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Palmitic and Stearic Acids: Absorption and Digestion

High palmitic acid supplements have gained popularity in recent years due to a series of very short term published production studies. There is now more scientific information to aid consultants and dairymen alike in making an informed decision on what type of a long chain fatty acid (LCFA) supplement they wish to use. First, a review of the major fatty acids (FA) in most LCFA supplements is necessary to understand what the cow prefers and how she utilizes each FA. Dry rumen inert fats usually contain high concentrations of LCFA with the most common being palmitic (C16:0), stearic (C18:0), and oleic (C18:1) acids. C16:0 is the most plentiful FA in nature followed closely by C18:0. C16:0 has a melting point of 145° F, C18:0 has a melting point of 157° F, and C18:1 has a melting point of 50° F.

The composition of dietary FA and those entering the small intestine are quite different. Wu et al. (1991) was one of the first to show C18:0 was the only FA to increase in amount flowing from the rumen above the amount fed with or without fat supplemented in the diet. Outflow of C18:0 from the rumen was 46%, 24%, and 44% of the total FA intake (Table 1) when no supplemental fat, Ca Salt of palm fatty acid distillate (PFAD, or animal-vegetable (AV) blend fat was fed in a diet of 40% concentrate and 60% forage (alfalfa hay, haylage, and corn silage). Intake and rumen outflow of C16:0 remained similar at 71 g and 83 g, respectively, when no fat was supplemented in the diet, but with rumen inert or AV supplementation, outflow of C16:0 was less than intake.

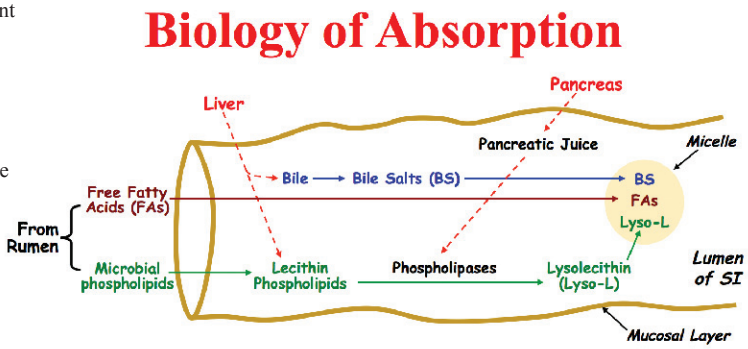
Table 1. Fatty acid intake and rumen outflow in cows fed a 40% concentrate diet without fat (control) or with rumen inert fat or animal-vegetable blend (AV)[1]

	Fat Supplementation		
Fatty acid, g/d	Control	Ca Salt of PFAD[2]	AV Blend
C16:0			
Intake	71	400	165
Outflow	83	313	152
C18:0			
Intake	12	39	104
Outflow	186	254	410
C18:1 - total			
Intake	79	308	297
Outflow	60	158	126
Total fatty acids			
Intake	431	1052	934
Outflow	402	837	810

[1]Adapted from Wu et al. (1991).
[2]57% of the C18:1 was biohydrogenated illustrating the non-inert nature of Ca Salts of PFAD.

Unsaturated free fatty acids (FFA) have relatively short half-lives in ruminal contents because they are rapidly biohydrogenated by microbes to more saturated end products. The initial step in biohydrogenation is an isomerization reaction that requires a LCFA with a free carboxyl group (Hawke and Silcock, 1970). All Ca salts of PFAD contain C18:1 and C18:2 which are biohydrogenated to a great extent in the rumen (Scollan et al., 2001). This illustrates that they are not inert nor are they by-pass fats because these FA are altered in the rumen.

Figure 1.



Davis, 1990

In the duodenum, pancreatic secretions and bile dissociate FFA adsorbed on feed particles to enable micelle formation (Figure 1). Both bile and pancreatic secretions are required for this process; bile supplies bile salts and lecithin, and pancreatic juice provides phospholipase enzymes to convert lecithin to lysolecithin and bicarbonate to raise the pH for enzymatic activity. Lysolecithin has a greater effect on solubility of C18:0 in micelles than any other natural or artificial amphiphiles tested. This is significant considering that C18:0 is the FA in largest quantity flowing into the duodenum of ruminants and requiring the capability to desorb FFA from feed particles and bacteria to form micelles. Once micelles are formed, they facilitate transfer of FFA across the unstirred water layer of intestinal epithelial cells.

Many claims have been made that C16:0 is more digestible than C18:0. Early FA digestibility studies based values on whole tract disappearance of FA that did not take into account disappearance of FA from the rumen, synthesis of FA by rumen microorganisms, or biohydrogenation of PUFA occurring in the rumen. Most of these claims were made before technology allowed researchers to measure the biohydrogenation of mono- and polyunsaturated FA accurately and how they came to transform into C18:0.

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Table 2. The average digestibility values of long chain fatty acids in dairy cows.

Fatty Acid	Ferlay and Doreau, 1994	Lock et al., 2006	Doreau and Chilliard, 1997	Enjalbert et al., 1997
C16:0	77	75	79	76
C18:0	76	72	77	79
C18:1		80	85	78
C18.2		78	83	66
C18:3		77	76	63

C16:0 average digestibility for all 4 studies is 76.8%. C18:0 average digestibility for all 4 studies is 76.0%.

For most LCFA of 16 to 18 carbon lengths, C18:0 is the lowest in intake, yet it is in the highest concentration in intestinal FA flow due to the unsaturated FA biohydrogenation. This led to erroneous digestibility values in early published studies. More recently several publications (Doreau and Ferlay, 1994, Doreau and Chilliard, 1997, Lock et al., 2006, and Enjalbert et al., 1997) have concluded that the digestibility of C16:0 and C18:0 are virtually the same. Table 2 illustrates these results. Demeyer and Doreau, 1999, concluded similarly that differences in digestibility among individual FA contribute very little to variation in digestibility of dietary fats.

As shown previously, the amount of C18:0 exiting the rumen greatly exceeds amount fed because of biohydrogenation and, as a result, individual digestibility of C18:1, C18:2, and linolenic acid (C18:3) will be overestimated and C18:0 digestibility underestimated when only amounts fed and excreted are considered. There appears to be more difference between studies and experimental diets than true differences in digestibility. For all intents and purposes, the digestibility of C16:0 and C18:0 are equal.

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