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Feeding fat in pig and dairy cattle

Alimentación con lípidos en cerdos y vacas lecheras

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Introduction

Fats are key components in animal nutrition for maintaining normal development and performance. They are organic, water-insoluble substances and are classified as saturated (SFA), unsaturated (USFA), monounsaturated (MUFA), and polyunsaturated (PUFA) fatty acids (1). The level of inclusion in the diet affects animal growth and feed conversion. The inclusion of fats in the diet differs in monogastric and polygastric animals as it is related to lipid metabolism. In ruminants, dietary fats are hydrogenated in the rumen before intestinal absorption, for this reason, absorbed fatty acids are more saturated than fatty acids supplied by the original diet. In contrast, in non-ruminants, the intestinal digestibility of fatty acids depends on the degree of saturation of these fatty acids supplied in the diet (2).

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1. Role of fat in animal nutrition

The role of fats in animal nutrition has been studied for more than 200 years. Fats are an important source of energy in the diet and in feed reduced powder. Traditionally, the fat content in the diet of livestock varies between 2-5% of digestible energy. Increasing the fat content in the diet of cattle, pigs and poultry has shown better feed conversion and faster growth rates. The quality of fats depends on their fatty acid content and influences the fatty acid profile of the tissues. An important advantage of fats is the additional caloric effect provided by unsaturated fatty acids, which provide more energy than saturated fats. High levels of oleic acid increase the resistance of fat to oxidation. For this reason, there is great interest in optimizing the amount and type of fat in the diet. The main objective of determining the proper level of dietary fat intake is to enhance animal performance and welfare (3).

2. Advantages of fat supplementation

2.1 Fat supplementation in dairy cattle and physiological changes

Fatty acids reaching the duodenum are adsorbed mainly on food particles and bacteria. Desorption occurs by bile salts and by enzymes such as lysolecithins, which allow their solubilization in the micellar phase. It is these micelles that allow the absorption of lipids in the jejunum. In the epithelial cells of the small intestine, fatty acids are esterified, triacylglycerols and phospholipids are incorporated into chylomicrons (lipoproteins) and very-low-density lipoproteins (4). Feed commonly consumed by cows contains only 4 to 6% lipids, which contribute directly to nearly 50% of the fat in milk and are the most concentrated source of energy in the diet. Lipids are largely hydrolyzed in the rumen, breaking the bonds, and producing glycerol and three fatty acids (Figure 1). Thus, glycerol is rapidly fermented to produce volatile fatty acids, another important function of the microorganisms present in the rumen is the hydrogenation of unsaturated fatty acids. These free fatty acids in the rumen tend to bind to feed particles and microorganisms to prevent an increase in rumen fermentation (1). The intestinal digestibility does not depend on the intake of fatty acids, and it should be noted that the absorption capacity of these fatty acids may be greater than 1 kg/d in dairy cows fed different fat sources or oil. Rapeseed released in the duodenum as evidenced in (Table 1) (4). On the other hand, the digestibility of fatty acids depends on the chain length (Figure 2) and seems to be lower for fatty acids with C20 and C22, but the digestibility of fatty acids with C12, C13, and C14 increases (5).

Fat supplementation in the early lactation of the cow reduces the loss of body condition, in general, the addition of lipids increases progesterone, which has a positive effect on fertility, improves feed efficiency and affects methanogenesis by several mechanisms, one of which is the hydrogenation of unsaturated fatty acids, as this mechanism leads to H2 ion binding (6). The addition of omega-3 to the diet has shown an improvement in pregnancy rates.

2.2 Protected fat as feed supplement in cattle

The main property of protected fats is to resist biohydrogenation by rumen microbes and to alter the fatty acid profile of body tissues and milk.

These protected fats rely on encapsulation of unsaturated fatty acids by a protective capsule that resists biohydrogenation, such as the conversion of fatty acids to fatty amides (7). Supplementation with oilseeds has shown a positive effect on the digestive process by encapsulating antimicrobial fatty acids in their hard outer seed coat. However, destruction of the outer seed coat by chewing and rumination often results in little ability of oilseeds to enhance unsaturated fatty acids in milk (7).

2.3 Fat supplementation in pigs and physiological changes

In monogastric animals, lipids emulsify and enter the duodenum as triacylglycerols and phospholipids. In contrast to bacterial lipases of ruminants, the action of pancreatic lipase on triacylglycerols releases two fatty acids and a monoacylglycerol molecule. These compounds form micelles with bile salts and are then absorbed. After re-esterification in the intestinal cells, transport in mammals is mainly via the lymph through the portal system as very low-density lipoproteins (8). Lipids are important components of the diet for pigs due to their high energy value in addition to the fact that they can provide fat-soluble vitamins and essential fatty acids (9). Dietary lipids can increase growth and feed efficiency in pigs and can also modify body lipid composition, chain length, and the degree of saturation of the double bonds of fatty acids determine the physicochemical properties of fatty acids, which suggests that it influences the use of lipids by pigs (10).

Lipids are important components of the diet of pigs because of their high energy value and the fact that they can provide fat-soluble vitamins and essential fatty acids (9). The inclusion of lipids in the diet can increase growth and feed efficiency of pigs and modify body lipid composition. The chain length and degree of saturation of the double bonds of fatty acids determine the physicochemical properties of fatty acids, suggesting that they influence the utilization of lipids by pigs (10). De novo lipogenesis in pigs occurs in adipose tissue, which is the main active site, and glucose is the main substrate. Lipogenesis can also occur in the liver where acetate, lactate, and propionate can be used as substrates instead of glucose (11). The addition of fat and oil in the diet improves feed efficiency and that supplementing corn and soybean diets with 6% fat improves feed efficiency of gilts (12), and the addition of 10% fat to a low-fat diet, regardless of source, increased daily gain and feed efficiency (13). Involving 70 gilts, carcass characteristics and primary cut yields were determined as a function of intake of different fat diets, as shown in Table 2 (14). Slaughter percentage was higher (P = 0.05) in gilts fed the diet without added fat than the diet based on an oil mixture (40% fish oil and 60% linseed oil). These results are in contradiction with other studies reported by Pettigrew and Moser (1991), in which they concluded that the addition of fat in the diet of growing pigs increased the fat content of the carcass. The percentage of lean loin meat was higher (P = 0.05) in sows fed suet compared to those fed no added fat (14).

3. Disadvantages of fat supplementation

Excessive intake of lipids in the diet of about more than 8% intake can have a negative effect on milk production and fat content. Unsaturated lipids have a more negative effect than saturated lipids, but these lipids can be protected to reduce the effect of hydrolysis and thus make them less reactive in the rumen, such as intake with the seed coat, which protects the lipids and reduces hydrolysis (1). The protected fat in lactation cows can reduce the consumption of dry matter (DM), even when the fat is supplied directly in the duodenum (15), suggesting that the decrease in consumption may be related to the increase in the concentration of free fatty acids that circulate and come from the incomplete tissue uptake of the hydrolysis of chylomicron triglycerides and very-low density lipoproteins by lipase (16).

4. Hazards of fat supplementation

Excessive intake of lipids in the diet of about more than 8% intake can have a negative effect on milk production and fat content. Unsaturated lipids have a more negative effect than saturated lipids, but these lipids can be protected to reduce the effect of hydrolysis and thus make them less reactive in the rumen, such as intake with the seed coat, which protects the lipids and reduces hydrolysis (1). The protected fat in lactating cows can reduce the consumption of dry matter (DM), even when the fat is supplied directly in the duodenum, suggesting that the decrease in consumption may be related to the increase in the concentration of free fatty acids circulating and coming from the incomplete tissue uptake of the hydrolysis of chylomicron triglycerides and very low-density lipoproteins by lipase (15). The consequences that may occur in the diet of dairy cows when fat is added to the diet to increase the energy value is an effect on the composition of milk, which may have consequences for human health due to variations in fatty acid saturation. Similarly, the variation in the saturation of trans fatty acids and how their excessive intake in humans can represent a high cardiovascular risk (17).

Conclusions

1. Fat availability in polygastric diets, such as cattle, is improved by using protected fats, which improves the lipid profile of milk, fertility, feed conversion, and reduce methane emissions, and in monogastric diets, such as pigs, optimizing the ratio of unsaturated/saturated fatty acids increase the energy efficiency of fats. Feeding a diet with no added fat to swine may result in fatter carcasses and cuts compared to diets formulated with a high-fat content.

2. The main property of protected fats is to resist biohydrogenation by rumen microbes and to alter the fatty acid profile of body tissues and milk. These protected fats rely on encapsulation of unsaturated fatty acids by a protective capsule that resists biohydrogenation, such as the conversion of fatty acids to fatty amides.

3. In dairy cows, excess lipids in the diet may reduce dry matter consumption, milk production, and milk fat composition.

4. Combining different fat sources and consuming lower amounts of fat in pigs can produce fatty acid profiles in the carcass with nutritional benefits without compromising meat quality.

5. Increasing the amount of long-chain fatty acids in the diet increases milk secretion, but also stops the synthesis of short- and medium-chain fatty acids.

6. It is important to emphasize that knowledge of the chemical composition and nutritional value of the foods included in the ration must be strategically planned to meet the requirements of the animals and achieve greater productive efficiency.

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Tables and figures

Table 1. **Effect of large amounts of fat on ruminal fatty acid (FA) balance and intestinal FA digestibility (5)**

	Control	Rapeseed oil (50 g/kg)	Rapeseed oil (100 g/kg)	Tallow (100 g/kg)
FA intake (g/d)	290	835	1500	1530
FA digestive flow (g/d)	365	625	1235	1235
FA intestinal digestibility (%)	89,1	84,5	77,1	74,6

Table 2. Least-squares means for carcass parameters and primal cut yields of gilts fed experimental diets (14).

Carcass parameters	T	HOSF	SFO	LO	FB	OB	NF	RMSEB
Caecass weight (kg)	78,1	79	76,6	75	79,4	73,7	79,6	6,66
Kolling out (%)	78,8ab	78,4ab	79,3ab	78,5ab	78,2ab	77,5b	80,0a	1,38
Flare fat (%)	1,5b	1,84ab	1,83 ab	1,62 ab	1,62 ab	1,71 ab	1,95a	0,313
Last rib fat depth (mm)	13,5	15,7	15,9	14,3	14	14,9	16,2	2,3
Fat depth 3-4 l.r c	15,1	17,9	17,9	16,3	16,1	16,7	18,6	2,64
Muscle depth 3-4 l.r c	51	49,8	49,7	50,8	51,7	49,2	52,3	4,01
Carcass lean (%)	56,3	53,6	53,6	55,3	55,6	54,6	53,5	2,4
Primary cut yields (%)								
Ham	24,5	24,38	24,17	24,67	24,65	24,35	24,43	0,802
Loin	18,29 ab	17,69 ab	18,42 ab	17,94 ab	17,23	18,4 ab	18,84 ab	0,931
Shoulder	13,86	13,7	13,54	13,54	13,77	13,84	13,4	0,539
Belly	9,08	9,84	9,88	9,5	9,82	9,49	9,69	0,694
Tenderloin	1,22	1,22	1,22	1,25	1,27	1,24	1,21	0,098
Other fat cuts D	7,92	8,48	8,19	7,98	8,34	8,08	7,7	0,599

[a,b] Within a row. Means lacking a common superscript letters differ (P < 0,05).

[A] T = tallow; HOSF = high-oleic sunflower oil; SFO = sunflower oil; LO = linseed oil; FB = fat blend (55% tallow. 35% sunflower oil and 15% linseed oil); OB = oil blend (40% fish oil and 60% linseed oil); and NF = no added fat.

[B] RMSE: Root Mean Square Error.

[C] Estimated with FOM. l.r.: last rib.
D Other fat cuts: belly trimmings plus jowl.

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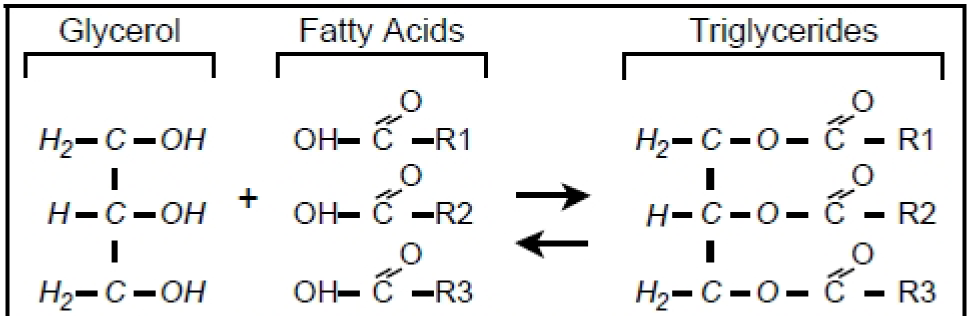

Figure 1: Basic structure of triglycerides. The radicals (R1, R2, and R3) are made of a carbon chain with variable lengths and degrees of saturation.

Figure 1. *Basic structure of triglycerides. The radicals (R1, R2 and R3) are made of a carbon chain with variable lengths and degrees of saturation (1).*

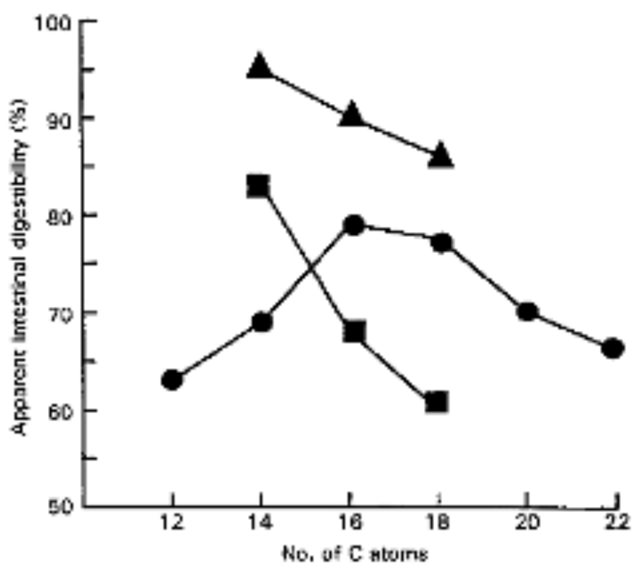

Figure 2. Effect of carbon chain length on saturated fatty acid digestibility in (•) rumiants (all fats).

(□) prerumiant calves (all fats except milk) and (□) poultry (tallow). (5).