Evaluation of the National Research Council (NRC) nutrient requirements for beef cattle: Predicting feedlot performance

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Okine, E. K., McCartney, D. H. and Basarab, J. B. 2003. **Evaluation of the National Research Council (NRC) nutrient requirements for beef cattle: Predicting feedlot performance.** Can. J. Anim. Sci. **83**: 787–792. The accuracy of predicted CowBytes® versus actual dry matter intake (DMI) and average daily gain (ADG) of 407 Hereford × Angus and Charolais × Maine Anjou (445.6 ± 36 kg) feeder cattle using digestable enery acid detergent fiber (DE) estimated from the (ADF) content [Laboratory analysis method (LAB)] and from values determined in vivo (INVIVO method) was examined. The diet consisted of a 73.3% concentrate diet, 22.0% barley silage, 1.6% molasses, and 3.1% feedlot supplement fed ad libitum (as-fed basis). The calculated DE values of the feed were used to predict the metabolizable energy (ME), net energy of maintenance (NE_m), and net energy of gain (NE_g) of the diet. These energy values were then used in CowBytes® to predict dry matter intake (DMI), ADG, and days on feed (DOF) necessary to meet targeted quality grade of AA and weights of 522 and 568 kg for the heifers and steers, respectively. There was no effect of gender and prediction method interaction ($P > 0.10$) on any of the variables measured. There were no ($P > 0.05$) differences in predicted DMI by either the INVIVO or LAB method but both methods underestimated DMI actually consumed by the cattle by 6.8 and 4.9% ($P = 0.007$), respectively. Indeed, regression values from these predictive methods and actual DMI were ($P < 0.05$) different from the one-to-one relationship expected by definition. In spite of the higher actual DMI, the actual ADG of the cattle was 14 and 11% ($P = 0.0004$) lower than was predicted by either the INVIVO or LAB methods. A possible reason for the lower ADG could be an overestimation of DE of the diet. Thus, if available, users of CowBytes® should use actual DMI from their experience in ration formulation. In addition, the effects of environmental temperature on digestibility of diets should be taken into consideration when using the DE of the diet as determined from in vivo digestibility trials or calculated from chemical analyses in determining the DMI of feedlot cattle.

Key words: Beef cattle, performance, CowBytes®, National Research Council

Okine, E. K., McCartney, D. H. et Basarab, J. B. 2003. **Évaluation des recommandations du Conseil national de recherches (CNRC) sur les besoins nutritifs des bovins de boucherie : prévision du rendement en parc d'élevage**. Can. J. Anim. Sci. **83**: 787–792. Les auteurs ont comparé la précision des résultats du programme CowBytes® à l'ingestion de matière sèche (IMS) et du gain quotidien moyen (GQM) réels de 407 bovins d'engrais Hereford × Angus et Charolais × Maine Anjou (445,6 ± 36 kg) établis après estimation de l'énergie digestible calculée selon la teneur en fibres au détergent acide (méthode LAB) ou les valeurs in vivo (méthode INVIVO). La ration examinée se composait à 73,3 % de concentré, à 22,0 % d'ensilage d'orge, à 1,6 % de mélasse et à 3,1 % de supplément pour bovins d'engrais et était servie à satiété (telle quelle). Les chercheurs ont utilisé la quantité d'énergie digestible de l'aliment pour prévoir les valeurs ME, NE_m et NE_g de la ration. Ensuite, ils se sont servis de ces valeurs avec le programme CowBytes® pour prévoir l'IMS, le GQM et la durée de l'engraissement nécessaire pour obtenir une viande de qualité AA et un poids de 522 kg (génisses) ou 568 kg (bouvillons). L'interaction entre le sexe et la méthode de prévision n'a aucune incidence ($P > 0,10$) sur les variables examinées. Il n'y a pas d'écart ($P > 0,05$) entre l'IMS prévue par la méthode INVIVO et la méthode LAB, mais les deux sous-estiment l'IMS réelle des bovins de 6,8 % et de 4,9 % ($P = 0,007$), respectivement. De fait, les valeurs de régression des deux méthodes et l'IMS réelle ne rendent pas ($P <0,05$) la relation d'équivalence que laissait prévoir la définition des méthodes. Malgré une IMS plus élevée, le GQM réel des bovins était de 14 % et de 11 % inférieur ($P = 0,0004$) à la valeur prévue par la méthode INVIVO et la méthode LAB. L'explication réside peut-être dans une surestimation de la quantité d'énergie digestible. Par conséquent, les utilisateurs du programme CowBytes® qui le peuvent devraient se servir de l'IMS réelle issue de leurs expériences pour préparer les rations. En outre, il conviendrait de prendre en compte l'effet de la température ambiante sur la digestibilité des aliments quand on se sert de l'énergie digestible obtenue lors des essais de digestibilité *in vivo* ou celle dérivée des analyses chimiques pour établir l'IMS des bovins dans les parcs d'élevage.

Mots clés: Bovins de boucherie, rendement, CowBytes®, Conseil national de recherches

Abbreviations: **ADF**, acid detergent fiber; **ADG**, average daily gain; **CP**, crude protein; **DE**, digestible energy; **DMI**, dry matter intake; **DOF**, days on feed; **INVIVO**, values determined in vivo; **LAB**, Laboratory analysis method; **ME**, metabolizable energy; **NDF**, neutral detergent fiber; **NE_g**, net energy for gain; **NE_m**, net energy for maintenance

The National Research Council (NRC), in 1996, released a beef model that includes new nutrient requirements for beef cattle based on various descriptions of dynamic variables such as environment, feed, and animal body condition scores. These requirements have been adapted to CowBytes® computer program, a ration-formulating program developed by Alberta Agriculture, Food and Rural Development. The basic difference between the NRC (1996) Level 1 and CowBytes® is a modification table in CowBytes®, which allows users to modify the output of the predictive equations from the NRC model. The NRC and CowBytes® models require accurate estimates of the diet energy and protein (degradable intake and undegradable intake protein) contents in order to predict DMI, feed conversion ratios, and ADG of feedlot cattle (McKinnon et al. 2002). However, there has been limited evaluation of the beef model (Fox et al. 1992; Block et al. 2001). The DE content of diets is routinely predicted from the ADF or bushel weight equations developed by various feed laboratories.

Research results reported by McKinnon et al. (2002) suggested that ADG predicted by the NRC (1996) model using estimated energy values were 20 to 50% below actual gains for growing cattle. Block et al. (2001) evaluated Level 1 and Level 2 of the NRC (1996) and found that the beef model accounted for only 31 and 27% of the variation in actual DMI for finishing cattle for Level 1 and 2, respectively. Both levels of the NRC program predicted values for ADG that were 52 and 86% of the actual values (Block et. al. 2001). However, limit feeding during the backgrounding and subsequent compensatory growth during finishing could have complicated the prediction of ADG reported by Block et al. (2001) and McKinnon et al. (2002). Block et al. (2001) and McKinnon et al. (2002) suggest that the under-prediction of ADG by the NRC (1996) models could be due to the overestimation of net energy of maintenance (NE_m) requirements under cold weather conditions. These authors indicated that there was a need to modify the NRC beef model to account for the overestimation of NE_m, which could then allow the model to be used to accurately predict performance under cold weather conditions. However, in the trials of Block et al. (2001) and McKinnon et al. (2002), the energy values of the rations were estimated from concentrations of ash, ether extract, neutral detergent fiber (NDF), acid detergent insoluble lignin, and acid and neutral detergent insoluble protein of feeds using the summative method of Weiss et al. (1992). Indeed, the beef NRC (1996) recommends that the energy content of feeds be calculated from chemical composition based on the model of Weiss et al. (1992). However, for complete feeds of mixed forage and concentrates the NRC (1996) makes no recommendation, and DE values are still mostly determined from ADF values (Bull 1981). In addition, Corbett and Mathison (1994) reported that in Alberta, both the ADF and summative methods accounted for only 46% of the variation of in vivo DE contents of 87 forage samples and thus these methods could be inadequate predictors of DE of feedstuffs. We hypothesized that improvements in the prediction of DMI, ADG, DOF, and carcass characteristics by the NRC (1996) model would be made by using actual DE values of feeds compared to DE calculated from ADF values of complete feeds (Bull 1981).

The objective of this study was to determine the accuracy of predicted DMI and ADG from CowBytes® versus the actual performance of feedlot cattle using DE estimated from the ADF values of the ration and from DE values determined in vivo.

MATERIALS AND METHODS

Animal Management and Feeding

Feedlot trials were conducted at the Lacombe Research Centre utilizing 407 Hereford × Angus and Charolais × Maine Anjou (445.6 ± 36 kg) feeder steers and heifers from the spring calving herd. The calves were divided into representative and replicated groups according to breed type, gender, and weight groups into 37 pens of 11 animals per pen. Cattle were housed in outdoor pens with protection from the wind with a 20% porosity fence. Cattle were weighed on days 1 and 3 of the trial and the weights were then averaged to obtain the initial test weights. A 4% shrink (NRC 1996) was used to convert live to shrunk weight for calculation based on the DE and NE systems (NRC 1996). All weight and ultrasound backfat measurements were taken every 26 d and were taken in the morning prior to new feed being added to the bunks. The ultrasound measurements were taken with an Aloka 500V diagnostic real time ultrasound machine with a 17-cm 3.5-Mhz linear array transducer (Overseas Monitor Corporation Ltd., Richmond, BC) using procedures described by Brethour (1992). Daily feed consumption and feed refusal were measured on a pen basis. A pen of cattle was slaughtered when the backfat averaged 8 to 10 mm to ensure that greater than 50% of the steers would grade AA at slaughter. The ultrasound backfat endpoints of 6 or 12 mm backfat have been used to specify the grading system (marbling) values of “trace” (1) or “small” (3), respectively (Block et al. 2001; Coleman et al. 1993). Carcass yield, yield grade, marbling score, longissimus thoracis area, grade fat thickness, and lean meat yield data were also collected (Agriculture Canada 1992).

Pen mud depths and animal hide conditions were noted visually during collection of feed samples and used as defaults in the CowBytes® program. Also used in the program were measures of previous and current temperatures, hair depth, and hide thickness as described by the NRC (1996).

Feed Inputs

Cattle were adapted to diets during a 34-d step-up regime. The cattle started ad libitum on an as-fed basis on a diet of 88% barley silage, 10.4% steam-rolled barley grain, and 1.6% feedlot supplement in a total mixed ration, with 30 mg kg^{-1} DM of Monensin (Rumensin 80, Elanco Animal Health, Indianapolis, IN). Over the next 34 d, the cattle were adjusted from the start-up diet to a 73.3% steam-rolled barley grain, 22.0% silage, 1.6% molasses, and 3.1% feedlot supplement with 22 mg kg^{-1} DM of Monensin fed ad libitum (as-fed basis, Table 1). The diet was formulated to meet the NRC (1996) requirements for energy, metabolizable protein, degradable, and undegradable intake protein, for cattle to be slaughtered at AA quality grade (26.8% of body fat; NRC 1996) at market weights of 522 and 568 kg for the heifers and steers, respectively.

Table 1. Composition of the finishing diet offered to cattle

Diet ingredients, (% as fed basis)	
Barley silage (31% DM)	22
Steam-rolled barley	73 . 3
Molasses	1.6
32% beef supplement	3.1
Diet composition^z	
Dry matter (%)	75
Crude protein (%)	12.3
Calcium (%)	0.44
Phosphorus (%)	0.37
ADF (%)	10.7
NDF (%)	23.5

^{z}Diet contained 0.55 mg kg $^{-1}$ Co, 1 mg kg $^{-1}$ I, 13.5 mg kg $^{-1}$ Cu, 42.4 mg kg $^{-1}$ Mn, 48.8 mg kg $^{-1}$ Zn, 4212 IU kg $^{-1}$ vitamin A, 421 IU kg $^{-1}$ vitamin D, 41 IU kg $^{-1}$ vitamin E, and 22 mg kg $^{-1}$ monensin sodium. The beef supplement contained 32% total CP, 11% ECP, P = 0.72%, Ca = 4.5%, Mg = 0.3%, S = 0.4%, Na = 2.0%, K = 0.5%, Co = 4 ppm, I = 20 ppm, Cu = 300 ppm, Mn = 8000 ppm, Zn = 1000 ppm, F = 360 mg kg^{-1}, vitamin A = 100 000 IU kg^{-1} , vitamin D = 10 000 IU kg $^{-1}$, vitamin E = 100 IU kg $^{-1}$.

Prior to the start of the experiment, feed samples were taken three times weekly for 4 wk, pooled and stored frozen until nutrient analysis. In addition monthly samples were taken. All feed samples were ground through a 1-mm screen (Wiley mill, Model no. 4, Arthur H. Thomas Co., Philadelphia, PA) and then analyzed for DM, CP, and ADF (Association of Official Analytical Chemists, 1990). Neutral detergent fiber was determined without the use of sodium sulfite (Van Soest et al. 1991). The ADF values were used to predict DE values of the ration using the equation TDN% = 92.2–1.12 ADF (Van Soest et al. 1979) and 1 kg TDN = 4.4 Mcal kg^{-1} DM (NRC 1996). The calculated DE values of the feed were used to predict the NE$_m$ and NE$_g$ of the diet using calculated ME values (NRC 1996). These energy values were then used in CowBytes® to predict DMI, ADG, and days on feed necessary to meet the targeted grade of AA and 522 and 568 kg for the heifers and steers, respectively. This method was designated as the Laboratory analysis method (LAB).

A digestibility trial was also conducted using six Suffolk sheep at the Metabolic Unit of the University of Alberta to determine the in vivo DE of the diet. The six sheep were gradually brought to full feed over a 3-wk period. After reaching ad libitum intake (5% orts left over), the sheep were put into metabolic crates. Feed intake, orts, and total fecal output were measured on a daily basis for 1 wk. Samples of the feed offered, orts, and feces were taken and composited for each animal. The samples were frozen until analyzed. Samples were dried at 75°C and weighed. Subsamples were then taken and dried at 100°C in a forced-air oven to a constant weight to determine DM. The gross energy in the feed, orts, and fecal samples were determined by bomb calorimetry using an automatically controlled Parr adiabatic calorimeter (Model 141, Parr Instrument Co., Moline, IL). The total intake energy was then adjusted for the energy in the orts. The in vivo DE was then calculated as DE (Mcal kg^{-1} DM) = [actual gross energy intake (Mcal) – actual fecal energy output (Mcal)]/feed intake (kg). This information was used in the method designated as the in vivo method (INVIVO) for predicting performance as indicated for the LAB method.

For both LAB and INVIVO methods, the ME, NE$_m$, and NE$_g$ of the diet were calculated from the determined DE using predictive equations (NRC 1996). To account for the effects of environmental temperature of digestibility (NRC 1996), the calculated DE (Mcal kg^{-1} DM) for both the LAB and INVIVO was adjusted using the reported decrease in DM digestibility of 0.18 percentage units per degree drop in temperature from 0°C (Westra and Christopherson 1976).

The third method was based on actual performance, and involved actual feed intake, rate of gain, and slaughter weight, yield and quality grade of the feedlot cattle. This actual performance, information was then used as the standard against which the predicted values from the LAB and INVIVO were compared.

All the animals used in this experiment were cared for under the guidelines of the Canadian Council on Animal Care (1993) under supervision of the Animal Policy and Welfare Committee at the University of Alberta.

Statistical Analysis

All data were analyzed using the General Linear Model Procedure (SAS Institute, Inc. 1996). Descriptive statistics were generated for all variables. Initially, the relationship between actual DMI and predicted DMI were examined by linear and quadratic regression (Draper and Smith 1988). The differences in DMI among prediction methods were tested using the following model:

$$Y_{ijkl} = \mu + P_i + S_j + PS_{ij} + M_k + PM_{ik} + SM_{jk} + PSM_{ijk} + e_{ijkl},$$

where Y_{ijkl} is the pen mean for a trait, μ is the overall mean, P_i is the *i*th previous feeding regime before entering the feedlot, S_j is the *j*th sex of feeder calves, M_k is the *k*th prediction methods, PS_{ij}, PM_{ik}, SM_{jk} and PSM_{ijk} are the interaction terms, and, e_{ijkl} is the residual error. No evidence of non-linearity was found, as all quadratic effects with predicted DMI were not significant ($P > 0.05$). In addition, the relationship between actual DMI and predicted DMI using the INVIVO method was further examined using the following model:

$$Y_{ijk} = \mu + P_i + S_j + PS_{ij} + \beta_1 INVIVO\ DMI_k + e_{ijk},$$

where Y_{ijk} is the pen mean for a trait; μ is the overall mean, P_i is the *i*th previous feeding regime before entering the feedlot, S_j is the *j*th sex of feeder calves, $\beta_1 INVIVO\ DMI_k$ is the regression of actual DMI on DMI as predicted by in vivo digestibility, PS_{ij} is the interaction term, and e_{ijkl} is the residual error. The relationship between actual DMI and predicted DMI using the LAB values used a similar model except that β_2LAB DMI$_k$ was substituted for β_1INVIVO DMI$_k$. The hypothesis that the regressions of actual versus predicted DMI, ADG, and DOF

Table 2. Means of weights, backfat thickness, diet digestible energy and actual and predicted DMI and ADG of cattle used in feeding trials

Traits	Pens	Mean	SD	Min.	Max.
Initial weight (kg)	37	445.6	36.3	378.9	522.5
Final weight (kg)	37	553.1	44.5	475.5	642.0
Initial back fat thickness (mm)	37	6.2	1.9	2.0	10.0
Final back fat thickness (mm)	37	8.9	2.3	6.0	14.0
Average daily gain in back fat (mm d^{-1})	37	0.044	0.027	0.013	0.114

	Predictive method				
	Actual	INVIVO	LAB	SEM	*P* value
Dry matter intake (kg d^{-1})	10.3*a*	9.6*b*	9.8*b*	0.16	0.0079
Digestible energy of diet (Mcal kg^{-1})	–	3.56	3.50	0.24	1.000
Average daily gain (kg d^{-1})	1.30*b*	1.51*a*	1.46*a*	0.04	0.0004
Days on feed	85	75	78	5.0	0.3798

were equal to the theoretical expectation of 1 was tested using methods described by Basarab et al. (1994).

RESULTS AND DISCUSSION

Analysis of the composite feed samples indicated ADF content (mean ± SEM) of 10.7% ± 1.2; NDF of 23.5% ± 1.6; and CP of 12.3% ± 0.8 (Table 1). Ambient temperatures during the finishing period were mild (–9°C ± 10.8) and there were only a few days when mean ambient temperature dropped below –20°C. Wind speed was not a major factor during the trial, and ranged from 1 to 9 km h^{-1} in an open area away from the sheltered pen. The DE of the diet estimated from the ADF of the ration for the LAB and from the INVIVO methods were 3.51 and 3.56 Mcal kg^{-1} DM, respectively, with no differences in the DE from these two methods. Differences between the DE from these two methods were expected since Corbett and Mathison (1994) reported that the DE was related to the ADF content of forages with an $R^2 = 0.46$ ($P = < 0.001$). Thus, ADF accounts for only 46% of the variation in DE content of feedstuffs. On the other hand, lack of difference between the LAB and INVIVO methods could attest to the accuracy of the equation of Van Soest et al. (1979) for complete diets with high concentrate feeds.

Gender and method of prediction did not affect any of the variables measured ($P > 0.10$). Table 2 shows initial and final weights, backfat thickness, diet DE, actual and predicted DMI, and ADG of cattle on test. The average weight of the cattle at the beginning of the trial was 445.6 kg with an ultrasonic backfat thickness of 6.2 mm. The ultrasound backfat endpoints of 8 to 10 mm backfat were used to specify the quality grade of AA or slight marbling (Block et al. 2001; Coleman et al. 1993). The average backfat thickness at the end of the trial was 8.9 mm with a calculated average daily gain in backfat thickness of 0.044 ± 0.027 mm d^{-1}. There were no ($P > 0.05$) differences in predicted DMI by either the INVIVO or the LAB method, both method underestimated DMI actually consumed by the cattle by 6.8 and 4.9% ($P = 0.0079$) using the DE of the diet from the INVIVO and LAB methods, respectively (Table 2). These results are contrary to those of Block et al. (2001) and McKinnon et al. (2002), who reported that the NRC model predicted accurately or overpredicted actual DMI for finishing cattle by about 2.5%.

Cattle were not implanted, but were fed an ionophore in the present study, and vice versa in those of Block et al. (2001), McKinnon et al. (2002), Rayburn and Fox (1990) and Fox et al. (1992). CowBytes® assumes feeders are implanted, and if not the predicted DMI is decreased by 6% (NRC 1996). In CowBytes®, ionophores are assumed to decrease DMI by 6% and increase NE$_m$ of the diet by 12% (NRC 1996). When an ionophore and implant are used together, DMI is not adjusted, but NE$_m$ of the diet is increased by 12% in CowBytes®. Differences in actual versus predicted DMI by either method could be due to an overestimation of the predicted digestibility relative to that of the diet actually consumed by the cattle. The perceived differences in digestibility are given some credence when one considers that the actual ADG of the cattle was 14 and 11% ($P = 0.0004$, Table 2) lower than was predicted by either the INVIVO or LAB methods. Indeed, the increase of 12% of the NE$_m$ of the diet when one uses an ionophore in CowBytes® would predicate that the NE$_m$ requirements for the cattle would have been met at a lower DMI with a spillover for gain. However, actual DOF were not different ($P = 0.38$) from predicted values and averaged 85 d for the cattle compared to the predicted values of 75 and 78 d for the INVIVO and LAB methods, respectively (Table 2). Lack of differences in DOF when differences existed between actual ADG and INVIVO and LAB estimated ADGs could be due to the high standard error of the mean for DOF.

In our study, we tested whether the regressions differed from 0 ($b = 0$) (Basarab et al. 1994) to indicate whether there was a relationship between actual and predicted values (Table 3). The $b = 0$ regression analyses were all significant ($P = 0.0001$) indicating a relationship between the variables of actual and predicted values. The regression was also tested as to whether it differed from 1 ($b = 1$), which is the theoretical expectation (Basarab et al. 1994). Predicted DMI using the INVIVO or the LAB methods were positively ($P < 0.01$) related to actual intake. A 1-kg change in actual DMI corresponded to a 0.69 ± 0.13 kg ($R^2 = 0.86$; $P = 0.028$) and 0.69 ± 0.14 kg ($R^2 = 0.84$; $P = 0.040$) change

Table 3. Regression (*b*) of actual dry matter intake (DMI) and average daily gain (ADG) on predicted DMI and ADG using the INVIVO and LAB methods to estimate the digestible energy of the diet

			P for Ho		
Prediction method[z]	b value	SE	$b = 0$	$b = 1$[y]	Model R^2
Actual DMI vs. INVIVO	0.69	0.13	0.0001	0.028	0.86
Actual DMI vs. LAB	0.69	0.14	0.0001	0.040	0.84
Actual ADG vs. INVIVO	0.93	0.17	0.0001	0.685	0.77
Actual ADG vs. LAB	0.86	0.19	0.0003	0.471	0.72
Actual DOF vs. INVIVO	1.01	0.13	0.0001	0.940	0.86
Actual DOF vs. LAB	0.89	0.12	0.0001	0.371	0.85

[z] INVIVO, in vivo method used to estimate DE of the diet; LAB, the laboratory method used to estimate DE of the diet from ADF.

[y] The student's t value for the hypothesis Ho: $b = 1$ is calculated as follows: $(1–b)/SE = t$. The probability for t is determined by using the SAS function (1-PROBT(ABS(x),DF)) × 2, where x is the t value and DF is the error degrees of freedom.

in DMI as predicted by the DE estimated from the INVIVO and LAB analysis, respectively. These values are different ($P < 0.05$) from the one-to-one relationship expected by definition. Thus, both the INVIVO and LAB methods explained about 85% of the variation of actual DMI indicating that about 15% of the variation in actual DMI could not be explained by either the INVIVO or the LAB method. On the other hand, regressions using the INVIVO data of DE of the diet on ADG and DOF indicated a relationship of 0.93 ($R^2 = 0.77$, $P = 0.69$) for ADG and 1.0 ($R^2 = 0.86$, $P = 0.94$) for DOF, respectively (Table 3). These values are not different ($P > 0.05$) from the one-to-one relationship expected by definition and thus suggest that when one uses the INVIVO DE value of the diet, CowBytes® could predict DOF accurately and would explain only 77% of the variation in ADG of the cattle. Similar relationships were noted for the LAB method where a 1-kg change in actual ADG corresponded to a 0.86 ± 0.19 kg ($R^2 = 0.72$, $P = 0.47$) change in predicted ADG, and a 1-d change in DOF corresponded to a 0.89-d change predicted DOF (Table 3).

These results are contrary to those of Block et al. (2001) who reported that predicted ADG from a method similar to the LAB method accounted for between 46 and 65% of the variation in actual ADG during the finishing phase for cattle. Block et al. (2001) and McKinnon et al. (2002) have suggested that underestimation of efficiency of gain and overestimation of NE_m, especially in a cold environment, by NRC (1996) could account for the poor prediction of ADG and DMI in their experiments. Cattle in the present trial were not exposed to cold stress situations (–9°C), since cattle with an average ADG of 1.1 kg are estimated to be cold stressed between –31°C and –48°C (NRC 1984; Webster 1970). There may be some merit that NRC (1996) may have incorrectly modeled NE_m requirements for cattle since the value of NE_m is increased by about 1% for each 1°C decrease in temperature of previous exposure by the animal. However, the 5% ($P = 0.0079$; Table 2) higher DMI of the cattle relative to the predicted values would suggest that either there was a slight increase in NE_m requirements even at (–9°C) or the increase was due to a decrease in digestibility of the diet.

The INVIVO DE of the diet was determined at ambient temperature and adjusted according to the data from Westra and Christopherson (1976). This approach represents an attempt to adjust for the effects of environmental temperature on the digestibility of the diet (NRC 1996). However, the use of this equation is equivocal since sheep on pelleted diets were used by Westra and Christopherson (1976). Essentially, the digestibility of the diet at 80.6% was reduced by 0.18 units per degree temperature drop from 0 to the mean of –9°C. This in effect reduced the determined DE of the diet from 3.56 to 3.47 Mcal kg^{-1} DM. Assuming that the 3.47 Mcal kg^{-1} DM was applied to actual DMI, the total DE intake of the cattle amounted to 35.7 Mcal d^{-1} compared to 34.2 and 34.3 Mcal d^{-1} for the INVIVO and LAB methods, respectively. However, this increased DE intake did not translate into increased ADG. Indeed, the ADG of the cattle was 1.30 kg d^{-1} compared to 1.51 and 1.46 kg d^{-1} predicted from the INVIVO and LAB methods, respectively. Since the DMI and ADG of the cattle were real (actual) the plausible rationale for the lower ADG could be an even lower digestibility of the diet than the corrected DE from Westra and Christopherson (1976) would suggest.

SUMMARY

The estimated DE of diets from either INVIVO or LAB methods was not accurate when used to predict actual DMI. The regression values from these predictive methods for actual versus predicted DMI are different from the one-to-one relationship expected by definition. Indeed, the INVIVO and LAB methods could not account for 15% of the variation in actual DMI. These differences could be due to an overestimation of the digestibility by both methods compared to that of the diet actually consumed by the cattle. Users of CowBytes® should use actual DMI from their experience in ration formulation if the DMI values are available. We also suggest that attempts should be made to adjust the DE of the diet for environmental temperature effects as determined from in vivo digestibility trials, or calculated from chemical analyses.

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