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STUDIES ON THE FEASIBILITY OF PREDICTING FEEDLOT PERFORMANCE FROM CERTAIN LABORATORY GRAIN ANALYSES[1,2]

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SUMMARY

Data from 14 cattle feeding trials were utilized to study the relationship between several laboratory analyses and animal feed intake (INTAKE), gain (ADG) and feed efficiency (F/G). Laboratory analyses considered were 6, 12 and 24 hr *in vitro* dry matter disappearance (IV6, IV12, IV24, respectively); *in vitro* gas production in 1 hr and 6 hr (GP1 and GP6, respectively); and degree of gelatinization (GEL). A multiple regression equation with variables for treatment and trial classification, initial weight and the quadratic effect of initial weight was fit to the data. The effect of initial weight was significant for all three performance variables, and the quadratic effect was significant for ADG and F/G. A second model was fit excluding the treatment classification, and the maximum R^2 procedure was utilized to examine how well laboratory analyses accounted for variation among residuals from this second model. More variation was accounted for in the dependent variables F/G (34.96%) and INTAKE (17.81%) than ADG (5.16%) when a combination of all laboratory analyses except GEL was included in the model. Moreover, correlations between residuals of the second model and the laboratory analyses were higher for INTAKE and F/G than ADG and were all negative for INTAKE and F/G, suggesting a negative response in intake and an improved F/G ratio as starch alteration increases. Correlations between the laboratory analyses were generally quite high. This study suggests that no single laboratory analysis considered would be useful for the development of accurate, reliable equations for the prediction of feedlot performance, and combinations appear to have value only in the case of F/G and INTAKE.

(**Key Words:** Multiple Regression, Feedlot Performance, Grain Analyses, Beef Cattle.)

INTRODUCTION

Numerous studies involving the feeding value of processed grains in high energy diets for finishing cattle have included laboratory evaluations of the grain. While it appears that laboratory evaluations such as *in vitro* gas production and degree of gelatinization yield valuable information with respect to the effect of processing on the starch fraction of the grain, little information exists on the relationship between laboratory analyses of grain and animal performance.

Albin *et al.* (1966) compared *in vitro* dry matter digestibility (IVDMD) of all concentrate diets with performance of feedlot steers receiving the same diets. Correlation coefficients of .88 and .99 were obtained between IVDMD and feedlot gain and efficiency, respectively. Klett and Ralson (1967) observed significant correlations between 12 and 24 hr IVDMD and *in vitro* digestion of ether extract, dry matter, energy and crude fiber. Kumeno *et al.* (1967) evaluated diets containing concentrates in varying proportions up to 75% of the total diet by a 48 hr IVDMD technique and simultaneous *in vivo* total tract evaluation in sheep. The correlation between IVDMD and *in vivo* DMD (.85) was highly significant. Trei *et al.* (1970) compared *in vitro* gas production by rumen microorganisms and IVDMD in processed grains. A correlation coefficient of .95 was found between gas production and IVDMD.

In this study, multiple regression and correlation analyses involving data from 14 feedlot trials were used in an effort to further investigate the relationship between animal perform-

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ance and laboratory analyses of processed grains. Correlations between the various laboratory analyses were also investigated.

EXPERIMENTAL PROCEDURES

Data from 14 cattle feeding trials involving the evaluation of processed grain were utilized to study the relationship between several laboratory analyses of grains and the feed intake (INTAKE), average daily gain (ADG) and feed efficiency (F/G) of cattle receiving the same grains. INTAKE, ADG and F/G were all expressed as pen averages. The grains, processing methods and other variables involved in the 14 trials are shown in table 1. Laboratory analyses of the grains considered in this study were total *in vitro* dry matter disappearance after 6, 12 and 24 hr (IV6, IV12 and IV24, respectively) incubation periods; *in vitro* gas production after 1 hr and 6 hr (GP1 and GP6, respectively) and degree of gelatinization (GEL). Methods of laboratory analyses have been reported previously by Croka and Wagner (1975b). Laboratory data were collected over a number of years by different individuals using the same procedures at one location. References regarding the data for the 14 feeding trials are as follows: Aimone (1975), Aimone and Wagner (1977a,b), Croka and Wagner (1975a,b,c), Christiansen and Wagner (1974a,b), Martin (1973), and Schneider, (1971).

One hundred and sixty-two pens of cattle varying from three to five animals per pen were used in this study. Information on GEL was available for only 72 pens. One hundred and thirty pens had information pertaining to IV6, IV12, GP1 and GP6. All pens had data available for IV24.

In an effort to remove as much variation as possible due to such factors as trial differences and pen differences in initial weight on test, measures of feedlot performance were first subjected to a regression analysis where the following model was fit:

$$Y = \beta o + \alpha_i + IW\beta_1 + IW^2\beta_2 + \epsilon$$

Where: Y = INTAKE (kg), ADG (kg) or F/G

βo = y intercept

α_i = Treatment-trial classification variable, i = 1, 2, . . ., 45 (14 trials, 45 total treatments)

IW = Initial weight on test in $kg^{.75}$ = $IW^{.75}_{kg}$

TABLE 1. SUMMARY OF FEEDING INFORMATION ABOUT 14 CATTLE FEEDING TRIALS INVOLVED IN THE ANALYSES

Trial	Processing method	Type of grain	% Grain[a]	Animals per pen	Pens per trt.	Length of trial, days	Sex
1	Dry rolled	Barley[c]	84	3	4	88	♂
	Reconstituted-rolled	Barley	84	3	4	88	♂
	High moisture	Barley	84	3	4	88	♂
2	Dry rolled	Sorghum[d]	84	5	2	114	♀
	38% H_2O–10 day storage	Sorghum	84	5	2	114	♀
	38% H_2O–20 day storage	Sorghum	84	5	2	114	♀
	30% H_2O–10 day storage	Sorghum	84	5	2	114	♀
	30% H_2O–20 day storage	Sorghum	84	5	2	114	♀
3	Dry rolled	Barley[e]	84	4	6	110	♂
	Reconstituted-rolled	Barley	84	4	6	110	♂
4	Dry rolled	Wheat	85	3	6	171	♂
	Micronized	Wheat	85	3	6	171	♂

5	Dry rolled	Wheat	85	3	5	112	♂
	Micronized	Wheat	85	3	5	112	♂
6	Dry rolled	Wheat[b]	70 (88.6)	4	4	129	♀
	Whole recon	Wheat[b]	70 (88.6)	4	4	129	♀
	Whole recon, rolled	Wheat[b]	70 (88.6)	4	4	129	♀
7	Dry rolled	Sorghum	84	4	3	136	♀
	Dry rolled	Wheat[b]	70 (88.6)	4	3	136	♀
	Whole recon	Wheat[b]	70 (88.6)	4	3	136	♀
	Rolled recon	Wheat[b]	70 (88.6)	4	3	136	♀
8	Dry rolled	Wheat[b]	70 (88.6)	5	2	137	♂
	Rolled recon	Wheat[b]	70 (88.6)	5	2	137	♂
	Ground recon	Wheat[b]	70 (88.6)	5	2	137	♂
	Whole recon	Wheat[b]	70 (88.6)	5	2	137	♂
9	Dry rolled	Sorghum	84	3	4	150	♀
	Steam flaked	Sorghum	84	3	4	150	♀
	High moisture	Sorghum	84	3	4	150	♀
	HM headchop	Sorghum	94	3	4	150	♀
10	Steam flaked, 6 min	Wheat[b]	70 (85)	3	4	150	♀
	Steam flaked, 12 min	Wheat[b]	70 (85)	3	4	150	♀
	Dry rolled	Wheat[b]	70 (85)	3	4	150	♀
11	Dry rolled	Sorghum	84	3	4	112	♂
	Steam rolled, 15 min	Sorghum	84	3	4	112	♂
	Steam rolled, 25 min	Sorghum	84	3	4	112	♂
	Steam rolled, 35 min	Sorghum	84	3	4	112	♂
	Steam rolled, 45 min	Sorghum	84	3	4	112	♂
12	Dry rolled	Sorghum	80	4	2	150	♂
	Micronized	Sorghum	80	4	2	150	♂
13	Dry rolled	Sorghum	80	4	3	172–207	♂
	Micronized – High GEL	Sorghum	80	4	3	172–207	♂
	Micronized – Med GEL	Sorghum	80	4	3	172–207	♂
	Micronized – Low GEL	Sorghum	80	4	3	172–207	♂
14	Dry rolled	Sorghum	80	3	5	84	♀
	Micronized	Sorghum	80	3	5	84	♀

[a]Percent grain in total ration on dry matter basis.

[b]Rations included 70% wheat plus from 15.0 to 18.6% sorghum. Number in parentheses represents the amount of total grain in the ration.

[c]Barley, grain (4-00-530).

[d]Sorghum, milo, grain (4-04-444).

[e]Wheat, grain (4-05-211).

IW^2 = Quadratic effect of $IW^{.75}_{kg}$ = $(IW^{.75}_{kg})^2$

β_1, β_2 = Partial regression coefficients

ϵ = Random errors

The treatment-trial classification variable (α_i) served to account for variation in trials due to grains, processing method, sex, length of trial, et cetera. Of interest was the effect that differences in initial weight (IW) on test had on measures of performance. Pen average initial weights ranged from 172 to 342 kg which corresponds to 47.4 and 79.4 $kg^{.75}$, respectively.

Importance of the treatment-trial classification variable, initial weight and the quadratic effect of initial weight was verified with the model above for INTAKE, ADG and F/G. The treatment classification was then eliminated from the model resulting in a second model with a trial classification (T_i, i = 1, 2, . . ., 14), IW and IW^2 as follows:

$$Y = \beta o + T_i + IW\beta_1 + IW^2\beta_2 + \epsilon$$

Where: Y = INTAKE (kg), ADG (kg) or F/G

βo = Y intercept

T_i = Trial classification variable, i = 1, 2, . . ., 14

IW = Initial weight on test in $kg^{.75}_{kg}$ = $IW^{.75}_{kg}$

IW^2 = Quadratic effect of $IW^{.75}_{kg}$ = $(IW^{.75}_{kg})^2$

β_1, β_2 = Partial regression coefficients

ϵ = Random errors

Thus, this second model differs from the first one only in that T_i represents the trial classification variable; whereas, α_1 represented the trial and treatment classification variable in the first model.

The data were subjected to multiple regression procedures to determine how well laboratory analyses of grain would substitute for the treatment classification variable in predicting performance for INTAKE, ADG and F/G. These are referred to as predicted values. This was accomplished by fitting the data to the second model and using the maximum R^2 procedure (Service, 1972) with laboratory analyses as independent variables and INTAKE, ADG and F/G residuals as dependent variables. The maximum R^2 procedure looks for the "best" one variable model, the "best" two variable model and so forth. It first finds the one variable model producing the highest R^2 statistic. It then adds the next variable which would yield the greatest increase in R^2. Each of the variables in the model is compared to each variable not in the model. The procedure determines if removing the variable in the model and replacing it with the presently excluded variable would result in an increased R^2. After all comparisons are made, the switch which produces the greatest increase in R^2 is made. Comparisons are made again, and the procedure continues until it finds no switch which will increase R^2. This is considered the "best" two-variable model. A third variable is added, and the process continues.

Residuals (the differences between predicted and observed values) were obtained for the model including T_i, IW and IW^2, and correlations between the residuals and the various laboratory analyses were obtained. Correlations obtained in this manner, therefore, represented correlations between adjusted dependent variables and laboratory analyses of the grains.

RESULTS AND DISCUSSION

Relationships between Initial Weight and Performance. Multiple regression equations with INTAKE, ADG and F/G as dependent variables and treatment-trial classification (α_i), IW and IW^2 as independent variables are shown in table 2. These equations are based on all 162 pens of cattle. It should be pointed out that those equations are not designed as prediction equations since slope and intercept coefficients may vary among treatment-trial classifications. Rather, the equations describe the average response observed over all pens of cattle.

The equation for the dependent variable INTAKE suggests that as IW (recall this is on metabolic body weight basis) increases INTAKE increases in an apparent linear fashion. The regression of INTAKE on IW, IW^2 and α_i accounted for 91.38% of the variation observed in INTAKE in these data. However, the R^2 of the simple linear regression model with α_i (treatment-trial classification variable) alone was 89.47%, indicating its importance relative to the initial weight components. The effect of IW after adjusting for α_i was significant, however ($P<.0001$). As observed with INTAKE, ADG (table 2) increased with increasing IW; however, the quadratic effect of initial weight (IW^2) was significant ($P<.0109$) after adjustment for α_i and IW. This suggests that cattle of

TABLE 2. MULTIPLE REGRESSION EQUATIONS FOR DEPENDENT VARIABLES, INTAKE, ADG, AND F/G. ADJUSTED FOR TREATMENT-TRIAL CLASSIFICATION AND INITIAL WEIGHT EFFECTS

Item	Equation
Intake	$Y = 4.302 + (\alpha_i)^a + .0174\ (IW_{i\,kg}^{.75}) + .0005\ (IW_{i\,kg}^{.75\,b})^2$ $Sy(x) = .4504$ $R^2 = .9138$
ADG	$Y = 3.1797 + (\alpha_i) - .07398\ (IW_{i\,kg}^{.75}) + .0068\ (IW_{i\,kg}^{.75})^2$ $Sy(x) = .1096$ $R^2 = .8393$
F/G	$Y = -7.7505 + (\alpha_i) + .4371\ (IW_{i\,kg}^{.75}) + .0035\ (IW_{i\,kg}^{.75})^2$ $Sy(x) = .4388$ $R^2 = .7872$

[a]Treatment-Trial Classification.
[b]$(IW_{i\,kg}^{.75})^2$ effect nonsignificant (P>.6561).

heavier starting weights gained relatively more rapidly, on a metabolic body weight basis, than those of lighter starting weights in these data. This is likely due to compensatory gain effects in cattle which were older and heavier at the start of the trial. For the variable ADG, the regression on IW, IW^2 and α_i accounted for 83.93% of the observed variation, although α_i alone accounted for 82.44%. Similar results have been reported by Luetingh (1963) in terms of increases in intake and gain with cattle fed concentrate diets at different weights and ages.

For the variable F/G (table 2), the quadratic effect of initial weight was significant (P<.0014) after adjustment for α_i and IW, suggesting cattle of heavy starting weights tended to be more efficient than those of intermediate weights. The reason for this trend is not readily apparent but may be due to compensatory gain in heavier, older cattle. Moreover, such cattle may have shown a slightly greater dilution of maintenance resulting in improved F/G, since heavier, older cattle also gained relatively more rapidly. Regression of F/G on α_i, IW and IW^2 accounted for 78.72% of observed variation in F/G. However, α_i alone accounted for a large percentage of the variation (76.18%). Luetingh (1963) observed a trend for pooorer TDN and gross energetic efficiency as cattle increasing in weight and age were fed 2:1, concentrate: roughage diets. His observations were likely related to altered body compositional changes.

It should be noted that even though the effects of IW were significant in all cases and IW^2 in two of the three, the α_i classification variable fitted in a simple linear regression model consistently accounted for a large percentage of the total variation.

Lab Analyses and Feedlot Performance. The ability of the various laboratory analyses to account for variation among residuals in the dependent variables (INTAKE, ADG or F/G), after correction for trial and initial weight effects, is shown in table 3. Since as noted previously, GEL data were available on only 72 pens of cattle, these results are shown with GEL either allowed or not allowed as variable for choice by the maximum R^2 procedure. Recall that residuals from the second model (T_i, IW and IW^2) were the dependent variables for the procedure. Laboratory analyses accounted for more of the variation among residuals in INTAKE (17.81%) and F/G (34.96%) than for ADG (5.16%). This was true whether or not GEL was included as possible selection. When GEL was included as a possible selection, the maximum variation accounted for was 28.49% for INTAKE, 28.60% for F/G and 15.62% for ADG. Thus, the laboratory analyses considered in this study would have more predictive value for INTAKE and F/G than for ADG; however, the actual percentage of variation among residuals accounted for by the various laboratory analyses was relatively small in all cases. If cattle eat to satisfy energy needs, and thus gain, on high concentrate diets, it is logical that the variation accounted for in ADG in this procedure would be lower than for

TABLE 3. VARIATION AMONG RESIDUALS FOR DEPENDENT VARIABLES INTAKE, ADG AND F/G ACCOUNTED FOR BY MAXIMUM R^2 SELECTED SINGLE OR COMBINATION LABORATORY ANALYSES AFTER CORRECTION FOR TRIAL AND INITIAL WEIGHT EFFECTS[a,b]

Variable	Laboratory analyses	% Variation among residuals accounted for
	GEL out of model (130 pens of cattle)	
INTAKE	IV24*	3.79
	GP1*, GP6*	11.13
	GP1*, GP6*, IV24*	16.30
	GP1*, GP6*, IV6, IV12*	17.72
	GP1*, GP6, IV6, IV12, IV24	17.81
ADG	GP6*	2.80
	GP1*, GP6*	4.84
	GP1, GP6*, IV24	5.06
	GP1, GP6*, IV12, IV24	5.15
	GP1, GP6*, IV6, IV12, IV24	5.16
F/G	GP6*	10.71
	GP1*, GP6*	30.77
	GP1*, GP6*, IV12*	34.12
	GP1*, GP6*, IV6, IV12*	34.96
	GP1*, GP6*, IV6, IV12, IV24	34.96
	GEL in model (72 pens of cattle)	
INTAKE	GEL*	5.03
	IV24*, GEL*	9.04
	GP1*, GP6*, IV24*	22.15
	GP1*, GP6*, IV6*, IV24*	28.15
	GP1*, GP6*, IV6*, IV24*, GEL	28.49
	GP1*, GP6*, IV6, IV12, IV24, GEL	28.49
ADG	GP6*	5.13
	GP1*, IV24	12.21
	GP1*, IV12, IV24*	14.29
	GP1*, IV6, IV12, IV24*	14.71
	GP1, GP6, IV12, IV24*, GEL	15.47
	GP1, GP6, IV6, IV12, IV24*, GEL	15.62
F/G	GP6*	16.25
	GP1*, GP6*	22.62
	GP1*, GP6*, GEL	24.23
	GP1*, GP6*, IV6, GEL*	26.22
	GP1*, GP6*, IV6, IV12, GEL	28.53
	GP1*, GP6*, IV6, IV12, IV24, GEL	28.60

*Significant regression F ($P<.10$).

[a]Model from which residuals were derived. $Y = \beta o + \Upsilon_i + IW\beta_1 + IW^2\beta_2 + \epsilon$ accounted for 80.51, 74.73 and 52.64% of variation in INTAKE, ADG and F/G, respectively, for all 162 pens of cattle.

[b]Simple linear regression model with $Y = \beta o + \Upsilon_i + \epsilon$ accounted for 78.45, 73.40 and 49.46% of variation in INTAKE, ADG and F/G, respectively, for all 162 pens of cattle.

INTAKE and F/G. Since dietary energy intake is not limited by bulk fill in high-concentrate diets, ADG would be largely a function of genetic potential. As laboratory analyses tend to measure factors related to energy values, they might not be expected to account for as

TABLE 4. BEST MULTIPLE REGRESSION EQUATIONS R^2 VALUES, AND STANDARD ERRORS OF ESTIMATES FOR DEPENDENT VARIABLES INT: ADG AND F/G BASED ON MAXIMUM R^2 IMPROVEMENT PROCEDURE[b]

No. of pens	Dependent variable	
		GEL out of model
130	INTAKE:	$Y = 1.781 + (\Upsilon_i)^a + .3076(IW) - .002(IW^2) + .039(GPHR) - .0151(GPTOT) - .004(IV6) - .032(IV12)$ $R^2 = .7915$ $Sy(x) = .528$
	ADG:	$Y = 2.802 + (\Upsilon_i)^a - .0659(IW) + .006(IW^2) - .0033(GPHR) + .00259(GPTOT)$ $R^2 = .6771$ $Sy(x) = .121$
	F/G:	$Y = -15.338 + (\Upsilon_i)^a + .7624(IW) - .0063(IW^2) + .0767(GPHR) - .0381(GPTOT) - .0415(IV6) + .0359(IV12)$ $R^2 = .7668$ $Sy(x) = .436$
		GEL in model
72	INTAKE:	$Y = .4645 + (\Upsilon_i)^a + .3114(IW) - .002(IW^2) + .002(GPHR) - .003(GPTOT) + .0015(IV6) - .0734(IV24)$ $R^2 = .8126$ $Sy(x) = .501$
	ADG:	$Y = 3.317 + (\Upsilon_i)^a - .0798(IW) + .007(IW^2) + .0032(GPHR) - .0051(IV12) + .0029(IV24)$ $R^2 = .6661$ $Sy(x) = .124$
	F/G:	$Y = -26.7267 + (\Upsilon_i)^a + 1.148(IW) - .009(IW^2) + .0807(GPHR) - .0455(GPTOT) - .0364(IV6) + .0273(IV12) + .008\ GEL$ $R^2 = .7785$ $Sy(x) = .477$

[a] Υ_i = values assigned for trials.

[b] Best model selected on maximum improvement in R^2 with no increase in regression error MS; all β values may not be significant ($P<.10$).

much variation in ADG as in INTAKE and F/G.

Multiple regression equations based on the "best" combination of laboratory analyses are shown in table 4. The best combination was one that resulted in maximum improvement in R^2 with no increase in the regression error mean square. These combinations were fit into a model which included trial and initial weight effects ($Y = \beta o + T_i + IW\beta_1 + IW^2\beta_2 + LA_i\beta_3 .... LA_n\beta_n + \epsilon$, where LA_i = ith lab analysis). As noted previously, the greatest R^2 values were obtained with the dependent variables INTAKE and F/G. Regression equations and R^2 values were similar whether or not GEL was considered. Note also that R^2 values resulting from these models are lower than those shown in table 2 when a treatment classification was included in the model (79.15% *vs* 91.38% for INTAKE in table 4 *vs* table 2). It is noteworthy, however, that the R^2 of 76.68% for F/G in table 3 (GEL out of model) is similar to the R^2 in table 2 of 78.72%, indicating that these analyses have predictive value for F/G.

It is important to consider that, based on information presented thus far, no single laboratory analysis would be a good predictor of animal performance. It would appear that combinations of laboratory analyses would be the most promising means of developing prediction equations. To further investigate the association between performance parameters (INTAKE, ADG, F/G) and various laboratory grain analyses, correlation analyses were performed on the data (table 5). Correlations of INTAKE with the various laboratory analyses are small (e.g., IV24 = −.36, GEL = −.22) and do not indicate a strong association, although many are significant. The fact that all the correlation coefficients are negative, however, is in agreement with the general belief that as gelatinization, starch availability and digestibility increase, intake should decrease as energy availability increases.

Similar results were again obtained with F/G, with all correlation coefficients being rather small and negative (−.22 and −.32 for IV24 and GEL, respectively). Nevertheless, correlations were highly significant ($P<.01$) for GP6, IV24 and GEL. The same rationale for negative correlations with INTAKE would apply to F/G.

Correlation coefficients between ADG and the laboratory analyses were all small and non-significant, thus, reaffirming the low R^2 values previously discussed in tables 3 and 4. In general, correlations between all dependent variables and laboratory analyses are not of the magnitude necessary for development of accurate, reliable prediction equations using any single analysis. These results are in contrast to those of Albin *et al.* (1966) who report r values of .88 and .99 between IVDMD and feedlot gain and efficiency, respectively.

Correlations among the various laboratory analyses are shown in table 6. These correlations, uncorrected for trial differences, reveal

TABLE 5. CORRELATIONS BETWEEN INT, ADG, AND F/G CORRECTED FOR TRIAL AND INITIAL WEIGHT EFFECTS AND VARIOUS LABORATORY ANALYSES

	Laboratory analyses					
Variable	GP1	GP6	IV6	IV12	IV24	GEL
INTAKE	-.0152[a]	-.1633	-.0879	-.1501	-.3609	-.2242
	.8583[b]	.0600	.6796	.0845	.0001	.0552
	130[c]	130	130	130	162	72
ADG	.0854	.1674	.0278	-.0178	-.1418	.0952
	.6648	.0538	.7523	.8351	.0683	.5677
	130	130	130	130	162	72
F/G	-.0911	-.3272	-.1084	-.1157	-.2175	-.3177
	.3031	.0003	.2170	.1866	.0056	.0066
	130	130	130	130	162	72

[a]Correlation coefficients.

[b]Significance level.

[c]Pens of cattle upon which correlation is based.

TABLE 6. CORRELATIONS AMONG VARIOUS LABORATORY ANALYSES

Variable	Laboratory analyses				
	GP1	IV6	IV12	IV24	GEL
GP1	.8934[a] .0001[b] 130[c]	.5437 .0001 130	.4549 .0001 130	.3852 .0001 130	.2328 .0462 72
GP6	. . .	.4655 .0001 130	.3357 .0003 130	.3166 .0005 130	.6684 .0001 72
IV6	. . .	. . .	.8615 .0001 130	.7249 .0001 130	-.2349 .0443 72
IV12	. . .	. . .	. . .	.9029 130	-.2094 72
IV24	. . .	. . .	. . .	. . .	-.2119 .0704 72

[a]Correlation coefficients.

[b]Significance level.

[c]Pens of cattle upon which correlation is based.

strong and generally obvious associations among several of the analyses. The significant correlation of .668 between GP6 and GEL supports the idea that gas production values provide information similar to gelatinization values in regards to the extent of starch alteration. The high, significant correlations between the three IVDMD measures (.9029 for IV12 and IV24) are expected as they are consecutive measures on the same sample.

The correlations between GP6 and any of the IVDMD measures were not as high as that reported by Trei *et al.* (1970). However, the gas production method used in our studies was a β amyloglucosidase enzyme and yeast utilization procedure; whereas, Trei *et al.* (1970) used rumen microorganisms in their gas production system.

In conclusion, it appears that no single laboratory analysis of grain will predict performance of animals fed that grain with a high degree of accuracy. Combinations of the lab analyses may have been predictive value for certain performance measures (e.g., F/G); however, it would seem that these analyses better serve the purpose of describing the effects of processing and extent of starch alteration in grains.

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