Saving energy and feed costs with nutritional emulsifier

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Energy is a major cost component in diets for high performing animals. Due to its high energy density, fats and oils are important energy sources in feed formulation. Improving the energy efficiency of these raw materials is of high interest from an economical point of view.

Nutritional emulsifiers can be used to improve fat digestibility and thus improve the energy efficiency. This will result in a lower feed cost and contribute to a more economical and sustainable animal production.

Fat digestion

The terms fat and oil (or lipid) refer to triglycerides of several profiles of fatty acids. Fatty acids that are not bound to other organic components as glycerol are the so-called free fatty acids. Lipids constitute the main energy source for animals and they have the highest caloric value among all the nutrients.

The amount of energy that an animal can obtain from the dietary fat depends on the digestibility of the fat. A higher digestibility will result in more available energy. The digestibility of fat by animals is related to different characteristics of the fat and the absolute amount of fat added to the diet. Animal factors such as age also influence the digestibility. Young birds have a low level of natural lipase production and a low rate of bile salt production and therefore have a limited fat digestion. Fat digestion can be enhanced by adding emulsifiers to the diet.

Fat digestion occurs in a few steps. Initially, the large fat globules are emulsified in the watery environment of the gut aided by peristaltic movement. Normally fat and water do not mix and therefore bile salts assist in this mixing process as a natural emulsifier. Smaller fat droplets are formed to increase the contact surface for the enzyme lipase.

This enzyme is produced by the pancreas and breaks down the fat.

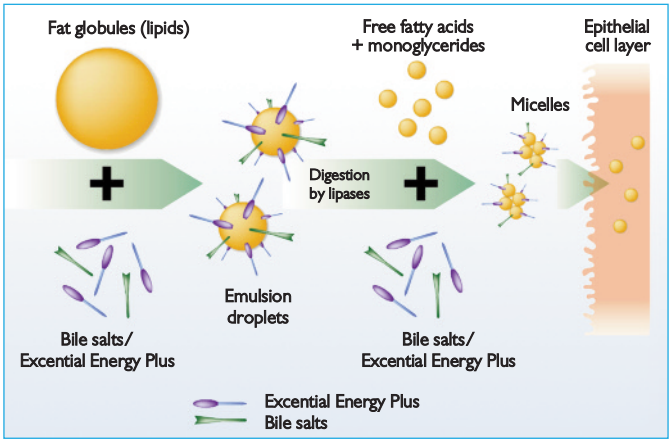


Fig. 1. Fat digestion in three steps: 1) formation of small emulsion droplets, 2) hydrolysis by lipase, 3) formation of micelles and uptake in epithelial cell layer. Emulsifiers (bile salts and exogenous emulsifier) aid in the fat digestion process.

Fats and oils are esters of three fatty acids and glycerol. The fatty acids are released (hydrolysed) from the glycerol by lipase. This results in two fatty acids and one monoglyceride.

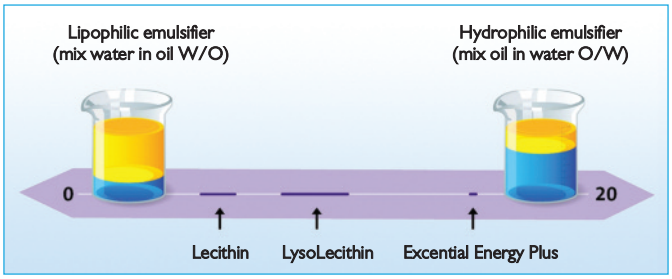
The next step is the formation of micelles. Micelles are water soluble aggregates of lipid molecules containing both polar and non-polar groups. The molecules are grouped in the micelles in such a way that the polar groups are on the outside in contact with the aqueous phase, while non-polar parts form the inner lipid core of the micelles.

Bile salts and monoglycerides aid as emulsifiers in the formation of micelles. When the micelles come into contact with the micro villous membrane they are disrupted and the fatty acids can be absorbed by the lipophilic cell membrane. The process of fat digestion is illustrated in Fig. 1.

Nutritional emulsifiers

Bile salts are natural emulsifiers. The monoglycerides that are formed after hydrolysis of the fat also act as emulsifiers. Nevertheless, the capacity of these natural emulsifiers can be a limiting factor for fat digestion. Young animals have a limited production of bile salts and therefore fat digestibility is limited in the early stage of life.

Fig. 2. Hydrophilic-Lipophilic Balance (HLB) ranges from 0 to 20. When a small amount of water is mixed in to a fat-rich environment, a lower HLB is advised (fat soluble emulsifier). If a small amount of fat is mixed into an aqueous environment, an emulsifier with a higher HLB is advised (water soluble emulsifier).



On the other hand the characteristics of the dietary fat can restrict the digestibility. Fatty acid mixtures with high amounts of free fatty acids lack the formation of monoglycerides and therefore have a lower emulsifying capacity.

Long chain unsaturated fatty acids and monoglycerides form micelles promptly, whereas saturated fatty acids have lower ability to form micelles because of their characteristic low polarity. These characteristics of the fat explain the difference in digestibility. In general, saturated fatty acids (mostly found in animal fat) are digested less easily compared to unsaturated fatty acids (like in vegetable fat).

High levels of free fatty acids also limit the digestibility. Exogenous nutritional emulsifiers can assist in the digestibility. Obviously, the positive effect of adding such emulsifiers is more pronounced for lower digestible fats than for very high digestible fats. The effect will also be more pronounced at higher levels of added fat. Nevertheless, in all cases, even with high digestible fats, positive effects have been observed.

Importance of HLB balance

An emulsifier is a molecule with a water soluble (hydrophilic) part and a fat soluble (lipophilic) part. The combination of these two characteristics in one molecule gives it the unique property that the emulsifier can dissolve as well in fat, as in water, and can aid in mixing the two fractions.

Different types of emulsifiers are commercially available. When choosing an emulsifier the principal of Hydrophilic-Lipophilic Balance (HLB) is important. HLB gives a value to how fat or water soluble a product is. The scale ranges from 0 to 20. The lower the HLB, the more lipophilic or fat soluble the emulsifier becomes. The higher the HLB, the more water soluble or hydrophilic the emulsifier will be (Fig. 2).

The objective of using an emulsifier determines whether a low or a high HLB is more suitable. Ideally,

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Broiler diet	Fat dig (%)	CP dig (%)	GE dig (%)	AMEn/kg DM		Upgrade vs control (kcal)
				(MJ)	(kcal)	
Control	63.0[a]	56.9[a]	68.3[a]	13.17[a]	3147[a]	–
Emulsifier A	68.5[b]	60.1[d]	71.1[b]	13.71[b]	3276[b]	129
Emulsifier B (Excential Energy Plus)	**70.5**[b]	**59.8**[cd]	**71.3**[b]	**13.74**[b]	**3283**[b]	**137**
Emulsifier C	68.6[b]	58.2[ab]	70.5[b]	13.60[b]	3250[b]	103
Emulsifier D	67.6[ab]	58.6[b]c	71.2[b]	13.75[b]	3285[b]	138

P<0.05

Table 1. Digestibility of fat, crude protein (CP), and gross energy (GE) and energy contenct (AMEn) of broiler diets.

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the emulsifier should be soluble in the continuous phase (rule of Bancroft). When a small amount of water is mixed in to a fat-rich environment, a lower HLB is advised (fat soluble emulsifier). If a small amount of fat is mixed into an aqueous environment, an emulsifier with a higher HLB is advised (water soluble emulsifier). In the case of a nutritional emulsifier a limited amount of fat is added to the watery environment of the gut.

A bird consumes 1.5-2.0 times more water than feed and the feed has only small amount of fat, so the amount of water is much higher than the amount of fat in the intestine. In this case a high HLB is more suitable.

Excential Energy Plus is a nutritional emulsifier with a very high HLB (very water soluble). This HLB is much higher than that of emulsifiers such as lecithin and lysolecithin (Fig. 2). Because of this high HLB the efficacy in terms of improving fat digestibility is very high.

Animal trials

Several experiments were set up to demonstrate the effect of emulsifiers on fat digestibility in broilers. In the first experiment four different emulsifiers (all nutritional emulsifiers, all with relatively high HLB values) were added to the diet. All four emulsifiers increased fat and energy digestibility and this resulted in a higher AMEn value of the diet. Emulsifier B (Excential Energy Plus) had the highest fat digestibility and an energy upgrade of almost 140 kcal (Table 1).

In a second experiment it was tested if it is possible to formulate a diet with a lower energy content and compensate this lower energy content with Excential Energy Plus. This was tested in two different basal diets with different fat composition. Diet 1 had a traditional fat composition. Diet 2 had a high level of saturated fatty acids and a high level of free fatty acids. The results of experiment two for the overall period are summarised in Table 2.

The diets with the reduced energy and the addition of the emulsifier performed at the same level as the control diets. The production performances show that the addition of Excential Energy Plus was able to compensate for a 5.3% lower energy content.

ME (kcal/kg)	3050	3100	3150	3200
Cost price diet ($/MT)	395	401	408	414
Added fat (%)	3.7	4.8	5.9	7.1
Total fat (%)	5.6	6.7	7.8	8.8
Cereals (%)	68	67	65	64
Soy bean meal (%)	25.3	25.5	25.7	25.8

Table 3. Cost price of typical broiler diet (grower, d10-30) formulated with different ME constraints.

Table 2. Performance during the overall period (0-39 days).

	Diet 1		Diet 2	
Fat composition	**High ratio U/S, low FFA***		**Low ratio U/S, high FFA**	
Energy level (ME)	**Basal**	**-5.3%**	**Basal**	**-5.3%**
Excential Energy Plus	**No**	**Yes**	**No**	**Yes**
Weight d39 (g)	2675	2630	2657	2714
ADG d0-39 (g/day)	67.5	66.3	67.0	68.5
WAFCR1500** (day 26)	1.549	1.546	1.505	1.504
WAFCR2500** (day 39)	1.464	1.505	1.493	1.507

*U/S = Unsaturated/Saturated fatty acids, FFA = free fatty acids **WAFCR = Weight Adjusted Feed Conversion

Save energy, save cost

The addition of Excential Energy Plus to a diet can compensate for a reduction in dietary energy. What does this mean for the practical farmer? If a diet can be formulated with a lower energy content, this means less addition of expensive fats and oils and as a result a lower cost price.

The extent of this effect on cost price depends on nutritional constraints in the formula and on raw material prices. These will differ between regions and will vary over time. To give an insight into the magnitude of the effect, a typical broiler diet was formulated with different energy levels.

In Table 3 the effect on cost price of the diets is shown. From this practical example it can be concluded that lowering the basal diet from 3150 to 3050 kcal will reduce the inclusion of oil and fat. This leads to a reduction of the cost price of more than 10 US$/MT.

Conclusion

Energy is a major cost component in diets for high performing animals. Nutritional emulsifiers can be used to improve fat digestibility and thus improve the energy efficiency.

From a practical point of view, this means that nutritionists are able to formulate diets with a lower energy content and keep the same performance. This will result in lower feed cost and contribute to more economical and sustainable animal production. ■