

## Omega-3 Fatty Acid Nutrition and Reproduction in Sows

**Introduction:** Fatty acids (FA) are components of fats and oils. They vary in chain length from 2 to 22 carbons. Some FA are saturated, which means they have no double bonds. These are the FA that are found in hard fats such as tallow and lard. Other FA are unsaturated, meaning they have anywhere from one to six double bonds. The higher the number of double bonds, the softer the fat. Plant and fish oils are very high in unsaturated FA (Table 1).

Table 1. Selected Fatty Acid Composition of Fats and Oils (%)

Name	Myristic	Palmitic	Stearic	Oleic	Linoleic	a-Linolenic	Arachidic	Arachidonic	Eicosapentaenoic (EPA)	Docosahexaenoic (DHA)
Structure: <sup>a</sup>	14:0	16:0	18:0	18:1	18:2	18:3	20:0	20:4	20:5	22:6
Type: <sup>b</sup>				n-9	n-6	n-3		n-6	n-3	n-3
Corn oil	0.1	10.9	2.0	25.4	59.6	1.2	0.4			
Soy oil	0.1	10.6	4.0	23.2	53.7	7.6	0.3			
Linseed oil		5.3	4.1	20.2	12.7	53.3				
Tallow	3.2	24.3	18.6	42.6	2.6	0.7	0.2			
Lard	1.5	26.0	13.5	43.9	9.5	0.4	0.2			
Poultry fat	0.8	25.3	6.5	37.7	20.6	0.8	0.2			
Salmon oil	5.3	15.8	3.3	15.5	3.4	1.0	2.5	0.3	16.6	13.4
Menhaden oil	8.6	21.2	3.3	15.0	7.0	1.3	0.4	1.9	13.4	1.4

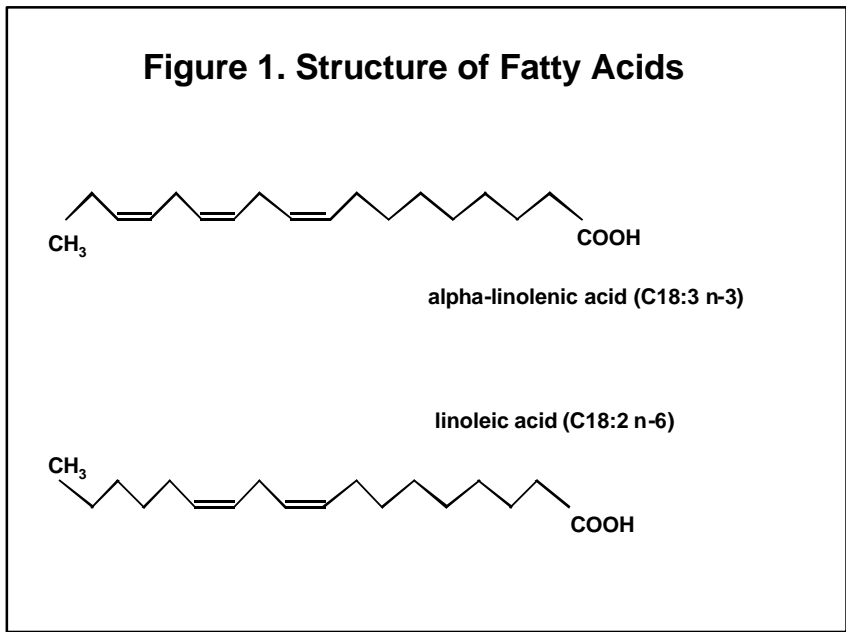
<sup>a</sup> Structure, chain length (the number of carbons): the number of double bonds.

<sup>b</sup> Type, n (omega end of FA)-carbon number of first double bond.

**Nomenclature:** FA have two ends: a methyl (CH<sub>3</sub>) end also known as the omega end, and a carboxyl (COOH) end. FA are named based on the number of carbons that make up the chain, as well as the number and position of the double bonds. If the carbon on the omega end of a FA is counted as number one, and the first double bond is located at carbon three, the FA is an omega-3 (Figure 1). If the first double bond does not occur until the sixth carbon from the omega end, the FA is an omega-6 (Figure 1).

**Metabolism:** Certain long chain unsaturated FA are essential for pigs, as they either cannot be synthesized in the body or only in small quantities. Thus, they must be supplied in the diet. These long-chain (≥18 carbons), polyunsaturated (PU; more than one double bond) FA play key roles

**Figure 1. Structure of Fatty Acids**



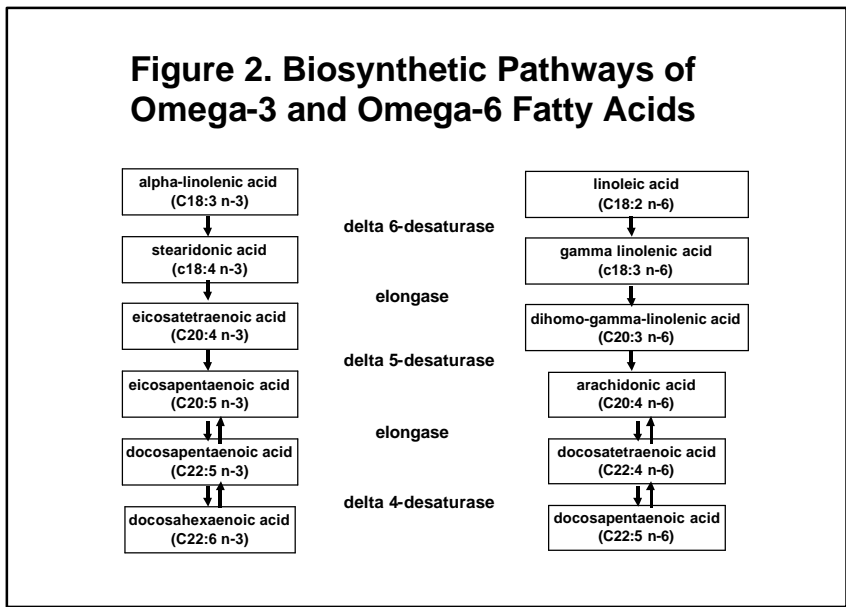
transform a-linolenic acid into EPA and DHA are not very efficient. Thus, if higher levels of these omega-3 PUFA are desired, they must be supplied directly in the diet. EPA and DHA are not present in plant oils, but they are abundant in fish oils (Table 1).

**Reproduction:** Recently, there has been interest in manipulating the FA composition of sow diets to enhance reproductive performance. The results of these attempts have been inconsistent at best. Rigau et al. (1995) fed 86 gilts either 1) corn-SBM-cornstarch control diet, 2) control + 4% coconut oil, 3) control + 4% soy oil, or 4) control + 4% menhaden oil (source of omega-3 PUFA). The diets were fed from day 10 to 17 after the first estrus to day 37 to 45 post-breeding. Gilts were mated at the third estrus, so all gilts received their respective dietary treatment for a minimum of 25 days pre-breeding. In this study, there were no effects of oil source on fetal survival rate through the beginning of the second trimester. Feeding menhaden oil decreased

in cell membrane integrity, hormone synthesis and immune function. Linoleic acid (C18:2 n-6) is supplied by corn and soy oil (Table 1). It is used by pigs to synthesize arachidonic acid, an important precursor for prostaglandin synthesis (Figure 2). Alpha-linolenic acid (C18:3 n-3) is high in certain oils such as linseed oil (Table 1). It is a precursor of other omega-3 PUFA such as EPA (C20:5 n-3) and DHA (C22:6 n-3) (Figure 2). Enzymatic processes in pigs that

long chain saturated FA levels, decreased arachidonic acid levels, and increased DHA and the ratio of omega-3 to omega-6 FA in fetal tissues. There were no differences in fetal n-3 or n-6 concentrations when sows were fed diets supplemented with starch, coconut oil, or soy oil.

**Figure 2. Biosynthetic Pathways of Omega-3 and Omega-6 Fatty Acids**



Rooke et al. (1998) fed 14 sows diets with either 3% soy oil or 3% tuna oil (source of omega-3 PUFA) from day 90 to 94 of gestation through day 7 of lactation. Sows were

induced to farrow on d-113 of gestation. In this study, piglet viability at birth decreased when tuna oil was fed to sows. In women, gestation length is increased when omega-3 FA are consumed. This may be due to competition for the desaturase and elongase enzymes that convert omega-6 and omega-3 FA to arachidonic acid (which is a prostaglandin precursor) and DHA, respectively (Figure 2). Affinity of desaturase and elongase enzymes is higher for n-3 vs. n-6 metabolism. Thus, if DHA synthesis is enhanced because more substrate is available for this process, less prostaglandin will be produced because the enzymes are being utilized for the alternate pathway. Prostaglandin is required for pregnancy termination. Thus, the authors speculate that the natural gestation length in sows fed tuna oil is increased, so inducing sows to farrow at d-113 decreased piglet viability. Feeding tuna oil to sows increased the proportion of long chain PUFA in tissues of piglets at birth.

In a follow up trial, Rooke et al. (2000a) fed 30 sows corn-wheat based diets supplemented with 1.75% corn oil, 1.75% tuna oil, or 1.75% corn/linseed oil mixture. Diets were fed from d-3 to 4 postmating to weaning. Sows were induced to farrow on d-113 of gestation. During lactation, sows were fed the same treatment diets except an additional 1.75% corn oil was added to increase the energy content of the diets. Fewer piglets died or were removed when sows were fed diets supplemented with corn oil vs. an omega-3 oil source (6.4%, 28.3%, or 25.5% died/removed for corn, tuna, or corn/linseed oil, respectively).

In studies where piglet tissue FA composition has been analyzed, improvements in DHA content as a result of feeding fish oil to sows has been accompanied by decreases in tissue arachidonic acid content (Rooke et al., 2000b). Birth weight in humans is positively correlated with tissue arachidonic acid status. Inclusion of fish oil in sow diets depresses birth weight of pigs. Low birth weight is a risk factor for preweaning mortality. Thus, Rooke and coworkers (2000b) attempted to establish an amount of dietary fish oil that would enhance piglet DHA status while minimizing reductions in piglet tissue arachidonic acid content. Twenty-four sows were fed isocaloric diets containing 1) 0% salmon oil + 2% palm kernel oil, 2) 0.5% salmon oil + 1.5% palm kernel oil, 3) 1% salmon oil + 1% palm kernel oil, or 4) 2% salmon oil + 0% palm kernel oil. Diets were fed at 5.5 lb/sow/d from d-60 of gestation to farrowing. Nine piglets per treatment were harvested at birth for analysis of FA composition (Table 2).

Table 2. Fatty Acid Composition (%) of Piglet Tissues at Birth When Sows are Fed Salmon Oil

Item	Salmon oil, %				P level
	0	0.5	1	2	
-----Brain FA level as a % of total brain FA content-----					
Brain wt, g/kg	25.2	28.6	30.6	26.7	.05 Q
C20:4 n-6	15.1	14.8	14.4	13.9	.05 L
C22:6 n-3	17.8	19.6	20.6	19.8	.05 Q
-----Liver FA level as a % of total liver FA content-----					
C20:4 n-6	13.5	13.0	11.7	9.6	.01 L
C22:6 n-3	6.8	9.6	9.9	10.0	.05 L

Rooke et al., 2000b

Although variable, it appeared that weight of piglet brain at birth may have increased when sows were fed diets supplemented with 0.5-1.0% salmon oil (Table 2). The authors concluded that the

optimal amount of dietary salmon oil (defined as that which gave the greatest response in brain DHA content of piglets with minimal reductions in arachidonic acid content) was between 0.5 and 1%.

In 2001, Rooke et al. fed 198 sows either a wheat-based control diet or the control diet + 1.75% salmon oil. Sows were fed their respective treatments from d-3 postmating to weaning, after which all sows were fed standard commercial diets. Sows were not induced to farrow, and pigs were weaned at 21 to 28 d of lactation. In this study, the only significant difference was for birth weight of piglets and gestation length, which were negatively affected by feeding salmon oil to sows (Table 3). During the subsequent parity when all sows were fed standard commercial diets, no carryover effects on conception and farrowing rates or litter size were detected based on previous salmon oil feeding.

Table 3. Effect of Salmon Oil Feeding of Sows on Reproductive Performance

Item	Control	Control + 1.75% salmon oil
Pigs born total, no./litter	11.9	12.3
Pigs born live, no./litter	11.6	11.8
Birth wt, lb/pig	3.4 <sup>a</sup>	3.2 <sup>b</sup>
Prewean mortality, %	11.7	10.2
Gestation length, d	115.4 <sup>a</sup>	115.9 <sup>b</sup>

Rooke et al., 2001.

<sup>a,b</sup> Treatment differs, P<.05.

**Conclusions:** From the available, independently published literature, we can conclude the following about feeding fish oil to sows:

1. No significant increase in litter size born (total or live).
2. Increased natural gestation length.
3. Increased preweaning mortality of piglets when sows are induced to farrow at d-113 of gestation.
4. Decreased piglet birth weight (even when sows are allowed to farrow naturally).
5. Enhanced DHA levels in piglet tissues.
6. Variable effects on brain weight of newborn piglets.

Based on these data and published reports, producers should use caution when feeding fish oil to sows. Besides cost increases and concerns about oil quality (fish oils are very prone to oxidative rancidity), results can be unpredictable and may not be consistent with desired outcomes. The benefits of increasing omega-3 FA levels in piglet tissues at birth are unknown. Certainly in humans, low tissue levels of PUFA at birth have been implicated in impaired visual function and poor cognitive development. These challenges have not been documented in pigs when sows are fed fortified corn-SBM diets. It is difficult to consistently and significantly increase litter size in sows that are fed adequate levels of required nutrients. Many factors and varying conditions influence litter size and can interfere with dietary manipulations to increase litter size.