



Influence of abomasal infusion of the non-ionic surfactant Tween 80 on postruminal fatty acids digestion in steers fed a fat-supplemented, high-energy diet

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Current standards for the NE_m and NE_g values of supplemental fats are 6.00 and 4.50 Mcal/kg (NRC 1996). Estimates based on these values are consistent with empirically derived measures if total fatty acid intake do not exceed 0.86 g/kg of BW (Plascencia *et al.* 2003). When fatty acid intake exceeds 0.86 g/kg of BW, the NE value of fat declines (Zinn and Plascencia 2007) attributable to decrease post-ruminal fatty acid digestion, mainly stearic and palmitic acids (Zinn 1994, Plascencia *et al.* 2003). On increasing level of fat supplementation, the bile: lipid ratio or emulsification capacity of intestinal chyme decreases (Plascencia *et al.* 2004). Polyoxyethylene sorbitan monooleate (Tween 80, TW), a non-ionic surfactant, has an HLB (hydrophile-lipophile balance) value of 15, almost 2-fold HLB value than natural soy lecithin (~8, McClements 2004). Compounds with HLB values greater than 12, act as oil-in water-emulsifier. Thus, TW may have potential as feed additive in ruminant diets to promote intestinal fatty acid absorption. The objective of this experiment was to evaluate the influence of varying levels of abomasal infusion of TW post-ruminal fatty acids digestion and DE value of a high-fat finishing diet fed to steers.

Four Holstein steers (171±8 kg) with T-type duodenal (6 cm of pyloric sphincter) and abomasal (fundic region) cannulas were used in a 4 × 4 latin square design experiment. Steers were maintained in slotted-floor pens (6.2 m²) with *ad lib.* access to water. The basal diet, containing (DM basis, g/kg): alfalfa hay, 80; sudangrass hay, 40; SF corn, 713; yellow grease, 60; cane molasses, 60; urea, 11, mineral

supplement 32 and 4 g of chromic oxide as digesta marker, was formulated for the feeding to steers. Calculated composition, DM basis (NRC 1996) was: CP, 131 g/kg; EN_m, 2.34 Mcal/kg, ether extract, 93 g/kg, calcium, 70 g/kg, and phosphorus, 2.7 g/kg. Composition of the yellow grease (YG) used in this study was similar to the standards set by American Fats and Oils Association (AFOA 1988), and was very similar to with those used in previous studies (Plascencia *et al.* 2003, 2004). Dry matter intake was restricted to 4.3 kg/day fed in equal portions at 0800 and 2000 h daily. Dietary treatments were prepared by transferring 0, 10.75, 21.50 or 32.25 mL of TW (Polysorbate 80) to a 2 litre volume flask and diluting to volume with water. Treatments were infused into abomasum via the cannula at a continuous rate of 90 mL/h using a variable flow peristaltic pump providing 0, 2.5, 5.0 or 7.5 mL of TW/kg of basal diet fed. Infusing tubing (3.1 mm d.i. × 5.1 m) was moored at the ceiling above each pen using 1 m lengths of 6.3 mm latex tubing to provide constant tension, permitting the free movement of steers during treatment infusion. The trial consisted of four 10-day periods. Each period was divided in 2 phases: the first 3-day was the non-infusion phase. The infusion phase began on day 4 and continued through day 10. Samples were taken twice daily on day 7 to day 10 as follow: day 7, 0750 and 1350; day 8, 0900 and 1500; day 9, 1050 and 1650; and day 10, 1200 and 1800 h. Individual samples consisted of approximately 500 mL duodenal chyme and 200 g (wet basis) of fecal material. Samples from each steer and within each collection period were composited for analysis. Samples were subjected to all or part of the following analysis: DM (oven drying at 105 °C until no further weight loss; AOAC 1986); ash (AOAC 1986); gross energy (GE; adiabatic calorimeter bomb); chromic oxide (Hill and Anderson 1958) and fatty acids (GC, one-step transesterification method with C17: 0 as internal standard, Sukhija and Palmquist 1988). The data were analyzed using GML procedures based in a model for 4×4 latin square experimental design. Treatment effects were

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Table 1. Effect of different levels of abomasally infused Tween 80 on fatty acid digestion in Holstein steers

Item	Tween 80 (ml/kg of diet)				SEM
	0	2.5	5	7.5	
Intake, g/d					
DM	3,732	3,730	3,749	3,727	
c16: 0	92.3	92.2	92.7	92.1	
c18: 0	30.5	30.5	30.6	30.5	
c18: 1	135.7	135.7	136.4	135.5	
c18: 2	27.9	27.9	28.0	27.8	
TFA	290.9	290.7	292.2	290.5	
EG, Mcal/d	17.80	17.79	17.88	17.77	
Flow to duodenum, g/d					
c16: 0	51.7	56.9	55.0	56.4	1.6
c18: 0	183.5	187.1	200.3	198.0	6.4
c18: 1	50.9	57.7	45.0	50.4	5.4
c18: 2	8.4	9.3	8.2	8.2	1.2
TFA	295.6	310.9	308.5	313.0	8.5
Fecal excretion, g/d					
c16: 0	11.4	11.4	10.4	10.0	0.89
c18: 0	59.4	59.9	61.6	62.4	5.56
c18: 1	7.6	8.5	6.6	7.1	1.20
c18: 2	1.3	1.7	1.4	1.4	0.10
TFA	79.7	81.4	80.0	80.9	6.70
EG, Mcal/d	4.01	3.90	3.91	3.91	0.10
Postruminal digestion,%					
c16: 0	78.17	79.97	81.08	81.99	1.90
c18: 0	68.14	68.65	69.20	68.51	2.98
c18: 1	84.99	83.76	85.39	85.52	2.39
c18: 2	84.31	82.89	82.57	81.49	3.10
TFA	73.11	73.76	74.06	73.93	2.65
Digestible energy					
DE,%	77.61	78.06	78.12	77.97	0.87
DE, Mcal/kg	3.70	3.72	3.73	3.72	0.41

tested by means of orthogonal polynomials and differences were considered to be significant when $P \leq 0.05$.

There were no treatment effects (Table 1, $P < 0.05$) on post-ruminal FA digestion, averaging 80.3, 68.6, 84.9 and 82.8% for C16: 0, C18: 0, C18: 1 and C18: 2, respectively. The greater (15%) post-ruminal digestion of C16: 0 vs C18: 0 is consistent with the concept that intestinal digestion of saturated fatty acids decreases with increasing chain length (Zinn 1989). Ruminal biohydrogenation was extensive as evidenced by the large contribution of C18: 0 fatty acid (62.7% of total fatty acid) flow to the small intestine, whereas, it makes only 10.5% of fatty acid intake. Total FA digestion averaged 73.7%, in close agreement with predicted (72.9%) based on level of FA intake (FA digestion, % = $87.56 - 8.591 \text{FA intake g/kg BW}$; Plascencia *et al.* 2003). There were no treatment effects ($P < 0.05$) on dietary DE.

Basis for the lack of exogenous surfactant effects on FA digestion is uncertain. The critical micelle concentration value for TW is from 0.01 to 0.016 (Bendikiene *et al.* 2008). Thus, the dosage used in the present experiment were 0.037,

0.074 and 0.111 mL TW/g of FA intake, respectively, doses of TW as low as 0.01 mL/L are expected to have appreciable emulsification potential (Jiao and Burgess 2002). Furthermore, Kan *et al.* (1999) observed a synergistic effect of phosphatidylcholine (main component of bile salts) and TW. However, Simões *et al.* (2005) determined *in vitro* that TW, depending on amphipath (amphiphile) concentrations, requires considerable time (up to several hours) to disintegrated lipid membranes. In as much as transit time of chyme in the small intestine of cattle is relatively short (180 min; Gonzalez *et al.* 2003), it may have limited the effectiveness of TW.

Supplementation with soy lecithin (a natural emulsifier) in low (~3.7% of FA; Jenkins and Fotouhi 1990) and high (~8%; Zinn 1989) fat supplemented diets has likewise failed to enhance FA digestion. However, lecithin undergoes extensive ruminal degradation (Jenkins and Fotouhi 1990). Furthermore, Enjalbert *et al.* (2000) observed that pre-emulsification of fatty acids with 0.025% before direct duodenal infusion did not improve intestinal fatty acid digestion.

It is concluded that, the infusion of up to 7.5 ml of Tween 80/kg of diet appeared to be insufficient to obtained a properly degree of emulsification to increase post-ruminal FA digestion of high-fat diets (93 g of fat/kg diet, DM basis).

SUMMARY

Four Holstein steers were used in a 4×4 latin square experiment to evaluate the potential benefits of the surfactant Tween 80 on intestinally fatty acids digestion. Tween 80 was infused continuously into the abomasum @ 0, 2.5, 5.0 and 7.5 mL/kg of a basal diet containing 93 g lipid/kg (DM basis). There were no treatment effects on post-ruminal digestion of FA and dietary DE. It is concluded that, the infusion of up to 7.5 mL of Tween 80/kg of diet appeared to be insufficient to obtained a properly degree of emulsification to increase post-ruminal FA digestion of high-fat diets (93 g of fat/kg diet, DM basis).

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