Palm Fats for Livestock Feeding

Palmquist, D L*

INTRODUCTION

Palm oil is second only to soyabean oil in world production of vegetable oils, and makes up more than half of total oil exports (Gunstone, 2003). Palm fatty acid distillate (PFAD), a by-product of palm oil refining, makes up approximately 5% of the 28 million tonnes of palm oil expected to be produced in 2004. A primary market for PFAD is the animal feed industry. PFAD is an attractive ingredient as a fat supplement for livestock; it is readily available, relatively stable to oxidant rancidity and relatively inexpensive, although prices have been volatile in recent years. Its use has continued to increase as fatty acids, as hydrogenated fatty acids, or as calcium soaps.

From the volume of published literature, it may be concluded that the greatest use of palm oil is in ruminant diets, especially dairy, either as hydrogenated fatty acids or as the calcium soaps. Rather less information is available using palm oil in diets of pigs, chickens and fish. No information was found from a search of literature for using palm oil in horse, dog or cat diets.

PFAD AS A FEED INGREDIENT

Although crude palm oil (CPO) may be used in animal feeding, PFAD predominates. Unesterified fatty acids are the main component of PFAD, with a minor portion contributed by triacylglycerols. The fatty acid profile is shown in *Table 1*. Palmitic acid (16:0) makes up 45% to 55% of total fatty acids in PFAD, oleic acid (18:1) about 35%, with lesser amounts of linoleic (18:2) and stearic acid (18:0). As PFAD is relatively low in essential fatty acids, its most important contribution to nutrition is to provide energy. Nevertheless, low unsaturation and high content of antioxidants contribute to oxidative stability, increasing its values as a feed ingredient. As shown in *Table 2*, PFAD is a rich source of vitamin E; tocotrienols constitute more than half of the total vitamin E activity.

PFAD FOR RUMINANTS

Advances in genetics, nutrition and management of dairy cattle have led to the need for concentrated energy feed supplements for lactating cows. However, dairy cattle have specific needs for forages in the diet and excessive feeding of cereals leads to ruminal acidosis, digestive upset, off-feed, low milk yield and low milk fat percent and fat cows (Davis and Brown, 1970; Sudweeks *et al*., 1981). Increasing fat content of dairy diets offers alternatives to feeding excessive amount of cereals, but also may compromise ruminal fibre digestion and milk fat percent (Palmquist and Jenkins, 1980). Calcium salts of fatty acids are utilized effectively by cattle without compromising ruminal fermentation and microbial growth (Jenkins and Palmquist, 1984; Palmquist, 1984). Ruminal biohydrogenation of the unsaturated fatty acids in calcium salts is about 50%, compared to 90% for most unsaturated feed fats (Wu *et al.,* 1991). Calcium salts of PFAD are now firmly established worldwide as the standard for dairy energy supplements (Onetti and Grummer, 2004).

In a meta analysis of data from 41 published studies with lactating cows, compared to feeding tallow, calcium salts of PFAD decreased feed intake while significantly increasing milk and milk field yield, without compromising milk fat percent (Onetti and Grummer, 2004). Both supplements decreased milk protein percent, but not yield. Feeding calcium salts of PFAD also significantly increased digestibility of feed neutral detergent fibre (NDF), whereas feeding tallow decreased NDF digestibility.

Compared with calcium salts of PFAD, hydrogenated PFAD (Elliot *et al.,* 1996) and hydrogenated palm oil (Weiss and Wyatt, 2004) decreased fatty acid digestibility. Hydrogenated palm oil decreased milk yield, whereas hydrogenated PFAD did not change yield.

Calcium salts of PFAD are especially useful to increase milk fat percent and yield in lactating ewes (Casals *et al.,* 1999), whereas they have little application for lactating beef

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* Ohio Agricultural Research and
Development Centre,
The Ohio State University,
Department of Animal Sciences,
Wooster, OH 44691, USA.
E-mail: palmquist.1@osu.edu

cows or fattening cattle. Adding palm oil (10.7% of dry matter) to fattening lamb diets increased carcass fatness without improving carcass quality (Lough *et al.,* 1993).

PALM OIL AND PFAD FOR NON-RUMINANTS

Published literature on palm oil utilization in non-ruminants is limited. Smith *et al*. (1996) reported that diets high in palmitic acid were most effective compared with other fatty acids or corn starch to reduce fatty acid synthesis by porcine subcutaneous adipose tissue, a response much different from that found in rat models. Digestibility of palm kernel oil by growing pigs was not influenced by concentration in the diet; however, free oil was more digestible than when provided as full-fat palm kernels or palm kernel meal (Agunbiade *et al.,* 1999). Traditional ether extraction methodology overestimated fat digestibility and energy value of the palm kernel products. Acid ether extraction or other newer methodologies (Palmquist and Jenkins, 2003) are required to determine correct digestibility of fatty acids.

Digestibility of fat by poultry is influenced profoundly by unsaturation, content of unesterified fatty acids, and by age of the birds (Palmquist, 2002). Higher saturation and unesterified fatty acids greatly decreased digestibility in birds at 1.5 weeks of age compared with 7.5 weeks and digestibility and apparent metabolizable energy (AME) of palm oil were lower than for soyabean oil or tallow (Wiseman and Salvador, 1991). Conversely, Pesti *et al.* (2002) found no differences in weight gain or feed conversion among broilers fed eight different fats, including palm oil, though metabolizable energy of the palm oil was measurably lower. Blending palm oil with low quality, low cost unsaturated fats, such as soya acid oil, increases the utilization of the unsaturated fatty acids (Blanch *et al.,* 1996). Interestingly, calcium salts of fatty acids were utilized as well as tallow by laying hens (Rising *et al.,* 1986). Higher saturation and antioxidant content of palm oil decreased the thiobarbituric acid reactive substances (TBARS) in eggs and white and dark meat of laying hens when included in diets at increasing levels (Kang *et al.*, 2001).

TABLE 1. FATTY ACID PROFILE (% of total fatty acids) OF SEVERAL PALM OIL PRODUCTS USED AS FEED ENERGY SUPPLEMENTS

Fatty acid	CPO[a]	PFAD[b]	Ca soap[c]
12:0	0.2	0.3	0.3
14:0	1.1	1.1	1.3
16:0	42.8	58.1	48.1
16:1	0.1	-	0.1
18:0	3.8	3.7	4.3
18:1	41.1	30.2	35.7
18:2 n-6	10.3	6.1	8.9
18:3 n-3	0.3	-	0.4

Notes:
[a] Crude palm oil. Data from Ng *et al*. (2003b).
[b] Palm fatty acid distillate. Data from Ng *et al*. (2003b).
[c] Calcium salt of PFAD; Megalac®, Church and Dwight Co., Inc., Princeton, NJ, USA.

TABLE 2. VITAMIN E ISOMERS IN PFAD[a]

Isomer	mg kg^{-1}
α Tocopherol	4.40
β Tocopherol	0
γ Tocopherol	0.66
α Tocotrienol	4.37
γ Tocotrienol	11.20
δ Tocotrienol	3.49
Total tocopherols + tocotrienols	24.13

Note: [a] Calculated from Ng *et al.* (2004).

PALM OIL FOR FISH

It is anticipated that the supply of fish oil for farmed fish will become limiting. In the search for alternate oil sources both CPO and PFAD were well utilized by African catfish when included up to 25% of dietary lipid (Ng *et al*., 2003a; 2004) and up to 50% of dietary lipid by Atlantic salmon (Bell *et al*., 2002). Digestibility of saturated fatty acids by rainbow trout was decreased by increasing content of CPO, and this effect was greater as water temperature was decreased (Ng *et al*., 2003b). Replacing fish oil with PFAD increased tocopherol and tocotrienol concentrations and the oxidative stability of muscle tissue in African catfish; further, it was concluded that in fish meal-based diets for African catfish, PFAD can totally replace added fish oil (Ng *et al*., 2004).

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