Blood meal variability affects dairy performance

High-quality blood meal was found to increase income over feed costs compared to a low-quality blood meal using current market prices of milk and feedstuffs.

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IN current dairy feeding programs in the U.S., digestible rumen undegradable protein (RUP) contributes 40-60% of the metabolizable protein (MP) supply of lactating cow rations.

All feeds can contribute to digestible RUP; the amounts are a function of the inclusion rate of the feed ingredients and their crude protein (CP), RUP and RUP digestibility values. Many ration formulation programs set RUP as a constant for each feed; however, in reality, RUP varies as a function of the rate of passage of feed particles from the rumen — a rate that likely varies with changes in dry matter intake.

RUP can be estimated by *in situ* incubation of feedstuffs in the rumens of cannulated cows. Average RUP values for many feedstuffs have been widely published. They can be found, for example, in the National Research Council's (NRC) 2001 *Nutrient Requirements of Dairy Cattle*, and are embedded in feed libraries of ration formulation programs based on the 2001 NRC and CPMDairy/CNCPS.

RUP digestibility is measured or estimated much less often than RUP. RUP digestibility can be estimated using *in vivo* or *in vitro* methods. More details on these methodologies can be found in Stern et al. (2007).

While all of these methods have advantages and disadvantages, the three-step procedure of Calsamiglia and Stern (1995), referred to throughout the rest of this article as the Minnesota three-step procedure, has been shown to be robust across feedstuffs and reasonably accurate compared to *in vivo* RUP and RUP digestibility measurements.

The initial three-step *in situ/in vitro* method described by Calsamiglia and Stern showed considerable inter-assay and inter-lab variation when applied to blood meal.

Modifications made in our laboratory at Ohio State University included: partial standardization of enzymes, use of fuzzy standards (i.e., standards whose analytical values are not precisely known), correction for wash-out and Bayesian statistics to adjust for inter-assay variation.

Using these modifications, the inter-assay variance was reduced five-fold

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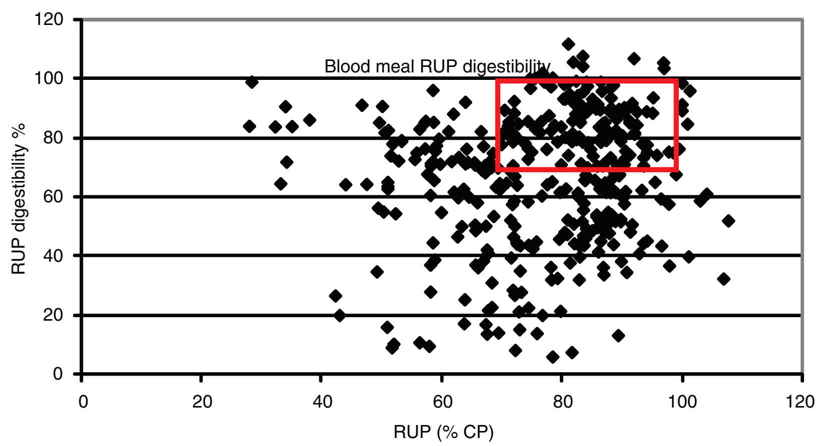
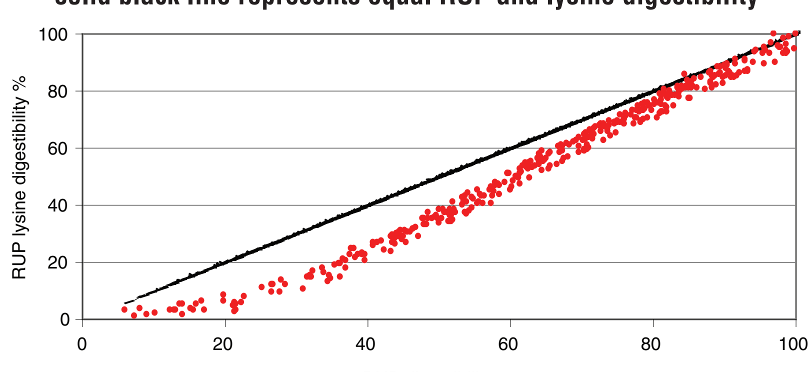
1. Lack of relationship between RUP and RUP digestibility in porcine and bovine blood meal from commercial sources. The most desirable blood meals for dairy cattle feeding are indicated by the red box. RUP and RUP digestibility can exceed 100% due to analytical errors



2. Lysine digestibility (red dots) in the RUP fraction of commodity blood meal samples is significantly lower than the digestibility of RUP itself and approaches zero at RUP digestibilities < 20%. The solid black line represents equal RUP and lysine digestibility



compared to the original three-step procedure. Amino acid digestibilities are corrected such that the sum of all digestible amino acids is equal to the adjusted digestible protein.

Blood meal variation

Over the past five years, Ohio State University has tested more than 265 samples of porcine and bovine blood meals — both ring dried and batch dried — and a summary of the results is given in Table 1.

The CP content (% of dry matter) can exceed 100% due to urine contamination of the blood during the slaughtering process as well as due to non-protein nitrogen that is naturally found in blood. The urea contributing to this contamination would be rumen degradable protein, not RUP.

The variation in blood meal CP is comparable to the variation found in soybean meal and is less than what is generally seen with other animal protein meals such as meat meal (NRC, 2001).

In contrast, RUP is more variable than CP, and RUP digestibility is considerably more so. Note that the ranges indicate that the statistical distributions of these measurements do not follow a normal distribution. Thus, the average plus or minus two standard deviations does not cover 95% of the samples.

RUP digestibility shows no relationship with RUP (Figure 1). RUP and RUP digestibility vary from source to source and within sources. This variation is assumed to be mainly due to differences in processing and drying equipment and procedures. Little of the variation is expected to be due to biological variation; the proportion of the primary blood proteins (hemoglobin, serum albumin and gamma globulins) is quite constant within a species, and only small differences exist between swine and cattle.

Some processors produce consistent blood meals over time, while others produce highly variable product. Identifying suppliers of consistently high-quality blood meal can have tremendous value in dairy cattle feeding programs.

Amino acid digestibilities were found to be similar to RUP digestibility, with the exception of lysine, which was lower (56.0 ± 27.1%). Lysine digestibility was more depressed than RUP digestibility at the lower end of the range and approached zero even when RUP digestibility was in the 15-20% range (Figure 2).

NRC comparison

In the Ohio State set of data, the CP average is slightly greater, while the RUP average is similar to those reported for ring-dried blood meal in the 2001 NRC (Table 2). However, the average RUP

1. Results from 265 blood meal samples tested by Venture Milling at Ohio State University using a modified Minnesota three-step procedure

	Avg.	Standard deviation	---Percentile-- 5th	95th
Dry matter (%)	89.8	1.65	87.1	92.4
CP (% as fed)	90.1	3.68	84.4	96
RUP (% of CP)	76.8	14.80	50.4	96.6
RUP digestibility (%)	64.6	23.06	19.9	97.6
Digestible RUP (% as fed*)	48.7	19.79	13.8	78.8
Amino acids (data from 238 samples)	-------------------------% of CP-------------------------			
Arginine	4.18	0.31	3.76	4.72
Histidine	6.56	0.81	5.06	7.90
Isoleucine	0.88	0.41	0.45	1.66
Leucine	13.26	0.92	11.50	14.63
Lysine	9.12	0.79	7.44	10.31
Methionine	1.18	0.30	0.75	1.59
Phenylalanine	7.10	0.54	6.30	7.99
Threonine	4.11	0.75	2.96	5.15
Tryptophan	1.36	0.33	0.77	7.80
Valine	8.91	0.61	7.85	9.85

*Digestible RUP is the product of CP (as fed) x % RUP x % RUP digestibility, as calculated on an individual sample basis. Means and percentiles do not equal arithmetic calculation due to non-normal distribution of data.

2. Comparison of current results with 2001 NRC reported values for blood meal (values given as mean ± standard deviation, with number of observations in parenthesis)

Nutrient	Commodity blood meal	Ring-dried blood meal	Batch-dried blood meal*
CP, % of dry matter	100.3 ± 3.8 (265)	95.5 ± 8.3 (84)	95.5
RUP, % of CP	76.8 ± 14.8 (265)	77.5 (5)	77.5
RUP digestibility, %	64.6 ± 23.1 (265)	80	65

*Batch-dried blood meal in the 2001 NRC was arbitrarily assigned the same CP and RUP contents as ring-dried blood meal, but with lower RUP digestibility.

3. Base ration for simulation of dairy cow performance when fed blood meals of varying quality

Ingredient	Dry matter (lb./day)	As fed (lb./day)
Corn silage	13.2	40.0
Alfalfa haylage	16.5	40.0
Ground corn	11.5	13.05
48% soybean meal	1.34	1.50
Expeller soybean meal	0.90	1.00
Corn gluten feed	2.68	3.00
Wheat midds	2.69	3.00
Blood meal	0.90	1.00
Vitamin/mineral premix	1.50	1.50
Smartamine M	0.03	0.03

4. Predicted nutrient supply from rations containing blood meals of varying quality

	Requirements	Low-quality	Average	High-quality
		-------------------Supply---------------------		
NEL (Mcal/day)	36.5	36.6	36.6	36.6
MP (g/day)	2,450	2,395	2,448	2,528
Lysine (g/day)	161.0	155.7	159.7	166.0
Methionine (g/day)	51.9	52.2	52.8	53.5
		-------------Failure rate (%)-------------		
NEL		22.3	43.1	74.3
MP		20.7	17.6	9.4
Lysine		55.4	36.6	12.6
Methionine		1.6	2.7	3.7
		-------Profitability ($/cow/day)-------		
Milk income		10.48 ± 0.59	10.74 ± 0.49	10.94 ± 0.36
Feed costs		4.59	4.59	4.59
IOFC		5.89	6.15	6.35

digestibility is significantly lower than the value for ring-dried blood meal and is close to the entry for batch-dried blood meal.

Note that in the 2001 NRC, batch-dried blood meal was arbitrarily assigned the same CP, RUP and amino acid contents as ring-dried blood meal, but with lower RUP digestibility. At the time of the 2001 NRC was compiled, RUP data were limited for most feed ingredients, and consequently, the values published were based on a limited number of samples.

Also in the 2001 NRC, RUP digestibilities were somewhat arbitrarily set for different ingredients. The current set of data provides a significant improvement in our knowledge regarding the digestibility and nutritional value of commodity blood meal and should improve the feed library values found in ration formulation software currently used throughout the dairy industry.

Animal performance

How does the variation in blood meal affect lactation performance? To answer this question, we used PingPong software developed at Ohio State University (Cobanov, 2006).

PingPong uses the average and standard deviation information provided for nutrients in different feedstuffs and simulates what happens as those nutrients vary, comparing the nutrient supply to nutrient requirements based on the 2001 NRC.

The same base ration was formulated for a 1,450 lb. Holstein cow producing 80 lb. of milk per day with 3.80% milk fat and 3.00% true protein (Table 3). The only ingredient that differed among the three rations simulated was blood meal, which was set at the median values of the lower third, middle third and upper third of the data set, representing low-quality, average-quality and high-quality blood meals, respectively. Smartamine M was supplemented to provide adequate metabolizable methionine.

Feed ingredient prices were based on reported prices for July 2010 in the Midwest, and the milk price was based on the federal milk marketing order component prices for July 2010.

Results of the simulated performance are given in Table 4. Although the rations were formulated, on average, to be adequate in net energy for lactation (NEL), the software predicts average milk production of 78.8 lb. per day rather than the target of 80 lb. due to the variation in all ingredients. Thus, the inherent variation in the nutritional composition of a ration is one factor explaining the necessity for using lead factors in ration balancing; there is a need to set a target production above the mean of a pen.

Also, supplementation with 14 g per day of Smartamine M ensured that the metabolizable methionine allowable milk was the same or above that of the NEL-allowable milk.

The nutrients in blood meal that were allowed to vary were CP, RUP and RUP digestibility. The individual amino acids as a percentage of CP were not varied. This simple variation in blood meal nutrient quality results in the ration not meeting the cows' requirements for MP and metabolizable lysine 75% of the time when using a low-quality blood meal (Table 4).

Even for average-quality blood meal, while the ration appears, on average, to be close to meeting the cows' MP and metabolizable lysine requirements, in fact, these nutrients will be inadequate 54% of the time (Table 4).

WHEN high-quality blood meal is fed, the MP and metabolizable lysine-allowable milk exceed the NEL allowable milk, and energy becomes first limiting in the diet (Table 4). As most cows past peak lactation tend to eat to meet energy requirements, energy would not be expected to be truly limiting, at least in the longer run.

As blood meal quality increased from the lowest to highest, average milk yield increased from 74.9 lb. to 76.6 lb. to 78.2 lb. per day and also became less variable. Feeding a high-quality blood meal resulted in a 40% reduction in milk yield variation compared to feeding a low-quality blood meal.

This is also reflected in gross profitability (Table 4). Using a more consistent, high-quality blood meal would result in additional income over feed costs (IOFC) of $16,790 per year per 100 lactating cows compared to feeding a low-quality blood meal and $7,300 more IOFC than using an average-quality blood meal. On a per ton basis, a high-quality blood meal is worth $400 more than an average-quality blood meal and $920 more than a low-quality blood meal based on the estimated improvements in production and a $14/cwt. milk price.

Many nutritionists manage this variation in blood meal quality by restricting the inclusion rate of blood meal in rations, typically to around 0.5 lb. per cow per day. This is, in fact, an expensive way to control the variation in the diet. A good quality control program based on sufficient sampling can be much more cost effective.

Blending blood meals from different sources can considerably reduce the variation of the blend compared to any of its components, although this practice also makes the resulting blend similar in composition to that of an average-quality blood meal unless one uses sources known to be of high quality.

There is also a frequent perception by field nutritionists that blood meal lacks palatability and that its use should be severely restricted in dairy cow rations. This perception probably arose from the frequent feeding of low- or variable-quality blood meal. Researchers at Ohio State University have fed up to 2.25 lb. per cow per day of a high-quality blood meal without any detrimental effect on feed intake.

In fact, an increase in dry matter intake associated with feeding high-quality blood meal is often observed, not through a palatability enhancement from blood meal but as a simple animal response to the greater milk, fat and protein production associated with feeding high-quality blood meal.

References

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