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Influence of Level and Method of Supplementation on the Utilization of Supplemental Fat by Feedlot Steers

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Abstract: Crossbreed steer calves (n=216; 267±6.8 kg) were used in a growth-performance trial to determine the influence of level and method of supplementation on the utilization of supplemental fat (tallow fatty acids) in high-energy diets for feedlot cattle. Three methods of fat supplementation (fat added directly to the grain, fat added directly to the hay, and fat added as the last step in the batch mixing) were compare at each 3 levels of supplementation (3, 6 and 9% fat). Adding fat directly to the grain, or as the last step in batch mixing had similar (P > 0.10) effects on growth performance. The addition of fat directly to the hay depressed DMI and ADG at the 3 and 9% levels of fat supplementation (fat level by method of supplementation interaction, P<0.05). Method of fat supplementation did not affect (P>0.10) dietary NE. Increasing the level of fat supplementation decreased (linear effect, P < 0.01) ADG, DMI, feed efficiency, and dietary NE. Observed/expected dietary NE_m was 1.03 with 3% supplemental fat and declined to 0.90 with 9% of fat supplementation. We conclude that the feeding value of fat is proportional to total fat intake. When total dietary fat intake is less than 6% the NE value of fat is consistent with tabular values. At greater dietary fat concentrations, energy intake, ADG, and the NE value of fat will decrease. When the proportion of fat added directly forage is greater than 20% of the fat-forage blend energy intake, and hence, daily weight gain may be depressed. However, there are no associative effects of method of supplementations on the dietary NE, even when the level of fat supplementation exceeds 2 g Kg BW^{-1}.

Key words: Cattle; Dietary Fat; Tallow; Fatty Acids; Performance

Introduction

While much attention has been directed at understanding factors influencing the NE value of supplemental fat (Zinn, 1994), alterations in NE do not necessarily form the basis for constraints on supplementation. Indeed, greater concern is often directed at potential negative associative effects of supplemental fat on diet acceptability and feed intake (Brethour *et al.*, 1957; Buchanan-Smith *et al.*, 1974; Cameron and Hogue, 1968; Cuitun *et al.*, 1975; Dinius *et al.*, 1975; Hatch *et al.*, 1972; Johnson and McClure, 1972; Lofgreen, 1965; etc). Although the reasons for the occasional negative impact of supplemental fats on diet acceptability are far from clear, each time the problem arises attention is drawn to the importance of "quality". The net energy value of the diet would only be influenced to the extent that digestibility of the diet is also modified. It has been proposed (Davison and Woods, 1960; MacLeod and Buchanan-Smith, 1974; Devendra and Lewis, 1974; Zinn, 1989b) that the coating of feed particles (particularly fiber) with supplemental fat during the process of feed mixing may reduce the rate of constituent digestion in the rumen. Decreased rate of digestion may increase ruminal fill to the extent that energy intake is also depressed. This consideration becomes more critical as level of fat supplementation increases. However, in dairy rations where fat has been supplemented in the concentrate portion of the diet, no depressing effects on digestion have been observed (Palmquist and Conrad, 1978, 1980).

The objective of the present study was to further evaluate the influence of method of fat supplementation (order of fat incorporation in the batching process) on the feeding value fat in finishing diets for feedlot cattle.

Materials and Methods

In a growth-performance trial involving 216 crossbred steers (267 kg±6.8 kg) approximately 25% Brahman breeding with remainder represented by Hereford, Angus, Shorthorn, and Charolais breeds in various proportions), three methods of supplementation were compared at each of 3 levels of fat supplementation (3, 6, and 9% fat). Methods of supplementation were: 1) fat added directly to the grain before addition of other dietary ingredients; 2) fat added directly to the hay before mixing the hay with other dietary ingredients; 3) fat added as the last ingredient in the batch mixing. Composition of dietary treatments is shown in Table 1. Steers were weighed, implanted with Synovex-S (Fort Dodge Animal Health, Fort Dodge, KS), and randomly assigned to 36 pens (6 head per pen). Pens were 43 m^2, with 22 m^2 overhead shade, automatic waters, and 2.4-m fence-line feed bunks.

The trial was conducted at the University of California Desert Research and Extension Center, located in El Centro, California. Fatty acids composition of supplemental fat was as follows: myristate, 3.7%; palmitate, 29%; palmitoleate, 3.7%; stearate 19.7%; oleate, 39.9%; linoleate, 3.9%. Steers were reimplanted with Synovex-S on d 56. Diets were prepared at weekly intervals and stored in plywood boxes located in front of each pen. Steers were allowed ad libitum access to dietary treatments. Fresh feed was provided twice daily. In determining steer performance, initial and final BW were reduced 4% to account for digestive tract fill. Estimates of steer performance were based on pen means. Hot carcass weights were obtained from all steers at time of slaughter. After the carcasses were chilled for 48 h the following measurements were obtained: 1) longissimus muscle area (ribeye area), taken by direct grid reading of the eye muscle at the 12th rib; 2) subcutaneous fat over the eye muscle at the 12th rib taken at a location ¾ the lateral length from the chine bone end and 3) kidney, pelvic and heart fat (KPH) as a percentage of carcass weight. Retail yields (boneless, closely trimmed retail cuts from the round, loin, rib and chuck as a percentage of carcass weight) were estimated from measures of carcass weight, longissimus muscle area, subcutaneous fat thickness and KPH according to USDA (1965). Energy retention (ER, megacalories) was derived from measures of live weight (LW, kilograms) and ADG (kilograms per day) according to the following equation: Steers EG = $(0.0557LW^{.75})\ ADG^{1.097}$ (NRC, 1984). Net energy content of the diet for maintenance and gain was calculated assuming a constant fasting heat production (MQ) of $0.077LW^{.75}$ Mcal d^{-1} (Lofgreen and Garret, 1968).The NE values of the diet for maintenance and gain were obtained by means of the quadratic formula: $x = -b \pm \sqrt{b^2 - 4ac}/2a$ where $a = -0.877DMI$, $b = 0.877EM + 0.41DMI + EG$ and $c = -0.41EM$ and $NE_g = 0.877NE_m - 0.41$ (Zinn and Shen, 1998). The trial was analyzed as a randomized complete block design with a 3x3 factorial arrangement of treatments (Hicks, 1973). Fat level effects were tested by means of orthogonal polynomials.

Results and Discussion

Treatment effects on growth performance are shown in Table 2. There were interactions between level of fat and method of supplementation on ADG ($P<0.01$) and DMI ($P<0.05$). Consistent with previous trials (Zinn *et al.*, 1998 and Plascencia *et al.*, 2001), the effects of method of supplementation on steer growth-performance were small when compared at 3 and 6% levels of fat supplementation. However, at the 9% level of supplementation, adding the fat directly to the grain as opposed to the hay increased ($P<0.05$) DMI and weight gain. Apparently, only at this higher level of supplementation does the addition of fat directly to the hay sufficiently coat fiber particles so that the rate of breakdown and digestion is impeded, as hypothesized by Davison and Woods (1960) and Devendra and Lewis (1974). As les digestible bulk accumulates in rumen, feed intake is reduced, decreasing rate of gain.
The interaction of method of fat incorporation into the diet at the 9% level of fat supplementations may not be so much a reflection of level of fat supplementation as it is a reflection of the relative proportion of fat to hay (9:20). In a previous study (Plascencia and Zinn, 2002) the inclusion of a fat:forage blend (20% fat, 80% alfalfa hay) to a steam-flaked corn-based finishing diet for feedlot cattle did not negatively affect energy intake, growth-performance, or fiber digestion, even when the total level of fat supplementation was 9% of dietary DM. However, with respect to the fat-forage interaction, source of forage is also an important consideration. Forages like alfalfa hay, having fragile cell walls, may be less affected by fat supplementation than lesser quality roughages like corn cobs and wheat straw (Erwin *et al.*, 1956 and Johnson and McClure, 1973).
Consistent with previous studies (Haaland *et al.*, 1981 and Zinn, 1994) rate of weight gain, feed intake and feed efficiency decreased (linear effect, $P<0.01$) with increasing levels of fat. Although reported for levels of supplementation as low as 3% (Hatch *et al.*, 1972), the depressing effects of level of fat supplementation on ADG are more notable when level of fat supplementation exceeds 5% (Ngidi *et al.*, 1990 and Zinn, 1994).
There were no treatment interactions ($P>0.20$) on dietary NE. Observed/expected diet NE_m was 1.03 at the 3% level of fat supplementation, declining to 0.90 at the 9% level of fat supplementation. Net energy values for supplemented fat that are greater than tabular values (NRC, 1996) are expected when levels of fat supplementation are less than 4% (Plascencia *et al.*, 2001).
Using the substitution technique, observed/expected dietary NE was related to fat according to the equation: Observed/expected diet NE = 1.09444 - 0.02167fat ($R^2 = 0.98$). Thus, at 4% fat, the NE value of fat corresponds to 100% of its assigned tabular value (NRC, 1996). Assuming that NE_m of fat at 3% level of supplementation was 6.38 Mcal kg^{-1} (Zinn, 1994 and Plascencia *et al.*, 2001), then the corresponding NE_m value of supplemental fat at 6 and 9% levels of supplementation declined by 16 and 43%, respectively (5.33 and 3.66 Mcal kg^{-1}, respectively). In like manner, Zinn (1994) observed that in steers fed a growing-finishing diet containing 22% forage, the NE_m value of supplemental fat decreased by 19 and 53% when fat supplementation was increased from 4% to 8 and 12%, respectively.
The decrease in observed/expected dietary NE with fat supplementation can be directly attributed to the influence of level of supplementation on intestinal fat digestion. Several studies (Palmquist, 1991; Zinn, 1994 and Plascencia *et al.*, 2003) have observed decreased intestinal fatty acid digestion and hence the NE value of fat with increasing fat intake. In a 7-trial summary, Plascencia et al (2003) observed that 89% of the variation in intestinal fat digestion is explained by the equation: Fat digestion, % = 87.56 – 8.59Fat intake, g kg^{-1} BW). Level of total fat intake for the present trial averaged 1.08, 1.59 and 2.08 g kg^{-1} BW for the 3, 6 and 9% fat levels, respectively. Accordingly, expected intestinal fatty acid digestion was 78.3, 73.9 and 69.7%, respectively.

Table 1: Composition of experimental diets

Item	Level of supplemental fat, %		
	3	6	9
Ingredient composition, g kg^{-1} of DM basis			
Alfalfa hay	100	96.7	93.4
Sudan hay	120	116	112.1
Steam-flaked wheat	350.0	338.5	326.8
Steam-flaked com	309	298.9	288.5
Cane molasses	70	67.8	65.4
Tallow fatty acids[a]	30	60	90
Limestone	3	2.9	2.8
Dicalcium phospate	7	7.3	8.1
Urea *	7	8	9.2
TM salt[b]	4	3.9	3.7
Vitamin A[c]	+	+	+
Lasalocid[d]	+	+	+
Nutrient composition (DM basis)			
NE, Mcal kg^{-1}[e]			
Maintenance	2.07	2.19	2.31
Gain	1.41	1.52	1.62
Crude protein, %	12.3	12.3	12.3
Ether extract, %	5.5	8.4	11.3
Calcium, %	0.55	0.55	0.55
Phosphorus, %	0.49	0.48	0.49

[a]Fatty acids profile, % of total myristate, 3.7; palmitate, 29; palmitoleate, 3.7; searate, 19.7; oleate, 39.9; linoleate, 3.9[b]Trace mineral salt contained: $CoSO_4$, .68%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, 1.24%; MnSO4, 1.07%; KI, 0.052% and NaCL, 92.96% [c]2200 UI/kg; [d]30g/T air dry feed. [e]Based on tabular NE values for individual feed ingredients (NRC, 1996).

Table 2: Influence of level and method of fat supplementation on animal performance and net energy value of the diet

Item	Treatments									
	3% Fat			6% Fat			9% Fat			
	On gain	On last	On hay	On grain	On last	On hay	On grain	On last	On say	SD
Pen reps	4	4	4	4	4	4	4	4	4	
weight, kg										
Initial	269	266	264	268	267	265	267	268	268	6.8
Final[a]	470	472	463	458	466	461	438	441	433	13.2
ADG, kg[ab]	1.35	1.30	1.23	1.18	1.19	1.27	1.06	1.07	0.96	0.10
Daily feed, kg[ac]	7.44	7.21	7.10	6.86	6.74	7.12	6.33	6.53	6.09	0.28
Feed/gain[ad]	5.52	5.54	5.79	5.83	5.69	5.64	5.99	6.21	6.43	0.42
Net energy Mcal kg^{-1}										
Maintenance[de]	2.15	2.16	2.10	2.12	2.17	2.13	2.11	2.07	2.07	0.07
Gain[de]	1.48	1.49	1.43	1.45	1.50	1.46	1.44	1.44	1.40	0.06
Observed/expected diet energy										
Maintenance[a]	1.03	1.04	1.02	0.97	0.99	0.97	0.91	0.89	0.90	0.03
Gain[a]	1.04	1.05	1.01	0.95	0.99	0.96	0.89	0.86	0.86	0.04

[a]Fat level, linear component, P<0.05
[b]fat level by method of supplementation interaction, P<0.05
[c]Fat level by method of supplementation interaction, P<0.01
[d]Fat level by quadratic component, P<0.1
[e]Fat level, linear component, P<0.1

There were no treatment interactions (P>0.10; Table 3) on carcass characteristics. Fat thickness decreased (linear effect, P<0.05) and retail yield increased (P<0.05) with increasing level of fat supplementation. There was a

Table 3: Influence of level and method of tallow fatty acid supplementation on carcass characteristics

	Treatments									
	3% Fat			6% Fat			9% Fat			
Item	On gain	On last	On hay	On grain	On last	On hay	On grain	On last	On say	SD
Animals	24	24	24	24	24	24	24	24	24	
Carcass weight, kg[a]	296	297	292	289	294	290	276	278	273	12.1
Fat thickness, cm[a]	1.14	1.42	1.30	0.99	1.19	1.27	0.84	1.02	0.94	0.22
Rib eye area cm^{2b}	76.7	76.1	75.4	79.9	79.9	79.9	75.4	77.4	76.1	0.83
Retail yield	55.3	54.4	54.8	56.0	55.4	55.2	56.2	55.8	56.0	1.8

[a]Fat level, linear component, $P<0.05$ [b]Fat level, quadratic component, $P<0.05$

quadratic effect ($P<0.05$) of level of fat supplementation on longissimus area, being 5% greater at the 6% fat level than at the 3 or 9% levels. The basis for this is not certain. Generally, increasing fat level increases fat thickness and decreases retail yield (Haaland *et al.*, 1981 and Zinn, 1989a). However, in the present study fat supplementation also had dramatic effects on carcass weight (295, 291 and 276 kg, respectively) and rate of gain (1.29, 1.21 and 1.03, respectively). Because composition of gain is directly affected by empty body weight and rate of gain (NRC, 1984), treatment effects on carcass characteristics are confounded with treatment effects growth performance.

Conclusion

We conclude that the feeding value of fat is proportional to total fatty acid intake. When total dietary fatty acid intake is less than 6% the NE value of fat is consistent with tabular values. At greater dietary fat concentrations, energy intake, average daily gain, and the net energy value of fat will decrease. When the proportion of fat added directly forage is greater than 20% of the fat-forage blend energy intake, and hence, daily weight gain may be depressed. However, there are no associative effects of method of supplementations on the dietary net energy values, even when the level of fat supplementation exceeds 2 g Kg BW^{-1}.

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