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ARTICLE

Grease trap waste (griddle grease) as a feed ingredient for finishing lambs: growth performance, dietary energetics, and carcass characteristics

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Abstract: Forty-eight (37.7 ± 3.4 kg, initial shrunk live weight) lambs were used in a 61 d experiment to evaluate the energy value of grease trap waste (GT) at four levels of supplementation (0%, 2%, 4%, and 6%). Supplemental GT replaced cracked corn in the basal diet. The GT contained 6.4% moisture, 3.1% impurities, and 79.8% total fatty acids (FA). Increasing GT level in diets did not affect dry matter intake and daily weight gain but linearly increased gain efficiency and estimated dietary net energy (NE). However, the ratio of observed-to-expected diet NE decreased with increased levels of GT. The estimated NE values for GT based on FA intake were in close agreement (98% and 102% of predicted, respectively) with those NE values determined by replacement technique for 2% and 4% supplementation level. However, the observed NE value for GT supplemented at the 6% level was 9% lower than predicted. Kidney–pelvic–heart fat increased as level of GT supplementation increased; otherwise, carcass characteristics and shoulder composition were not affected. We conclude that GT is a suitable alternative to conventional feed fats in diets for finishing lambs. The estimated NE of GT is 93% the energy value assigned by current standards for tallow and yellow grease.

Key words: recycled fats, dietary energy, finishing lambs, performance, carcass.

Résumé : Quarante-huit agneaux (37,7 ± 3,4 kg, poids corporel initial réduit) ont été utilisés dans une expérience de 61 j afin d'évaluer la valeur d'énergétique des déchets provenant des collecteurs de graisse (GT — « grease trap waste ») à raison de 4 niveaux de supplémentation (0 %, 2 %, 4 %, et 6 %). Les suppléments de GT remplaçaient le maïs concassé dans la diète de base. Le GT contenait 6,4 % d'humidité, 3,1 % d'impuretés, et 79,8 % d'acides gras (FA — « fatty acids ») totaux. Augmenter le niveau de GT dans les diètes n'a pas eu d'effet sur la consommation des matières sèches et le gain de poids quotidien, mais a augmenté de façon linéaire le gain en efficience et l'énergie nette (NE — « net energy ») alimentaire estimée. Par contre, le rapport NE observée à attendue de la diète a diminué avec l'augmentation du niveau de GT. Les valeurs estimées de NE pour le GT selon la consommation de FA avaient une concordance étroite (98 % et 102 % des chiffres prévus, respectivement) avec ces valeurs de NE déterminées par la technique de remplacement pour les niveaux de supplémentation de 2 % et 4 %. Par contre, la valeur de NE observée pour les suppléments de GT à raison de 6 % était 9 % plus faible que prévue. Le gras rein–bassin–cœur a augmenté à mesure que le niveau de supplémentation en GT augmentait; autrement, il n'y a pas eu d'effet sur les caractéristiques de carcasse et la composition de l'épaule. Nous concluons donc que le GT est un choix acceptable aux gras alimentaires traditionnels dans les diètes des agneaux en finition. Le NE estimé du GT est de 93 % de la valeur énergétique assignée selon les normes actuelles pour le suif et la graisse jaune. [Traduit par la Rédaction]

Mots-clés : gras recyclés, énergie alimentaire, agneaux en finition, performance, carcasse.

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Introduction

Due to increasingly stringent environmental regulations, restaurants and cafeterias place traps in the rinse water lines to collect grease (Food Safety and Inspection Services 2016). When recycled separately, this material is commonly referred to as "griddle grease" or grease trap waste (GT). In the United States, an estimated 1.8 billion kg·yr^{-1} of waste fat is recovered as GT (Tran et al. 2016). Grease trap waste has greater concentrations of moisture, impurities, and unsaponifiables [lower total fatty acid (FA) concentration], and approximately threefold greater free FA concentration than conventional feed fat (tallow/yellow grease; Zinn and Plascencia 2007). Some variation in composition of GT is attributable to the process used for GT recovery and the final process applied before distribution (Henriksson 2016). Plascencia et al. (1999) observed that the estimated net energy (NE) value of GT was 88% that of yellow grease when included as 5% of a finishing diet for feedlot. To our knowledge, there are no reported studies that evaluate nutritional characteristics (acceptability and energy value) of GT in finishing diets for feedlot lambs. The objective of this experiment was to evaluate the feeding value of GT in finishing feedlot lambs based on measures of growth performance, estimated dietary NE, and carcass characteristics.

Materials and Methods

Animal management procedures were conducted within the guidelines of locally approved techniques for animal use and care (NOM-062-ZOO-1999). These regulations are in accordance with the principles and specific guidelines presented in the Guidelines for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS 2010).

This experiment was conducted at the Universidad Autónoma de Sinaloa Feedlot Lamb Research Unit, located in the Culiacán, México (24°46′13″N and 107°21′14″W). Culiacán is about 55 m above sea level and has a tropical climate.

Animal, diets, and sample analyses

Forty-eight Pelibuey × Katahdin [21 ± 2 wk of age; 37.7 ± 3.4 kg initial shrunk body weight (SBW)] crossbred intact male lambs were used in a 61 d growth-performance experiment to evaluate a rinse trap griddle grease waste (GT) as a supplemental fat in a corn-based high-energy finishing diet. During the course of the experiment, air temperature averaged 27.8 °C (minimum and maximum of 29.9 and 23.6 °C, respectively) and relative humidity 53% (minimum and maximum of 46.8 and 75.5 °C, respectively). Three weeks before initiation of the experiment, lambs were treated for parasites (Albendaphorte 10%, Animal Health and Welfare, México City, México), injected with 1×10^6 IU vitamin A (Synt-ADE®, Fort Dodge, Animal Health, México City, México) and vaccinated for *Mannheimia haemolityca* (One Shot Pfizer, México City, Mexico). Upon initiation of the experiment, lambs were weighed just prior to the morning meal (electronic scale; TOR REY TIL/S: 107 2691, TOR REY Electronics Inc., Houston, TX, USA), blocked by weight, and assigned within weight groupings to 24 pens (two lambs per pen, six pens per treatment). Pens were 6 m^2 with overhead shade, automatic waterers, and 1 m fence-line feed bunks. Treatments consisted of GT supplementation at levels of 0%, 2%, 4%, and 6% [dry matter (DM) basis; Table 1], with supplemental GT replacing cracked corn in the basal diet. The GT, obtained from an oil recycling company (Acidulados la Tapatía, S.A. de C.V., Guadalajara, México), contained 6.4% moisture, 3.1% impurities, and 79.8% total FA. Dietary treatments were randomly assigned to pens within blocks. Lambs were reweighed prior to the morning meal on day of harvest. Lambs were provided fresh feed twice daily at 0800 and 1400 in a 30:70 proportion (as fed basis), allowing for a feed residual of refusal of ~50 g·kg^{-1} daily feed offering. Feed bunks were visually assessed between 0740 and 0750 each morning, and residual feed was collected and weighed. Feed samples were collected daily and composited weekly for DM analysis (oven-drying at 105 °C until no further weight loss; method 930.15, AOAC 2000).

Feed samples were subjected to the following analyses: DM (oven-drying at 105 °C until no further weight loss; method 930.15, AOAC 2000); crude protein (N × 6.25; method 984.13, AOAC 2000), ether extract (method 920.39, AOAC 2000), and neutral detergent fiber [NDF; Van Soest et al. 1991, corrected for NDF-ash, incorporating heat-stable α-amylase (Ankom Technology, Macedon, NY, USA)]. Chemical composition (moisture, impurities, and total FA) of supplemental fat sources were assayed by Industrial Analyses Laboratory (Culiacán, Sinaloa, México).

Calculations

Average daily gain (ADG) was computed by subtracting the initial SBW (full live weight × 0.96; Cannas et al. 2004) from the final SBW and dividing the result by the number of days on feed. The efficiency of SBW gain was computed by dividing ADG by the daily DM intake (DMI).

The estimations of dietary NE and expected DMI were performed based on the initial and final SBW. The estimation of expected DMI was performed based on observed ADG and average SBW according to the following equation: expected DMI (kg·d^{-1}) = (EM/NE$_m$) + (EG/NE$_g$); where EM (energy required for maintenance, Mcal·d^{-1}) = $0.056 \times SBW^{0.75}$ (NRC 1985); EG (energy gain, Mcal·d^{-1}) = $0.276 \times ADG \times SBW^{0.75}$ (NRC 1985); NE$_m$ (net energy of maintenance) and NE$_g$ (net energy of gain) are the corresponding estimated NE values of each treatment (Table 1; derived from tabular values based on the ingredient composition of the experimental diet; NRC 2007). The coefficient (0.276) was estimated assuming a

Table 1. Dietary composition of experimental diets fed to lambs.

	GT level ($g \cdot kg^{-1}$ of DM)			
Item	0	20	40	60
Ingredient composition ($g \cdot kg^{-1}$ of DM)				
Corn grain cracked	670	650	630	610
Sudangrass hay	80	80	80	80
GT[a]	0	20	40	60
Soybean meal	105	105	105	105
Cane molasses	90	90	90	90
Urea	4	4	4	4
Zeolite	3	3	3	3
Mineralized salt[b]	21	21	21	21
Net energy concentration ($Mcal \cdot kg^{-1}$ of DM)[c]				
EN_m ($Mcal \cdot kg^{-1}$)	1.96	2.04	2.13	2.21
EN_g ($Mcal \cdot kg^{-1}$)	1.33	1.40	1.47	1.54
Nutrient composition ($g \cdot kg^{-1}$ of DM)[d]				
Crude protein	138.5	136.6	134.8	133.5
NDF	140.6	138.5	136.4	134.0
Ether extract	31.0	45.6	62.0	80.2

Note: DM, dry matter; EN_m, net energy of maintenance; EN_g, net energy of gain; NDF, neutral detergent fiber; GT, grease trap waste.

[a]Composition of GT was (%) moisture = 6.48; impurities = 3.05; total fatty acids = 79.80.

[b]Mineralized salt contained calcium, 13.58%; sodium, 7.8%; chlorine, 12.2%; phosphorus, 2.2%; magnesium, 1.0%; potassium, 0.7%; $CoSO_4$, 0.068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; zinc oxide, 1.24%; $MnSO_4$, 1.07%; potassium iodide, 0.052%.

[c]Based on tabular NE values for individual feed ingredients (NRC 2007), including GT, which has an assumed energy value similar than conventional fats.

[d]Dietary composition was determined by analyzing subsamples collected and composited throughout the experiment. Accuracy was ensured by adequate replication with acceptance of mean values that were within 5% of each other.

mature weight of 113 kg for Pelibuey × Katahdin male lambs (Canton and Quintal 2007). Dietary NE was estimated by means of the quadratic formula: $x = (-b - \sqrt{b^2 - 4ac})/2c$; where $x = NE_m$; $a = -0.41$ EM; $b = 0.877$ EM + 0.41 DMI + EG; and $c = -0.877$ DMI (Zinn et al. 2008).

The estimated NE value of supplemental GT was estimated using the replacement technique. Accordingly, the comparative NE_m values for the supplemental GT at 2%, 4%, and 6% levels of substitution were estimated as NE_m ($Mcal \cdot kg^{-1}$) of tested GT = [(EN_m observed for each diet containing supplemental GT − EN_m observed for the control diet)/Y] + 2.23. The divisor (Y) represents the amount of supplemental GT in the diet expressed as 0.02, 0.04, or 0.06, and the constant 2.23 represent the NE_m value of the dry cracked corn replaced (NRC 2007). The NE_g value of supplemental GT was derived from their estimated NE_m (Zinn et al. 2008).

Carcass characteristics

All lambs were harvested on the same day. After humane sacrifice, lambs were skinned and the gastrointestinal organs were separated and weighed. After carcasses (with kidneys and internal fat included) were chilled in a cooler at −2 to 1 °C for 48 h, the following measurements were obtained: (1) back fat thickness perpendicular to the *m. longissimus thoracis* (LM), measured over the center of the ribeye between the 12th and 13th rib; (2) LM surface area, measured using a grid reading of the cross sectional area of the ribeye between 12th and 13th rib; and (3) kidney, pelvic, and heart fat (KPH). The KPH was removed manually from the carcass and then weighed and reported as a percentage of the cold carcass weight (USDA 1982). Shoulders were obtained from the forequarter. The weights of shoulder were subsequently recorded. The shoulder composition was assessed using physical dissection (Luaces et al. 2008).

Statistical analyses

Performance, ADG, DMI, gain efficiency, estimated dietary NE, and carcass data were analyzed as a randomized complete block design using pen as the experimental unit. Treatment effects were tested by means of orthogonal polynomials (Statistix 10, Analytical Software, Tallahassee, FL, USA). Treatment effects were considered significant when $P \leq 0.05$, and tendencies were identified when $P > 0.05$ and ≤ 0.10.

Results and Discussion

Chemical composition of GT is shown as footnote in Table 1. The GT used in the present study had a similar level of impurities (3.0%) to that reported by Plascencia et al. (1999), but it was lower in moisture (0.6% vs. 6.5%) and total FA (79.8% vs. 83.9%). These differences are expected due to plant-to-plant variations in GT recovery process and subsequent handling that affect moisture content (Williams et al. 2012; He et al. 2017). Total FA content is inversely proportional with moisture (Henriksson 2016).

The main objective of this experiment was to evaluate GT as an alternative to conventional supplemental fats used in finishing diets. Due to the limited information about energy value of GT, most comparisons are for conventional fats (i.e., tallow and yellow fat) using energy concepts. The effect of supplemental GT on growth performance and estimated dietary NE are shown in Table 2. Increasing GT level in diets did not affect DMI and ADG. Nevertheless, gain efficiency increased (linear effect, $P < 0.01$) with increasing level of cracked corn substitution with GT. Lack of treatment effects on DMI confirm that supplementation with GT at levels as high as 6% of diet DM does not affect diet acceptability. Likewise, Plascencia et al. (1999) did not observe a negative effect of 5% supplemental GT on DMI of feedlot cattle. The improvement of gain efficiency with GT is consistent with prior studies evaluating conventional

Table 2. Effect of supplementation level of GT on growth performance, dietary energy, and estimated NE.

	GT level (g·kg^{-1} diet DM)					*P* value	
Item	0	20	40	60	SEM	Linear	Quadratic
Days on test	61	61	61	61	—	—	—
Pen replicates	6	6	6	6	—	—	—
LW (kg)[a]							
Initial	37.83	37.65	37.48	37.72	0.331	0.72	0.54
Final	50.48	49.97	50.08	51.79	0.851	0.31	0.21
Average daily gain (kg)	0.207	0.202	0.206	0.230	0.015	0.29	0.34
Dry matter intake (kg·d^{-1})	1.239	1.150	1.135	1.215	0.055	0.73	0.15
Gain to feed (kg·kg^{-1})	0.167	0.176	0.181	0.189	0.005	<0.01	0.76
Observed dietary NE (Mcal·kg^{-1})							
Maintenance	1.96	2.05	2.10	2.12	0.018	<0.01	0.09
Gain	1.31	1.39	1.43	1.45	0.016	<0.01	0.08
Observed to expected dietary NE ratio							
Maintenance	1.00	1.01	0.98	0.96	0.008	<0.01	0.11
Gain	0.98	0.99	0.97	0.94	0.010	0.01	0.86
Observed to expected daily dry matter intake	1.01	1.00	1.02	1.06	0.010	<0.01	0.09
Estimated GT NE (Mcal·kg^{-1})							
Maintenance	—	5.83	5.86	4.99	—	—	—
Gain	—	4.70	4.72	3.97	—	—	—

Note: GT, grease trap waste; NE, net energy; DM, dry matter; SEM, standard error of mean; LW, live weight.
[a]Initial LW was reduced by 4% to adjust for the gastrointestinal fill. Final LW was obtained following an 18 h fast without access to feed (access to drinking water was not restricted).

Table 3. Effect of supplementation level of GT on carcass characteristics of lambs.

	GT (g·kg^{-1} of DM)					*P* value	
Item	0	10	20	30	SEM	Linear	Quadratic
Pen replicates	6	6	6	6	—	—	—
Hot carcass weight (kg)	28.83	28.39	28.65	29.58	0.618	0.37	0.29
Dressing percentage	57.10	56.83	57.21	57.16	0.532	0.81	0.84
LM area (cm)	18.64	19.32	18.60	18.94	1.149	0.97	0.88
Back fat thickness (cm)	0.22	0.23	0.24	0.25	0.017	0.30	0.97
KPH (%)	2.99	3.77	4.33	4.56	0.246	<0.01	0.28
Shoulder composition (%)							
Muscle	66.51	66.20	65.34	66.37	0.018	0.79	0.55
Fat	16.51	16.05	16.27	16.11	0.012	0.85	0.90
Muscle to fat ratio	4.08	4.40	4.13	4.44	0.457	0.69	0.99

Note: GT, grease trap waste; DM, dry matter; SEM, standard error of mean; LM, *m. longissimus thoracis*; KPH, kidney–pelvic–heart fat.

supplemental fats in finishing diets for feedlot cattle (Zinn and Plascencia 2007) and finishing lambs (Bhatt et al. 2013). This improvement is expected, reflecting the increase in dietary energy density with fat supplementation.

Consistent with observed enhancement in gain efficiency, estimated dietary NE increased with increased levels of GT substitution for corn (linear effect, $P < 0.01$). However, the ratio of observed-to-expected diet NE decreased (linear effect, $P < 0.01$) with increased levels of GT. This effect is expected, in as much as the NE value of dietary fat declines in a linear fashion with increased levels of supplementation (Zinn and Plascencia 2007), due to the inverse relationship between level of fat intake and intestinal FA digestion (Plascencia et al. 2004). Plascencia et al. (2003) observed that the NE value of fat was closely associated ($r^2 = 0.89$) with level of FA intake: NE_g (Mcal·kg^{-1}) = [87.56 − 8.59 × FA intake (expressed as g·kg^{-1} live weight)] × 6.03. The average FA intake in the present experiment were 0.96, 1.28, and 1.74 g·kg^{-1} live weight for the 2%, 4%, and 6% levels of supplementation, respectively. Accordingly, the corresponding NE_g value of GT is 4.78, 4.61, and 4.38 Mcal·kg^{-1}, respectively. Using the replacement equation, the estimated NE for maintenance and gain ($Mcal \cdot kg^{-1}$) of supplemental GT are 5.83 and 4.70, 5.86 and 4.72, and 4.99 and 3.97, for 2%, 4%, and 6% supplementation level, respectively (Table 2). Thus, the predicted NE values for GT based on FA intake are in close agreement with observed for the 2% and 4% levels of supplementation (98% and 102% of predicted, respectively). However, the observed NE value for GT supplemented at the 6% level was lower (9%) than predicted. Considering that the NE of maintenance and gain of conventional fats in the current standards (NRC 2007) is 6.3 and 5.1 $Mcal \cdot kg^{-1}$, at moderate levels of supplementation (up to 4%), the NE of supplemental GT is 93% that of conventional feed fat (i.e., tallow and yellow grease). This slightly lower NE value reflects the greater moisture content and hence lower FA concentration of GT.

Effect of supplemental GT on carcass characteristics and shoulder composition are shown in Table 3. The proportion of KPH increased (linear effect, $P < 0.01$) with increased levels of GT supplementation. Otherwise, carcass characteristics and shoulder composition were not affected by GT inclusion. Likewise, Plascencia et al. (1999) observed increased KPH in feedlot cattle supplemented with 5% GT. Bhatt et al. (2011) and Estrada-Angulo et al. (2017) noted increases in carcass fat, including increased proportion of shoulder fat in finishing lambs supplemented up to 6% with vegetable oil (coconut oil or jatropha oil). Increased carcass fat due to supplementation with conventional fats (≥4% supplementation level) has also been commonly observed in feedlot cattle (Zinn 1989; Nelson et al. 2008).

Conclusions

Grease trap waste is a suitable lower cost alternative to conventional feed fats in diets for finishing feedlot lambs. Inclusion of GT does not appear to affect diet acceptability. However, its chemical composition (total FA and moisture content) should be considered. As will all supplemental fats, the NE value of GT is a function of its total FA concentration. The estimated NE of GT is 93% the energy value assigned by current standards (NRC 2007) for tallow and yellow grease.

Conflict of interest

No potential conflict of interest was reported by the authors.

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