EFFECTS OF SOY LECITHIN AND DISTILLED MONOGLYCERIDE IN COMBINATION WITH TALLOW ON NUTRIEN DIGESTIBILITY, SERUM LIPIDS, AND GROWTH PERFORMANCE IN WEANLING PIGS

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Summary

Four hundred twenty pigs (21 d of age and 12.3 lb avg initial wt) were used to determine if adding soybean oil, lecithin, and monoglyceride to diets containing tallow affects nutrient digestibility, serum lipids, and growth performance. Treatments were: 1) a high nutrient density diet (HNDD) with 10% soybean oil; 2) HNDD with 10% tallow; 3, 4, and 5) diet 2 with 9% tallow and 1% soybean oil, lecithin, and monoglyceride, respectively. Adding soybean oil, lecithin, and monoglyceride to tallow increased digestibility of total fat, long-chain saturated fatty acids, and medium-chain fatty acids, but reduced serum concentrations of triglycerides and total, HDL (high density lipoprotein), and LDL (low density lipoprotein) cholesterol. From d 0 to 14, pigs fed soybean oil had greater ADG and ADFI than pigs fed the other treatments, and pigs fed tallow without emulsifiers had the lowest ADFI. From d 0 to 7 and 0 to 14, pigs fed diets with lecithin had improved F/G compared to pigs fed monoglyceride. For d 0 to 35, fat source or emulsifier treatment did not affect growth performance. The addition of emulsifiers increased digestibility of tallow but had only small effects on growth performance early in the nursery phase.

(Key words: Starter, Digestibility, Growth, Soybean oil, Tallow, Lecithin, Monoglyceride.)

Introduction

Early-weaned pigs have unique needs for nutrient sources and concentrations in their diet. Milk products and fat sources have become common additives to increase the nutrient density of diets and reduce post-weaning lag in performance. Although addition of fat to starter diets generally increases performance for the overall nursery phase, it has not eliminated the growth lag typically observed for the first 1 to 2 wk post-weaning. Fat digestibility increases with time post-weaning, and animal fats are less digestible than those of vegetable origin. Those responses have been attributed to the high degree of saturation and long chain length of animal fats, factors that decrease micelle formation. In young pigs, capacity of the small intestine to absorb micellar lipid exceeds normal influx into the gut. Therefore, entry of fatty acids into the micellar phase has been implicated as limiting fatty acid digestibility rather than absorption of fatty acids from the micelles into the intestinal mucosa. Emulsifying agents promote incorporation of fatty acids into micelles and should increase digestibility of fat. The objective of the present study was to determine the effects of feeding exogenous emulsifiers in combination with tallow on digestibility of nutrients, serum lipids, and growth performance in weanling pigs.

Procedures

A total of 420 pigs (21 d of age and 12.3 lb avg initial wt) was allotted on the basis of

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sex, weight, and ancestry to five treatments in a randomized complete block design. Treatments were: 1) HNDD with 10% added soybean oil; 2) HNDD with 10% added tallow; 3, 4, and 5) diet 2 with 9% tallow and 1% soybean oil, lecithin[2], and monoglyceride[3], respectively. Orthogonal constrasts were used to separate treatment means. Treatment comparisons were: 1) soybean oil vs all other treatments; 2) tallow vs tallow plus soybean oil, lecithin, and monoglyceride; 3) tallow plus soybean oil vs tallow plus lecithin and monoglyceride; 4) tallow plus lecithin vs tallow plus monoglyceride.

Pigs were housed (seven per pen) in an environmentally controlled nursery with 4 ft × 5 ft pens and woven wire flooring. Pigs were allowed to consume feed and water ad libitum during the 35-d growth assay, and all diets were pelleted. The Phase 1 and Phase 2 basal diets are given in Table 1. When soybean oil, lecithin, and monoglyceride were added to tallow, they were rigorously blended prior to addition to diets. Pigs and feeders were weighed weekly to determine ADG, ADFI, and F/G. On d 13 and 14 of the experiment, fecal samples were collected by rectal massage. The samples were pooled within pen; lyophilized; and analyzed for N, DM, GE, Cr, and fatty acids. Also on d 14, blood samples were collected from all pigs, and serum was harvested and pooled within pen. The pooled sera were analyzed for triglycerides; non-esterified fatty acids (NEFA); and total, HDL, and LDL cholesterol.

Table 1. Composition of Basal Diets[a]

Ingredient, %	Phase 1	Phase 2
Corn	25.82	43.19
SBM (48% CP)	21.20	28.10
Dried skim milk	20.00	—
Dried whey	20.00	20.00
Fat[b]	10.00	5.00
Monocalcium phosphate	1.12	1.65
Limestone	.51	.86
Lysine-HCl	.10	.10
Salt	—	.10
Vit/Min/ Antibiotic[c]	1.00	1.00
Chromic oxide	.25	—

[a]Diets were formulated to supply 1.5% lysine, .9% Ca, and .8% P in Phase 1 and 1.25% lysine, .9% Ca, and .8% P in Phase 2.
[b]Fat sources were soybean oil, tallow, and 9% tallow with 1% soybean oil, lecithin, or monoglyceride.
[c]Provided the following per ton of complete diet: 100 g chlortetracycline, 100 g sulfathiazole, and 50 g penicillin.

Results and Discussion

Chemical analyses of the fat sources and emulsifiers are given in Table 2. The fatty acids in soybean oil were primarily long-chain (> C 14) and unsaturated, with 86% as 18:1, 18:2, and 18:3. Tallow also was essentially long-chain fatty acids (78%) of which half were saturated. The fatty acid profile of lecithin was similar to that of soybean oil, as might be expected, because it was a soybean product. The monoglyceride also was a soybean product, but the fatty acid composition was changed to 65% stearic acid (C 18:0) by a saturation process and was predominately a β-monoglyceride. The monoglyceride was a dry powder.

Pigs fed soybean oil had the greatest digestibilities of total fatty acids, long-chain un-

[2]Lecithin was Centrol 3F UB, Central Soya Company, Fort Wayne, IN.

[3]Monoglyceride was Myverol 18-06, Eastman Chemical Products, Inc., Eastman-Kodak Co., Kingsport, TN.

saturated fatty acids, and long-chain saturated fatty acids (Table 3). Addition of soybean oil, lecithin, and monoglyceride to tallow increased digestibilities of total fatty acids and long-chain saturated fatty acids. Unsaturated:saturated fatty acid ratios (U/S) were: 5.6:1, 1.3:1, 1.4:1, 1.3:1 and 1.1:1 for diets with soybean oil; tallow; and tallow plus soybean oil, lecithin, and monoglyceride, respectively. The differences observed in fatty acid digestibility between soybean oil and tallow treatments could be related to the greater U/S for soybean oil and the greater fat digestibility that is associated with increased U/S. However, differences in fatty acid digestibility between diets with tallow and diets with tallow plus soybean oil, lecithin, and monoglyceride cannot be explained by different U/S, adding support to the argument that these additions increased emulsification and, thus, digestibility of tallow. Digestibilities of N, DM, and GE were not affected by treatment.

Pigs fed soybean oil had the lowest serum triglycerides; NEFA; and total, HDL, and LDL cholesterol. Adding soybean oil, lecithin, and monoglyceride to tallow reduced serum triglycerides; NEFA; and total, HDL, and LDL cholesterol. Lecithin and monoglyceride additions to tallow tended to decrease serum triglycerides more than soybean oil. Serum HDL:LDL ratio was not affected by treatment.

From d 0 to 7, ADG was not affected by treatment, although pigs fed soybean oil had numerically the greatest ADG, and pigs fed tallow, the lowest (Tabel 4). Daily feed intake was greater for pigs fed soybean oil than those fed other treatments and was improved with the addition of soybean oil, lecithin, or monoglyceride to tallow. Pigs fed diets with lecithin had improved F/G compared to pigs fed diets with monoglyceride.

From d 0 to 14, pigs fed soybean oil had greater ADG than pigs fed other treatments, pigs fed tallow tended to have the lowest ADG, and pigs fed tallow plus the emulsifiers tended to have intermediate ADG. Addition of lecithin to tallow increased ADG by 6%. Feed intake was greater for pigs fed soybean oil compared to pigs fed other treatments, and addition of soybean oil, lecithin, and monoglyceride to tallow increased ADFI. Addition of lecithin to tallow improved F/G compared to addition of monoglyceride.

From d 0 to 35, growth performance was not affected by treatment. This response indicates that as pigs get older, differences in saturation of fat sources become increasingly less important.

In conclusion, benefits from adding fat to diets for early-weaned pigs (21 d of age and less) are inconsistent, and the fat source chosen seems to have an effect. In the present experiment, soybean oil was superior to tallow, but addition of soybean oil, lecithin, and monoglyceride to tallow improved digestibility of fat. Furthermore, diet costs were reduced by using emulsified animal fat compared to soybean oil.

Table 2. Chemical Analysis of Fat Sources and Emulsifiers

Item	Soybean oil	Tallow	Lecithin	Monoglyceride
Moisture, %	.14	.12	.65	.51
Peroxide value, mEq/lb	1.81	2.70	5.68	.81
Acetone insolubles, %	.26	.32	62.77	24.65
Unsaponifiable matter, %	1.10	.26	4.26	1.35
Esterified fatty acids, %	79.52	81.83	45.68	28.87
Fatty acids, %[a]				
C 8:0	.00	.00	.00	.00
C 10:0	.00	.03	.00	.00
C 12:0	.00	.00	.37	.00
C 14:0	.06	2.79	.05	.07
C 16:0	7.86	21.31	10.13	7.88
C 16:1	.06	3.00	.02	.00
C 18:0	3.57	17.63	3.00	64.91
C 18:1	19.09	33.98	10.47	.00
C 18:2	58.70	1.81	52.94	.03
C 18:3	8.50	.39	7.87	.72

[a]Number of carbon atoms and double bonds are designated to the left and right of the colon, respectively.

Table 3. Effect of Fat Source, Fat Blends, and Emulsifiers on Apparent Digestibility of Nutrients and Serum Lipids in Weanling Pigs[a]

Item	Soybean oil	Tallow	Tallow + soyoil	Tallow + lecithin	Tallow + monoglyceride	CV
Apparent digestibility, %						
Total fatty acids[hi]	94.2	80.8	86.8	85.4	85.0	6.3
Long-chain unsaturated fatty acids[bf]	96.0	91.8	93.8	93.8	93.2	3.3
Long-chain saturated fatty acids[cfj]	81.4	63.4	74.2	72.2	74.2	13.2
Medium-chain fatty acids[dfi]	97.5	93.0	95.7	95.2	94.8	2.7
N[l]	86.5	85.9	86.8	87.7	87.1	3.1
GE[l]	89.4	87.4	88.1	88.7	88.5	3.2
DM[l]	88.7	88.4	88.4	88.9	88.8	2.4
Serum lipids						
Triglycerides, mg/dL[gk]	41.7	57.7	51.7	47.3	44.8	14.2
NEFA, mEq/L[ck]	.21	.33	.25	.24	.26	24.2
Total cholesterol, mg/dL[ej]	85.7	102.6	94.7	96.0	91.1	7.5
HDL cholesterol, mg/dL[ei]	30.3	35.4	33.7	32.1	31.7	10.0
LDL cholesterol, mg/dL[fi]	55.4	67.2	61.0	63.9	59.4	10.2
HDL:LDL ratio[l]	.55	.53	.55	.50	.53	14.2

[a]Seven pigs/pen and six pens/treatment, with an avg initial wt of 12.3 lb/pig.
[b]Fatty acids were C16:1, C18:1, C18:2 and C18:3.
[c]Fatty acids were C16:0 and C18:0.
[d]Fatty acids were C8, C10, C12 and C14.
[cfgh]Soy oil vs other treatments ($P<.10$, $P<.05$, $P<.01$, $P<.001$, respectively).
[ijk]Tallow vs tallow + soy oil, lecithin, and monoglyceride ($P<.10$, $P<.05$, $P<.01$, respectively).
[l]No treatment effect ($P>.32$).

Table 4. Effect of Fat Source, Fat Blends, and Emulsifiers on Growth Performance of Weanling Pigs[a]

Item	Soybean oil	Tallow	Tallow + soyoil	Tallow + lecithin	Tallow + monoglyceride	CV
d 0 to 7						
ADG, lb[i]	.61	.55	.58	.59	.58	12.8
ADFI, lb[ce]	.64	.56	.59	.59	.62	11.1
F/G[g]	1.05	1.02	1.02	1.00	1.07	8.8
d 0 to 14						
ADG, lb[b]	.70	.63	.63	.67	.64	14.4
ADFI, lb[dfg]	.84	.71	.77	.78	.83	9.4
F/G[h]	1.20	1.13	1.22	1.16	1.30	12.1
d 0 to 35						
ADG, lb[i]	.95	.96	.96	.99	.98	9.2
ADFI, lb[i]	1.57	1.53	1.60	1.64	1.63	7.3
F/G[i]	1.65	1.59	1.67	1.66	1.66	10.2

[a]Seven pigs/pen and six pens/treatment, with an avg initial wt of 12.3 lb/pig.
[bcd]Soybean oil vs other treatments ($P<.10$, $P<.05$, $P<.01$, respectively).
[cf]Tallow vs tallow + soy oil, lecithin, and monoglyceride ($P<.05$, $P<.01$, respectively).
[gh]Lecithin vs monoglyceride ($P<.10$, $P<.05$, respectively).
[i]No treatment effect ($P>.11$).