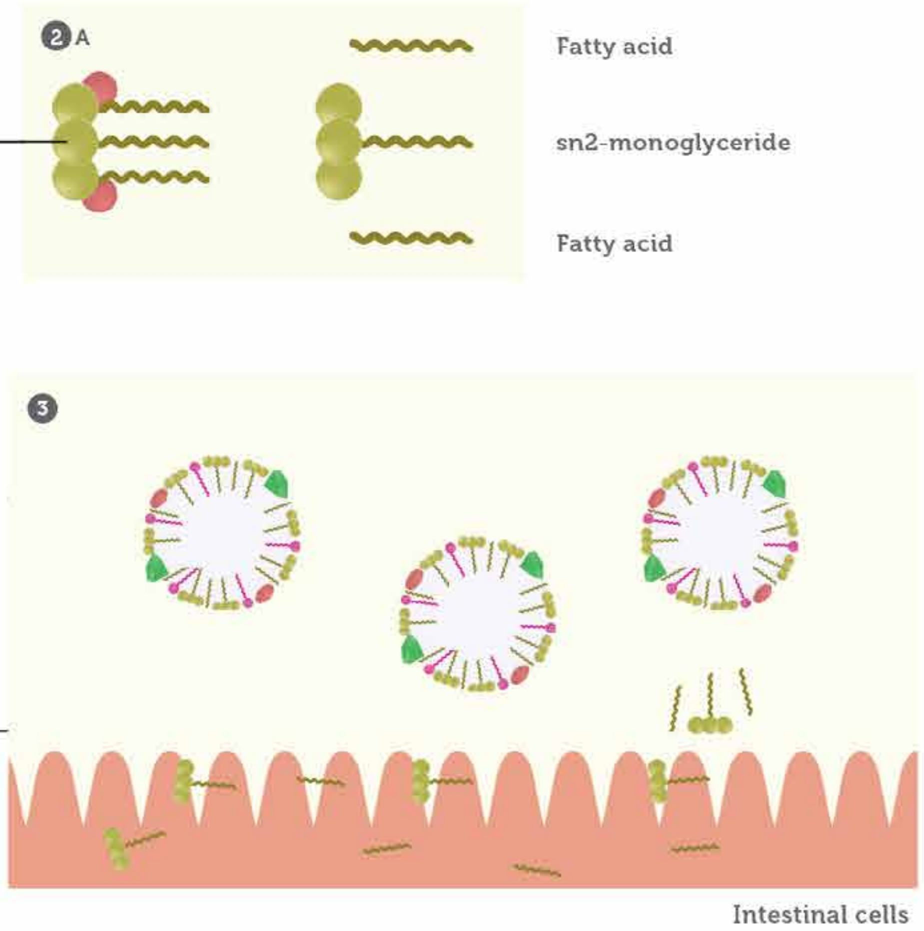


Figure 5.
Schematic overview of the fat digestion and the role of lysolecithins.

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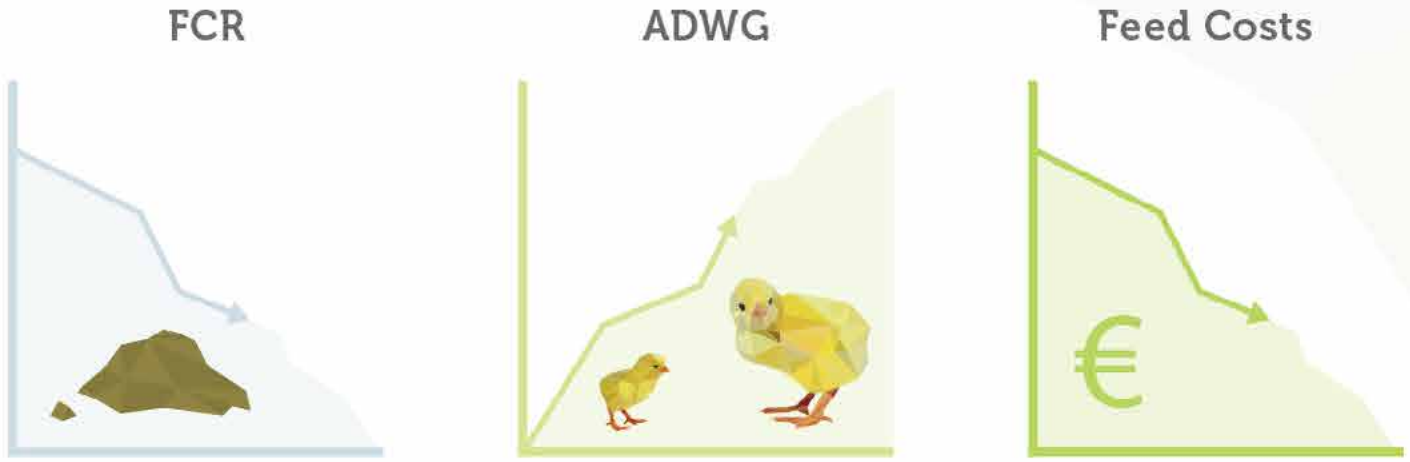

Figure 6.
The effect of lysolecithins on feed conversion ratio (FCR), average daily weight gain (ADWG) and feed costs.

Lysolecithins improve the fat emulsification, fat hydrolysis and fat absorption ***(Figure 5)***. As a result more nutrients and energy are available for the animal which leads to an increased average daily weight gain and an improved feed conversion ratio ***(Figure 6)***.

Lysolecithins can be added on top of the diet or reformulated into the diet. Fat can be dosed in lower quantities since lysolecithins makes the fat more available. This will result in lower feed costs ***(Figure 6)***.

Conclusions

Lysolecithins improve fat digestion by the promotion of an oil-in-water emulsification in the aqueous environment of the gastro-intestinal tract. This results in an increased surface area for the pancreatic enzymes, stimulating optimal fat hydrolysis. By the formation of small and stable mixed micelles, lysolecithins assist in the nutrient transportation through the unstirred water layer surrounding the enterocytes. An enhanced fat emulsification improves fat digestibility and apparent metabolic energy of animal feed. Feeding lysolecithins to different animal species has shown to improve animal growth and feed conversion ratio. Moreover, maximizing the metabolic energy from fat allows lowering the fat content in the diet which saves feed costs.

For more information and trial results of lysolecithin based products we advise you to check out the individual product flyers.

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FRAmelco is a family-owned company specialized in the development, manufacturing, and marketing of animal feed and drinking water additives worldwide. We provide the industry with additive solutions that allow both agriculture and aquaculture to increase productivity and profitability in a sustainable manner.

Head office	t:	+31 (0) 880 443 300
Ruisvoorn 5	f:	+31 (0) 162 521 589
4941 SB Raamsdonksveer	e:	info@framelco.com
The Netherlands	i:	www.framelco.com