FEEDING FOR MAXIMUM MILK PRODUCTION AND REPRODUCTIVE PERFORMANCE

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INTRODUCTION

A total program of reproductive management encompasses an understanding of the various systems responsible for maximizing reproductive efficiency in the dairy cow. With this knowledge, various factors limiting reproductive performance under routine herd management conditions such as nutrition, disease and stress can be identified and improved or corrected. The importance of energy and protein will be discussed in this paper.

Fertility in lactating dairy cows as reported in Dairy Herd Improvement Associations (DHIA) has trended downward in recent years and at a time when rapid advances were being made in milk production. A recent study at Cornell (10) showed that when herds were stratified into groups milking less than 15,000 lbs, 15,000 to 19,000 lbs., and greater than 19,000 lbs., the lowest conception rate was for the highest level of milk production. In another study, Ferguson (2,3) compared cows milking less than 20,000 to those milking in excess of 20,000 lbs. In the higher group, conception rate was significantly lower if inseminated before 100 days in milk. However, if cows were inseminated over 100 days, there was no difference in conception rate.

Good body condition at calving is important because many high producing cows cannot consume enough feed to meet their energy needs in early lactation, making it necessary to draw on body reserves during this period. The nutrient requirements for dairy cows during the late dry period are outlined in Table 1 (NRC 1988).

Table 1. Nutrient Requirements During the Dry Period (last 2 months of gestation)

Body wt.	Crude Protein	NEL	TDN	Ca	Phos.
	(lbs)	(Mcal)	- - - - - lbs - - - - -		
1000	1.61	10.3	10.0	0.07	0.04
1200	1.90	11.8	11.5	0.08	0.05
1400	2.18	13.2	12.9	0.10	0.06

NEL=net energy for lactation, TDN=total digestible nutrients.

The body reserves of dairy cows are evaluated by a procedure known as body condition scoring. The cow is scored according to the fat covering around the rump and loin area. She is then given a numeric score between 0 and 5 with half scores in between. A desired score at the time of dry off for cows is 3.0 to 3.5 and at calving is 3.5 to 4.0.

Conditioning of dairy cows for subsequent lactations should start near the end of lactation and not to any large degree during the dry period. The key to success is to have the cow in the right condition at dry off and slightly higher at calving. Body condition at calving can affect feed intake, milk yield, and the magnitude of negative balances of energy.

The dry period can be separated into two periods: the early dry period and prepartum period. During the early dry period, there is a final mammary tissue involution and stability. It is a period of fetal growth and a period of tissue maintenance. The prepartum period is characterized by accelerated fetal growth, new mammary milk synthesis tissue growth, and certain hormonal changes that prepares the cow for calving and milk synthesis.

Most information suggests that over-conditioned cows consume less dry matter, produce less milk and have greater incidence of retained placenta, mastitis, and cystic ovaries. The severity of over-conditioning probably determines the impact of body condition at calving on reproduction and health. Cows with postpartum fatty infiltration of the liver often have reduced reproductive performance.

FEEDING DRY COWS

Dry cow feeding is important in attaining maximum performance from the animals after calving. The goal is to maintain good body condition and adequate protein reserves by developing good dry cow feeding strategies (Table 1).

The forages and minerals for dry cows are probably the most frequently mismanaged component of the dry cow feeding program. The reason is probably due to the different forages that are available and the easily accessible mineral mixtures used for lactating cows. Minerals of concern are usually calcium, phosphorus, magnesium, potassium and salt (sodium chloride). As an example, too much salt and potassium lead to udder edema and an imbalance of calcium, phosphorus and magnesium are associated with milk fever.

The forages or roughages used in the dry cow feeding program tend to be associated more with animal health and ration balance. More flexibility may be used in feeding early dry cows than prepartum cows. Early dry cows are usually fed more pasture and/or roughage than prepartum cows. Suitable forages for both groups are good quality grass hay, limited amounts of silage (20-25 lbs) and byproduct roughages such as cottonseed hulls if needed. The key criterion is to keep the cows consuming a lower quality feed in order to maintain rumen volume and tone. Since feedstuffs such as corn, corn silage and alfalfa hay tend to over-condition cows, limit their intake or avoid as much as possible.

A variety of feeding programs can be used to feed dry cows. An example ration is in Table 2.

Table 2. A Typical Dry Cow Ration for Prepartum Cows.

	lb	DM	CP	TDN	Ca	Phos	ADF	NDF	Cost
			- - - - - - - - - lbs - - - - - - - - -						($)
Bermuda hay	12	10.7	.84	5.28	.04	.01	4.1	8.2	.36
Sorghum silage	25	7.5	.63	4.00	.02	.01	3.0	4.5	.38
Grain mix (14)	8	7.2	1.12	5.44	.06	.05	0.8	1.0	.56
	45	25.4	2.59	14.72	0.12	0.07	7.88	13.62	1.30
Requirements (1400 # BW)[1]			2.20	13.20	0.10	0.06			

[1]NRC - 1988.

The protein concentration in the example ration is somewhat higher as compared to NRC recommendation, but would assure adequate intake. Also, a lower degradable protein is suggested for the prepartum cows as compared to the early dry cows. Beginning about two weeks prior to parturition, the amount of energy feed should be increased somewhat in order to adapt the dry cow to consuming more feed. Continue with ample amounts of long grass hay during the prepartum and early postpartum period in order to avoid metabolic problems.

LACTATING COWS

As the dry cow enters the lactating herd, she will be under some stress for a few days. A fresh cow group is frequently maintained for a period of 1 to 2 weeks or until such time the cow is declared healthy. Again, adequate amounts of long should continue to be fed to avoid problems such as displaced abomasum.

The most critical period in the cow's lactation is from parturition until peak production which takes from 5 to 8 weeks postpartum. It is during this period that the "stage is set" for obtaining the highest possible peak in production and also for the onset of normal reproductive cycling which may occur as early as 2-3 weeks in some cows. To be successful, the best strategies must be applied that include many areas such as feeding and management practices, quality and balance of feed, feed bunk management, milking practices, and the maintenance of good health. In general, cows entering the high group will be fed ad libitum for a period of 3 to 5 months or more depending on their performance. Afterwards, cows should be moved to lower producing groups as their performance dictates.

MAINTAINING ENERGY BALANCE

It is common knowledge that early lactating cows do not eat as much feed as they do at 2-3 months into lactation even though the level of milk production may be the same (Figure 1). Feed intake lags behind peak milk production by about 2 to 4 weeks. This results in a negative energy balance and as such, body reserves are mobilized to overcome the energy deficit which results in some body weight loss. Although it is normal for high producing cows to lose weight in early lactation, the energy and especially protein available from body stores can supply only a limited amount of her needs. As body fat is mobilized to

produce more milk (one pound of fat can provide energy to produce 7-8 lbs of milk) proportionally more energy is available than protein. Therefore, the percent protein in the ration during early lactation should be higher in order to maximize the efficiency of energy utilization and to meet the added protein needs.

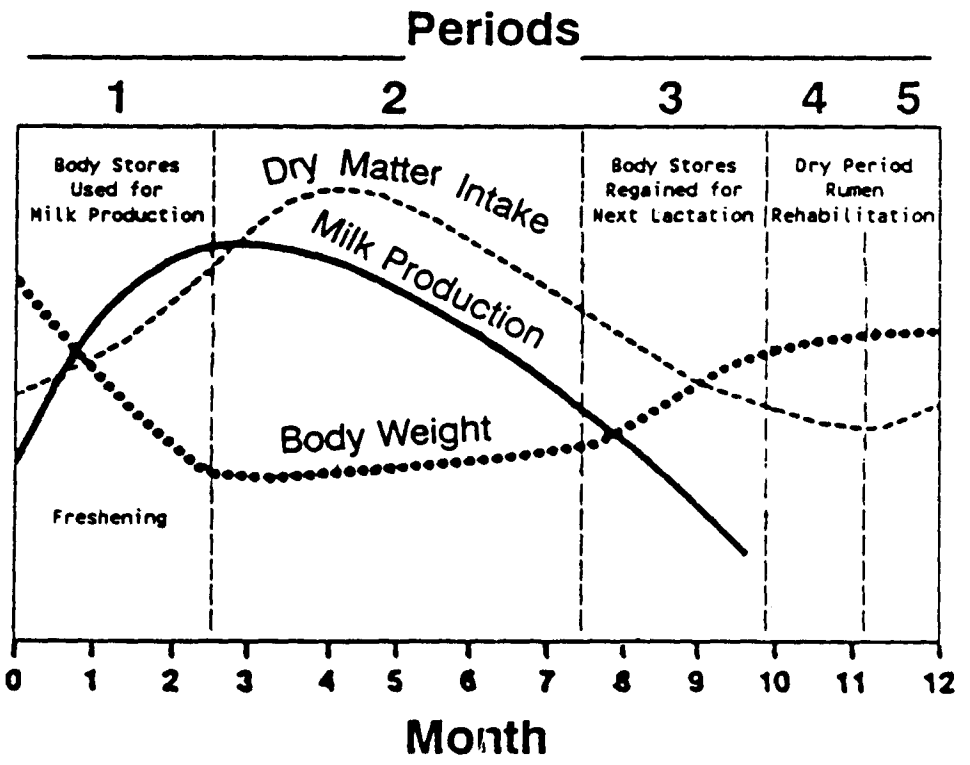

Figure 1. Dry matter intake, milk yield, and body weight changes and relationship during a lactation cycle.

Since high producing cows lose body weight in early lactation, a number of studies have attempted to correlate body weight losses to performance. Studies at Cornell (2, 10) showed that when cows were regrouped on the basis of body condition score loss during the first five weeks of lactation (<.5 units, .5 to 1.0 units, > 1.0 unit), only cows losing > 1.0 units of body condition had lower fertility (increased days to first ovulation, estrus and first service, lower first service conception rate).

Both the extent of negative energy balance and the rate of recovery of energy balance appear to be important. In well fed cows, the negative balances of energy begin to decrease at about week four of lactation. Recovery in energy balance from its most negative state may be a signal for initiation of ovarian activity. Thus, negative energy balance may impair fertility by delaying first estrus by limiting the number of estrus cycles occurring before the preferred breeding period. A number of studies (2, 3, 10) have indicated that conception is positively correlated with the number of ovulatory cycles preceding insemination.

First ovulation usually occurs at 17 to 42 days after parturition (3). It has been suggested that the greater the level of milk production the slower the cow is to first ovulation. For this reason, program strategies must be developed so that the high producing cow will have every opportunity to maximize her energy intake without compromising on her needs for fiber. Concentrated sources of energy such as whole cottonseed and ruminally inert fats may be beneficial in early lactation.

PROTEIN FEEDING

With increasing levels of milk production, dairymen are tending to feed higher levels of protein and a greater amount of bypass protein feedstuffs. The National Research Council suggests 19% crude protein in the ration dry matter for early lactating cows and 17-18% protein for high producing cows. The concentration of protein in the diet of cows can be expected to increase in the future as management technology and genetic selection further enhance milk producing ability.

The new 1988 NRC publication on nutrient requirements of dairy cattle list the protein requirements for dairy cattle as total crude protein and absorbed protein. The requirements for absorbed protein is expressed as UIP (undegraded intake protein) and DIP (degradable intake protein). The UIP or bypass protein recommended for lactating dairy cows varies from 35% for low producing cows up to about 38% for high producing cows. The greatest efficiency in protein utilization should occur in this range.

Protein that bypasses the rumen is degraded to amino acids and absorbed from the small intestine. The degraded protein or ammonia not utilized by the rumen microbes is absorbed from the rumen into the blood stream and converted to urea by the liver. This safeguards the animal, since ammonia is toxic while urea is not. The urea may then be excreted in the urine or recycled to the rumen in the saliva or by passage through the rumen wall.

During recent years, a number of scientists have suggested that feeding rations high in protein may have an adverse effect on reproductive performance of dairy cows. Production of ammonia from dietary protein metabolism in amounts exceeding the body's ability to detoxify or convert the ammonia to urea, may negatively affect reproductive processes. Since urea synthesis and gluconeogenesis are operating near maximum at peak production, cows receiving excess protein in their diet would need extra energy for the conversion of ammonia to urea thereby creating a possible energy shortage. In addition, a high concentration of ammonium ions tend to depress gluconeogenesis. An energy deficient in early lactation appears to be the mechanism associated with reduced fertility. Huber (6) reviewed several studies where the reproductive performance of dairy cows fed diets with different protein concentrations was reported and concluded no conflict between reproduction and feeding high dietary protein.

Jordan and Swanson (7) compared total ration dry matter levels of 13, 16 and 19% protein. Rations consisted of soybean meal, barley, corn or grass silage and some alfalfa hay. Rations were formulated to contain 30:70 forage to grain in the dry matter. Heats were determined by visual observation aided by

progesterone tests. Breeding of the 15 cows per treatment started at 45 days postpartum. The results are in Table 3.

Table 3. The Effect of three levels of protein on certain reproductive parameters.

Treatment	- - Ration Crude Protein - - 12.7	16.3	19.3
Days Open	69[a]	96[b]	106[c]
Days to first observed estrus	36[a]	45[c]	27[b]
Service/conception	1.47[a]	1.87[a]	2.47[b]

[a,b,c]Values with different superscripts in the same row are significantly different. Jordan and Swanson, JDS 62:58, 1979. (Oregon)

Cows receiving the 19.3% CP rations had 27 days to first estrus while the 16.3 and 12.7% CP groups averaged 41 days. Delaying the time of breeding to 45 days may have biased the results in the high protein group because of their earlier expression of estrus.

Folman et al. (4) used three groups of 20 cows in an experiment to study three levels of protein - 15.9, 16.6 and 20.3%. Forage to grain ratio was 22:78. The low protein ration contained formaldehyde treated soybean meal. Treating with formaldehyde reduces the protein degradation in the rumen. Cows were visually checked for heats four times daily and bred only when showing standing heats. Breeding started at 60 days postpartum. The results are in Table 4.

Table 4. The Effect of Formaldehyde Treatment and Two levels of Protein on Certain Reproductive Parameters.

Treatment	- - Ration Crude Protein - - 16.0-F	16.0	20.3
Days Open[a]	84	98	102*
Days to first standing estrus	37	40	38*
Service/conception[a]	1.45	1.79	2.25*
Conception rate (%)	69.0	56.0	44.0
Milk production (lb)	89.0	85.6	84.5

*Three cows culled before pregnancy diagnosis were assumed pregnant.
[a]Apparent difference are not statistically significant
Folman, Neumark, Kaim and Kaufmann, JDS 64:759, 1981. (Israel).

The authors reported that 3 cows in the 20% protein group were inseminated 4 to 7 times and then culled before confirmation of pregnancy. These cows may have had other problems that were not reported. However, these cows were included in the group data. The conception rate was the lowest for the higher protein group.

In another experiment, Kaim et al. (8) included data from 224 cows. Low protein rations contained soybean meal treated or untreated with formaldehyde whereas the high protein ration contained only untreated soybean meal. Breeding

commenced at 60 days. Cows not seen in heat were excluded from the experiment. The results are in table 5.

Table 5. The Effect of Two Levels of Protein on Certain Reproductive parameters.

	15-16%	19-20%
Days to first estrus	41	39
Services/conception	1.75	2.30[a]
First Serv. conception rate	.55	.49
Pregnant at 126 d. (%)	79.0	65.0[a]

[a]Values are significantly different, mainly due to differences seen in cows past third lactation.
Kaim, Folman, Neumark, and Kaufmann, Anim. Prod. 37:229, 1983, (Israel).

The reason for the significance seems to be that the older cows are more affected by the high protein than younger cows. It was indicated that the older cows lost an average of 80 pounds during the first 9 weeks as compared to 55 pounds for the younger cows. Since no difference was obtained from the treated soybean meal, the data was pooled.

In a recent study, Oklahoma workers (5) investigated the reproductive performance of 146 Holstein and Ayrshire cows on either 15 or 20% total protein ration dry matter. Rations were based on sorghum silage with additional protein provided by soybean meal. The forage to grain ratio was 45:55. Cows were visually observed for heat twice daily. Breeding began at 55 days postpartum. Cows were eliminated from the trial due to chronic uterine infection or other sever illness. Numbers eliminated were not related to protein level. The results are in Table 6.

Table 6. Reproductive Performance of Dairy Cattle Fed Either Moderate or High Protein Diets.

Treatment	14.5	19.4
Days Open	80	80
Days to first observed estrus	41	38
Avg. no. services/90 d expt. breeding period		
All cows	1.55	1.47
Cows conceiving	1.39	1.40
Percent pregnant on Expt.	87.0	85.0

No significant Differences
Howard, Aalseth, Adams and Bush, submitted to JDS.
Cows were eliminated if treated for ovarian cysts.

While milk production was enhanced by the 20% protein diet, milk fat and milk protein percent was not affected by diet. Actual decreases in body weight and condition were small. Plasma urea nitrogen increased rapidly, with cows on the 20% protein diet maintaining a 10 mg/dl advantage after the fourth week on

the experiment. There was no conflict between protein level and reproductive performance in the experiment.

In a Florida study, Staples and Thatcher (11) monitored 54 Holstein cows in their second or more lactation from parturition through 9 weeks of lactation for feed and body weight change (energy loss or gain). Cows received a 55:45 roughage (corn silage) to concentrate diet (DM). The results are in Table 7.

Table 7. Performance of lactating Holstein cows differing in activity the first nine weeks of lactation.

Measurement	- - - Classification - - -		
	EC	LC	NC
No. of cows	25	14	15
Dry matter intake, lb/d	41.4	39.0	33.5
4% FCM, lb/d	73.6	69.9	62.8
Days to ovulation	21.9	43.1	----
Days to first heat	47	73	110
Percent of cows conceiving	84	93	36

[1]EC=early cycling; LC=late cycling; NC=noncycling

During the 9 weeks, blood plasma was measured regularly for progesterone in order to detect day of ovulation for each cow. Based on tests, 15 cows were anestrus for the entire 9 weeks. Twenty-five cows returned to estrus within 40 days of parturition and 14 cows between 40 and 60 days after parturition. The study shows the importance of energy intake in early lactation. The earlier cycling cows produced more milk, consumed more energy and experienced the smallest negative energy balance.

The exact relationship of high protein to reproduction is not well defined. There are probably other more important causes. Protein requirements must be supplied for good reproduction. A good balance of both degradable and undegradable protein might support equal production with less total protein in the ration and, in addition, reduce high blood urea nitrogen levels sometimes associated with reduced reproduction. It seems apparent that the key to good reproductive performance in dairy cattle is good nutrition in early lactation under suitable management conditions.

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