Supplementary Tables

Table S1. Sum of the absolute difference between observed and predicted milk yield between milk yield equations at different peak milk yield groups in the dairy calf dataset.

Peak Milk Group[1]	NASEM[2]	WOOD	SEM	P-value
2.72 kg/d	3.695	0.518	1.02	0.14
5.44 kg/d	6.982	1.552	1.02	0.01
8.16 kg/d	9.962	2.871	1.02	0.01
10.88 kg/d	10.631	8.395	1.09	0.56
13.6 kg/d	9.603	15.442	1.02	0.01

[1] Peak milk groups are treatment groups used by Abdelsamie [28].
[2] NASEM = milk yield equation from National Academy of Science Engineering and Medicine [2]; WOOD = milk yield equation from Wood [26].

Table S2. Descriptive statistics of the dairy cattle serial slaughter dataset used to evaluate the empty body weight gain equation of the National Academies of Science, Engineering and Medicine [2] and develop a new equation.

Item	N	Mean	SD	Minimum	Maximum
Initial empty body weight, kg	62	82.6	86.9	24.9	345.0
Final empty body weight, kg	62	124.8	108.9	29.3	432.0
Empty body weight, kg	62	103.7	97.6	27.1	388.5
Empty body gain, kg/d	62	0.65	0.25	0.16	1.21
Empty body protein gain, kg/d	62	0.116	0.047	0.031	0.264
Empty body fat gain, kg/d	62	0.137	0.134	0.013	0.680
Retained energy, Mcal/d	62	1.933	1.311	0.437	6.829

Table S3. Evaluation of the empty body weight gain equation of the National Academies of Science, Engineering and Medicine [2] in the dairy cattle serial slaughter dataset.

Item[1]	Preweaning[2]	Postweaning	Overall
CCC	0.314	0.934	0.329
Cb	0.427	0.983	0.514
MB (SD), kg/d	0.470 (0.268)	0.042 (0.090)	0.401 (0.294)
MB, %	75.62	5.14	61.47
Intercept ± SE	0.1317 ± 0.0677	0.0716 ± 0.0902	0.2128 ± 0.0724
Slope ± SE	0.4488 ± 0.0585	0.8673 ± 0.1006	0.4173 ± 0.0646
Pr > F	<0.0001	0.1941	<0.0001

[1] CCC = concordance correlation coefficient; Cb = bias correction factor; MB = mean bias; Intercept = intercept coefficient of linear regression of observed on predicted values; Slope = slope coefficient of linear regression of observed on predicted values; Pr > F = p-value for linear hypothesis test.
[2] Preweaning = < 200 kg final empty body weight; Postweaning = > 200kg initial empty body weight.

Table S4. Significance of model coefficients and fit statistics for equations developed to predict empty body weight gain in the dairy cattle serial slaughter dataset.

Model[1]	P-value (a)	P-value (b)	P-value (c)	AIC[2]
Eq1	<0.0001	<0.0001	-	-59.39
Eq2	0.0003	<0.0001	-	-23.34
Eq3	<0.0001	<0.0001	<0.0001	-88.92
Eq4	<0.0001	<0.0001	-	-109.10
Eq5	<0.0001	<0.0001	-	-90.14
Eq6	0.0009	<0.0001	0.0291	-109.16

[1] Eq1 = $a \times RE^b$ fixed effect model; Eq2 = $a \times (RE/EBW^{.75})^b$ fixed effect model; Eq3 = $a \times RE^b \times EBW^c$ fixed effect model; Eq4 = $a \times RE^b$ mixed effect model; Eq5 = $a \times (RE/EBW^{.75})^b$ mixed effect model; Eq6 = $a \times RE^b \times EBW^c$ mixed effect model
[2] AIC = Akaike Information Criteria

Table S5. Cross validation of the final mixed effect equation (EBG = a×RE^b×EBW^c) to predict empty body weight gain in the dairy cattle serial slaughter dataset[1].

Item[2]	Value
RMSE (SD), kg/d	0.060 (0.027)
R^2 (SD)	0.825 (0.149)
Mean absolute error (SD), kg/d	0.050 (0.025)
Intercept ± SE	-0.0071 ± 0.0229
Slope ± SE	1.0093 ± 0.0321

[1] EBG = empty body weight gain, kg/d; RE = retained energy, Mcal/d; EBW = empty body weight, kg; a = 0.78621 ± 0.24082, p = 0.0009; b = 0.78512 ± 0.06029, p = <0.0001; c = -0.14361 ± 0.07423, p = 0.0291.
[2] RMSE = root mean square error; SD = standard deviation; R^2 = coefficient of determination; Intercept = intercept coefficient of linear regression of observed on predicted empty body gain; SE = standard error; Slope = slope coefficient of linear regression of observed on predicted empty body gain

Table S6. Descriptive statistics of the forage in vitro/in vivo digestibility dataset used to develop and evaluate forage digestibility equation.

Item[1]	N	Mean	SD	Minimum	Maximum
Crude protein, %	112	10.27	4.59	3.60	23.20
NDF[1], %	82	67.50	9.77	42.80	86.41
ADF, %	79	41.12	6.44	30.30	54.60
IVDMD, %	149	57.69	9.23	30.60	81.60
IVOMD, %	56	54.22	10.09	33.20	82.90
DMD, %	142	56.66	7.85	27.30	76.00
OMD, %	52	56.17	10.93	29.20	83.00

[1] NDF = neutral detergent fiber; ADF = acid detergent fiber; IVDMD = in vitro dry matter digestibility; IVOMD = in vitro organic matter digestibility; DMD = in vivo dry matter digestibility; OMD = in vivo organic matter digestibility

Table S7. Evaluation of in vitro versus in vivo digestibility in the forage digestibility dataset.

Item[1]	DMD	OMD
N	127	40
CCC	0.495	0.887
Cb	0.966	0.976
MB (SD), % units	-1.582 (7.757)	2.263 (4.590)
MB, %	-2.75	3.97
Intercept ± SE	31.7540 ± 3.8753	9.4319 ± 3.6123
Slope ± SE	0.4339 ± 0.0652	0.8691 ± 0.0647
Pr > F	< 0.0001	0.0021

[1] DMD = In vitro vs. in vivo dry matter digestibility; OMD = in vitro vs. in vivo organic matter digestibility; N = number of observations; CCC = concordance correlation coefficient; Cb = bias correction factor; MB = mean bias; SD = standard deviation; Intercept = intercept coefficient of linear regression of observed on predicted values; SE = standard error; Slope = slope coefficient of linear regression of observed on predicted values; Pr > F = p-value for linear hypothesis test.

Table S8. Evaluation of dry versus organic matter digestibility in the forage digestibility dataset.

Item[1]	In vitro	In vivo
N	33	27
CCC	0.901	0.948
Cb	0.960	0.959
MB (SD), % units	2.607 (3.194)	2.525 (1.371)
MB, %	4.78	4.65
Intercept ± SE	6.2582 ± 3.2216	3.3906 ± 1.6176
Slope ± SE	0.9297 ± 0.0611	0.9833 ± 0.0308
Pr > F	0.0002	< 0.0001

[1] In vitro = in vitro dry matter digestibility vs. in vitro organic matter digestibility; In vivo = In vivo dry matter digestibility vs. in vivo organic matter digestibility; N = number of observations; CCC = concordance correlation coefficient; Cb = bias correction factor; MB = mean bias; SD = standard deviation; Intercept = intercept coefficient of linear regression of observed on predicted values; SE = standard error; Slope = slope coefficient of linear regression of observed on predicted values; Pr > F = p-value for linear hypothesis test.

Table S9. Published equations evaluated to predict in vivo dry matter digestibility from in vitro dry matter digestibility in the forage digestibility dataset.

Equation No.	Study	Equation[1]
1	Tilley and Terry [30]	DMD = 0.99 × IVDMD – 1.01
2	McLeod and Minson [36]	DMD = 1.0 × IVDMD + 0.5
3	McLeod and Minson [36]	DMD = 0.83 × IVDMD + 11.8
4	McLeod and Minson [36]	DMD = 0.73 × IVDMD + 18.3
5	Terry et al. [37]	DMD = 1.02 × IVDMD – 0.41
6	Terry et al. [37]	DMD = 0.89 × IVDMD + 8.79
7	Goldman et al. [38]	DMD = 0.933 × IVDMD + 1.48
8	Genizi et al. [39]	DMD = 0.896 × IVDMD + 4.4
9	Genizi et al. [39]	DMD = 0.856 × IVDMD + 5.9
10	Genizi et al. [39]	DMD = 0.889 × IVDMD + 4.2
11	Genizi et al. [39]	DMD = 0.771 × IVDMD + 17.3
12	Carro et al. [40]	DMD = 0.788 × IVDMD + 15.8
13	Khazaal et al. [41]	DMD = 0.3 × IVDMD + 41.5
14	Geisert [42]	DMD = 1.1626 × IVDMD – 15.5

[1] DMD = in vivo dry matter digestibility, %; IVDMD = in vitro dry matter digestibility, %

Table S10. Evaluation of published equations to predict in vivo DMD from in vitro DMD in the forage digestibility dataset.

Equation[1]	CCC[2]	Cb	MB (SD), % units	MB, %	Intercept ± SE	Slope ± SE	Pr > F
1	0.515	0.987	0.039 (7.650)	0.07	31.7326 ± 3.7412	0.4458 ± 0.0647	< 0.0001
2	0.497	0.953	-2.058 (7.701)	-3.61	31.0617 ± 3.8376	0.4413 ± 0.0641	< 0.0001
3	0.468	0.897	-3.365 (6.917)	-5.89	25.0083 ± 4.7097	0.5317 ± 0.0772	< 0.0001
4	0.437	0.838	-3.987 (6.560)	-6.99	20.2194 ± 5.4013	0.6045 ± 0.0878	< 0.0001
5	0.491	0.942	-2.325 (7.805)	-4.07	31.4598 ± 3.7804	0.4327 ± 0.0628	< 0.0001
6	0.456	0.875	-3.882 (7.171)	-6.80	26.9238 ± 4.4335	0.4958 ± 0.0720	< 0.0001
7	0.515	0.988	0.900 (7.369)	1.58	30.5823 ± 3.9066	0.4730 ± 0.0687	< 0.0001
8	0.520	0.998	0.155 (7.198)	0.27	29.1152 ± 4.1177	0.4925 ± 0.0715	< 0.0001
9	0.516	0.990	1.006 (7.024)	1.76	28.2406 ± 4.2437	0.5155 ± 0.0749	<0.0001
10	0.518	0.993	0.767 (7.167)	1.34	29.1974 ± 4.1059	0.4964 ± 0.0721	< 0.0001
11	0.395	0.757	-5.397 (6.696)	-9.45	21.3801 ± 5.2336	0.5724 ± 0.0831	< 0.0001
12	0.415	0.795	-4.896 (6.757)	-8.58	22.4338 ± 5.0814	0.5600 ± 0.0813	< 0.0001
13	0.309	0.592	-1.911 (6.207)	-3.35	-29.7655 ± 12.6457	1.4710 ± 0.2137	0.0003
14	0.438	0.841	4.384 (8.609)	7.68	37.1660 ± 2.9624	0.3796 ± 0.0551	< 0.0001

[1] Equation number refers to the Equation No. in Table S9.

[2] CCC = concordance correlation coefficient; Cb = bias correction factor; MB = mean bias; SD = standard deviation; Intercept = intercept coefficient of linear regression of observed on predicted values; SE = standard error; Slope = slope coefficient of linear regression of observed on predicted values; Pr > F = p-value for linear hypothesis test.

Table S11. Cross validation of the final equation (OMD = a + b × IVDMD) to predict in vivo organic matter digestibility in the forage digestibility dataset[1].

Item[2]	Value
RMSE, % units	3.087
R^2	0.8706
Mean absolute error, % units	2.547
Intercept ± SE	0.0000 ± 5.0460
Slope ± SE	1.0000 ± 0.08636

[1] OMD = in vivo organic matter digestibility, %; IVDMD = in vitro dry matter digestibility, % a = 7.7718 ± 4.3825, p = 0.0979; b = 0.8937 ± 0.0772, p = <0.0001.

[2] RMSE = root mean square error; R^2 = coefficient of determination; Intercept = intercept coefficient of linear regression of observed on predicted empty body gain; SE = standard error; Slope = slope coefficient of linear regression of observed on predicted empty body gain

Table S12. Descriptive statistics of the milk composition dataset used to develop milk energy equation.

Item	N	Mean	SD	Minimum	Maximum
Yield, kg/d	125	7.37	2.06	2.52	12.70
Days in milk, d	125	100.4	49.9	7	225
Fat, %	125	4.65	1.43	1.15	6.83
Protein, %	125	3.32	0.33	2.70	4.17
Lactose, %	125	4.90	0.25	4.17	5.26
Energy, Mcal/kg	125	0.82	0.14	0.49	1.03

Table S13. Regression coefficients (±SE), least square means, and fit statistics for mixed model equations developed to predict milk composition in beef cows.

Item[1]	Fat (%)	Protein (%)	Lactose (%)	Energy (Mcal/kg)
Intercept	3.832 ± 0.375*	3.867 ± 0.183*	4.485 ± 0.0102*	0.7285 ± 0.0372*
Yield	-	-0.089 ± 0.019*	0.039 ± 0.010*	-
DIM	0.0056 ± 0.0011*	0.001 ± 0.0005*	-	0.00070 ± 0.00016*
Yield × DIM	-0.0011 ± 0.0002*	-	-	-0.00012 ± 0.00003*
Breed means				
Taurus	3.57[a]	3.29	4.79	0.709[a]
Taurus cross	3.48[ab]	3.34	4.79	0.702[ab]
Zebu	4.12[b]	3.23	4.95	0.766[b]
Zebu cross	3.69[ab]	3.36	4.80	0.727[ab]
Method means				
Machine	3.73	3.33	4.82	0.730
Weigh-suckle-weigh	3.70	3.28	4.85	0.722
RMSE	0.348	0.197	0.117	0.039
AIC	211.9	40.7	-86.3	-308.8
Adjusted fixed R^2	0.528	0.446	0.269	0.497

[1] Yield = daily milk yield, kg/d; DIM = days in milk, d; Breed = beef cow breed type categories; Method = method of measuring milk yield; RMSE = root mean square error; AIC = Akaike Information Criteria; Adjusted R^2 = coefficient of determination adjusted to remove variation associated with random effects

* Regression coefficient is significantly different from zero at $P \leq 0.05$.

[ab] LSMeans without a common superscript in the same column and predictor variable differ at $P \leq 0.05$.

Table S14. Cross validation of the final mixed effect models to predict milk composition in beef cows.

Item[1]	Fat (%)	Protein (%)	Lactose (%)	Energy (Mcal/kg)
RMSE (SD)	0.266 (0.172)	0.167 (0.122)	0.103 (0.100)	0.034 (0.022)
R^2 (SD)	0.538 (0.361)	0.504 (0.351)	0.317 (0.295)	0.497 (0.348)
Mean absolute error (SD)	0.220 (0.139)	0.140 (0.115)	0.093 (0.100)	0.029 (0.019)
Intercept ± SE	-0.033 ± 0.111	-0.164 ± 0.231	-0.144 ± 0.242	-0.008 ± 0.022
Slope ± SE	1.007 ± 0.023	1.049 ± 0.069	1.029 ± 0.049	1.009 ± 0.027

[1] RMSE = root mean square error; SD = standard deviation; R^2 = coefficient of determination; Intercept = intercept coefficient of linear regression of observed on predicted empty body gain; SE = standard error; Slope = slope coefficient of linear regression of observed on predicted empty body gain

Table S15. Descriptive statistics of the beef cattle serial slaughter dataset used to evaluate the empty body weight gain equation of the National Academies of Science, Engineering and Medicine [2] and develop a new equation.

Item	N	Mean	SD	Minimum	Maximum
Initial empty body weight, kg	170	266.3	64.7	31.2	491.8
Final empty body weight, kg	170	419.6	94.2	143.0	617.7
Empty body weight, kg	170	342.9	71.8	94.4	523.9
Empty body gain, kg/d	170	1.03	0.43	0.09	2.21
Empty body protein gain, kg/d	170	0.145	0.079	-0.013	0.513
Empty body fat gain, kg/d	170	0.397	0.194	0.024	0.913
Retained energy, Mcal/d	170	4.54	2.10	0.54	9.98

Table S16. Evaluation of the empty body weight gain equation of the National Academies of Science, Engineering and Medicine [2] in the beef cattle serial slaughter dataset.

Item[1]	Preweaning	Postweaning	Overall
CCC	0.843	0.770	0.777
Cb	0.876	0.913	0.920
MB (SD), kg/d	0.142 (0.124)	-0.152 (0.227)	-0.139 (0.231)
MB, %	24.33	-14.46	-13.56
Intercept ± SE	-0.3218 ± 0.1213	0.1349 ± 0.0490	0.1036 ± 0.0487
Slope ± SE	1.2477 ± 0.1568	1.0186 ± 0.0510	1.0404 ± 0.0509
Pr > F	0.0360	< 0.0001	< 0.0001

[1] Preweaning = observations with < 200 kg final empty body weight; Postweaning = observations with > 200 kg initial empty body weight; CCC = concordance correlation coefficient; Cb = bias correction factor; MB = mean bias; SD = standard deviation; Intercept = intercept coefficient of linear regression of observed on predicted values; SE = standard error; Slope = slope coefficient of linear regression of observed on predicted values; Pr > F = p-value for linear hypothesis test.

Table S17. Fit statistics for equations developed to predict empty body weight gain (kg/d) in beef cattle serial slaughter dataset.

Equation[1]	P-value (a)[2]	P-value (b)	P-value (c)	AIC
1	< 0.0001	< 0.0001	-	-92.81
2	< 0.0001	< 0.0001	-	-12.18
3	0.0343	< 0.0001	0.0351	-95.00
4	< 0.0001	< 0.0001	-	-139.36
5	< 0.0001	< 0.0001	-	-95.51
6	0.0076	< 0.0001	< 0.0001	-66.25

[1] Eq1 = $a \times RE^b$ fixed effect model; Eq2 = $a \times (RE/EBW^{.75})^b$ fixed effect model; Eq3 = $a \times RE^b \times EBW^c$ fixed effect model; Eq4 = $a \times RE^b$ mixed effect model; Eq5 = $a \times (RE/EBW^{.75})^b$ mixed effect model; Eq6 = $a \times RE^b \times EBW^c$ mixed effect model; RE = retained energy, Mcal/d; EBW = empty body weight, kg.

[2] a = intercept coefficient; b = exponent for RE; c = exponent for EBW.

Table S18. Cross validation of the final mixed effect equation ($EBG = a \times (RE/EBW^{.75})^{b}$) to predict empty body weight gain in the beef cattle serial slaughter dataset[1].

Item[2]	Value
RMSE (SD), kg/d	0.115 (0.071)
R^2 (SD)	0.777 (0.269)
Mean absolute error (SD), kg/d	0.099 (0.066)
Intercept ± SE	-0.0035 ± 0.0311
Slope ± SE	1.0031 ± 0.0294

[1] EBG = empty body weight gain, kg/d; RE = retained energy, Mcal/d; EBW = empty body weight, kg; a = 7.92787 ± 0.82538, p = < 0.0001; b = 0.70834 ± 0.03853, p = < 0.0001.

[2] RMSE = root mean square error; SD = standard deviation; R^2 = coefficient of determination; Intercept = intercept coefficient of linear regression of observed on predicted empty body gain; SE = standard error; Slope = slope coefficient of linear regression of observed on predicted empty body gain.